EU ACADEMY OF SCIENCES

EUAS

EU ACADEMY
2025 ANNUAL REPORT

The President of EUAS

Professor E.G. Ladopoulos

& The Board Governors of EUAS

Contents

"Energy World" by "Universal Mechanics"- The Improved Theory for the Millenium

by Evangelos Ladopoulos, President & CEO of EUAS

Short Biography
Prof. Dr. Civil Engineer, Mechanical (Aerospace) Engineer & Petroleum Engineer, D.Sc.
Included in the list of 2000 Outstanding Scientists of 20th Century by Cambridge Bio Centre.
Included in the list of 2000 Outstanding Scientists of 21st Century by Cambridge Bio Centre.
Included in the list of 100 Top Scientists of 2007 by Cambridge Bio Centre.
Over 600 publications in high quality scientific journals and 5 books.
Project Manager for over 500 Projects in Civil Engineering, Mechanical Engineering, Aerospace Engineering and Petroleum Engineering.
Chairman and Professor by Interpaper Research Organization.
Visiting Professor at Universities in Europe and USA.
Editor-in-Chief of many SCI Engineering Journals.
High Index by Google Scholar.
President & CEO of the EU Academy of Sciences.
Member by several Academies in USA.

For the design of the future spacecraft of any speed, even approaching the speed of light, the leading technology of ***"Universal Mechanics"*** is proposed and investigated. The innovative and pioneering theory of *"Universal Mechanics"* consists to the combination of the theories of *"Relativistic Elasticity"* and *"Relativistic Thermo-Elasticity"*. Thus, according to the above theories there is a considerable difference between the absolute stress tensor and the stress tensor of the airframe even in the range of speeds of 50,000 km/h. Also, for bigger speeds of the absolute spacecraft, like c/3, c/2 or 3c/4 (c=speed of light), then the difference between the two stress tensors is very much increased. Thus, for the future spacecraft with very high speeds, the relative stress tensor will be therefore very much different than the absolute stress tensor. Besides, for velocities near the speed of light, then the values of the relative stress tensor are very much bigger than the corresponding values of the absolute stress tensor. Such future spacecraft will be moving by using laser engines. In that case the onboard fuel would converted almost entirely in photons. So, engine would be entirely a photon rocket.

When approaching the speed of light an "***Energy World"*** would appear. Is that possible ? Yes it is possible. Over the past years many people have seen in the sky several lights in the form of spacecraft or flying saucers. So, these might be aliens much more developed than humans with their science very much developed and their spacecraft is in energy form. Consequently, if the spacecraft exceeds the speed of light, then it becomes an energy spacecraft. In that case an "***Energy World"*** would be possible.

Another question is what will be next ? Has the energy world to do anything with the life after death ? So, is the soul a kind of energy ? Could be the soul connected to the energy world ? Also, the theory of the "***Energy World"*** in connection with ***"Universal Mechanics"*** is the improved theory of the Millenium. ***For experimental approval needs a lot of funds by the big Space Administarions.***

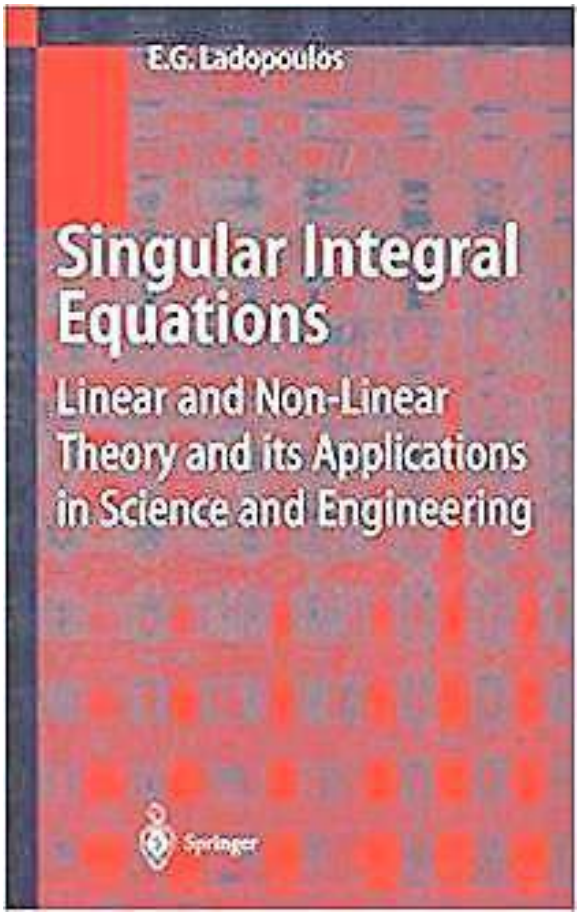
The theory of *"Relativistic Elasticity"* is a combination between the theories of "Classical Elasticity" and "Special Relativity" and results in the ***"Universal Equation of Elasticity"***. Furthermore, the theory of *"Relativistic Thermo-Elasticity"* is a combination between the theories of "Classical Thermo-Elasticity" and "Special Relativity" and results in the ***"Universal Equation of Thermo-Elasticity"***. The "structural design" of super speed vehicles requires the consideration of mass pulsation and energy-mass interaction at high velocity space-time scale, as the relative stress intensity factors are different than the corresponding absolute stress intensity factors. Such theory results in the ***"Universal Stress Intensity Factors"***. Hence, the *"Universal Equation of Elasticity"*, the *"Universal Equation of Thermo-Elasticity"* and the *"Universal Stress Intensity Factors"* are parts of the general theory of ***"Universal Mechanics"***.

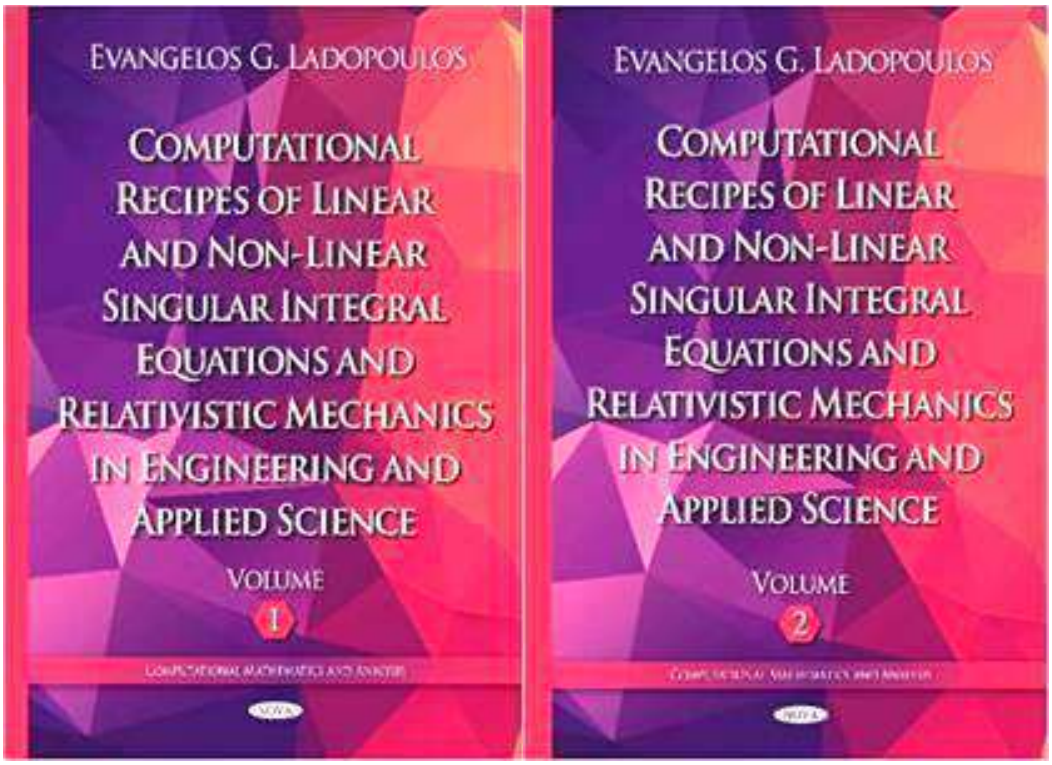
The scope by the International Space Agencies is to achieve in the future, a new generation spacecraft moving with very high speeds, even approaching the speed of light. How far could be this future ? According to NASA's experts this needs many hundreds, or even many thousands of years. On the other hand, according to current author's research and opinion such future could be much closer than everybody believes. For the future spacecraft the relative stress tensor will be much different than the absolute stress tensor and so special solid should be used for the construction of the future spacecraft. In our published theory there is a lot of ***confidential information***. Consequently, if Space Agencies would be interested for the application of our theory, should come in contact directly with us and not through our publications to try to get some innovative information.

In addition, in order the future spacecraft to achieve very high speed, even approaching the speed of light, then such new generation spacecraft should be moving by using laser engines with photonics. Laser is light and so their speed is the speed of light. So, the use of laser engines for the future spacecraft might be the best device. The study of such laser engines with photonics is under investigation. Besides, special material should be used for the construction of such spacecraft. Such special meterial is under study and investigation.

A second question is the following: What happens with our leading theory if somebody in the very future proves that the speed of light is not the maximum speed in the whole universe, but there is another type of energy with higher speed than light ? The answer is that our theory of ***"Universal Mechanics"*** will valid over the centuries and the milleniums, as the spacecraft when reaching the speed of light then becomes energy and will not be mass any more. Consequently, after the speed of light there is no mass available, but only energy. **This would lead to New Physics.** According to NASA the Large and Small Magellanic clouds were thought to be the closest galaxies to ours, until 1994, when the Sagittarius Dwarf Elliptical Galaxy (SagDEG) was discovered. In 2003, the Canis Major Dwarf Galaxy was discovered - this is now the closest known galaxy to ours. Thus, The Canis Major Dwarf Galaxy is only 25,000 light years from the Sun, and 42,000 light years from the Galactic center. It too, is well-hidden by the dust in the plane of the Milky Way - which is why it wasn't discovered until recently. To get to the closest galaxy to ours, the Canis Major Dwarf, at Voyager's speed, it would take approximately 749,000,000 years to travel the distance of 25,000 light years! If we could travel at the speed of light, it would still take 25,000 years. On the other hand, the galaxy MACS0647-JD appears very young and is only a fraction of the size of our own Milky Way. The galaxy is about 13.3 billion light-years from Earth, the farthest galaxy yet known, and formed 420 million years after the Big Bang. The universe itself is only 13.7 billion years old, so this galaxy's light has been traveling toward us for almost the whole history of space and time.

More details can be seen by the following books:


E.G. Ladopoulos
Singular Integral Equations
Linear and Non-Linear Theory and its Applications in Science and Engineering
Springer


EVANGELOS G. LADOPOULOS
COMPUTATIONAL RECIPES OF LINEAR AND NON-LINEAR SINGULAR INTEGRAL EQUATIONS AND RELATIVISTIC MECHANICS IN ENGINEERING AND APPLIED SCIENCE
VOLUME 1
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VOLUME 2

Consider the state of stress at a point in the stationary frame S^0, defined by the following symmetrical stress tensor: (Fig.1)

$$\sigma^0 = \begin{bmatrix} \sigma_{11}^0 & \sigma_{12}^0 & \sigma_{13}^0 \\ \sigma_{21}^0 & \sigma_{22}^0 & \sigma_{23}^0 \\ \sigma_{31}^0 & \sigma_{32}^0 & \sigma_{33}^0 \end{bmatrix} \tag{1}$$

where: $$\sigma_{21}^0 = \sigma_{12}^0, \sigma_{31}^0 = \sigma_{13}^0, \sigma_{32}^0 = \sigma_{23}^0 \tag{2}$$

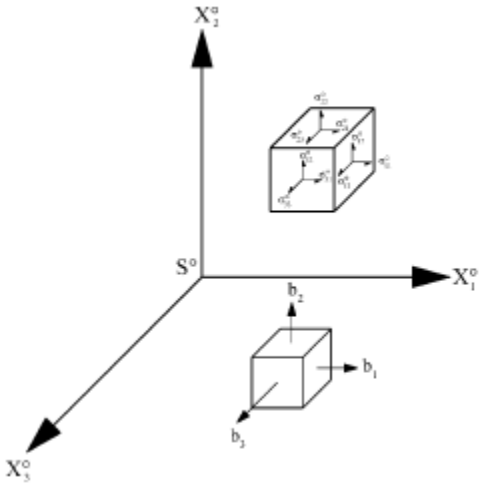

Fig. 1 The state of stress σ_{ik}^0 in the stationary system S^0.

Additionally, we consider an infinitesimal face element df with a directed normal, defined by a unit vector **n**, at definite point p in the three-space of a Lorenz system. The matter on either side of this face element experiences a force which is proportional to df.

Consequently, the force is valid as:

$$\mathrm{d}\boldsymbol{\sigma}(\mathbf{n}) = \boldsymbol{\sigma}(\mathbf{n})\,\mathrm{d}f \tag{3}$$

The components $\sigma_i(\mathbf{n})$ of $\boldsymbol{\sigma}(\mathbf{n})$ are linear functions of the components n_k of **n**:

$$\sigma_i(\mathbf{n}) = \sigma_{ik} n_k, \; i,k = 1,2,3 \tag{4}$$

where σ_{ik} is the elastic stress tensor, also called as the relative stress tensor, in contrast to the space part σ_{ik}^0 of the total energy-momentum tensor T_{ik}, referred as the absolute stress tensor (Fig. 2).

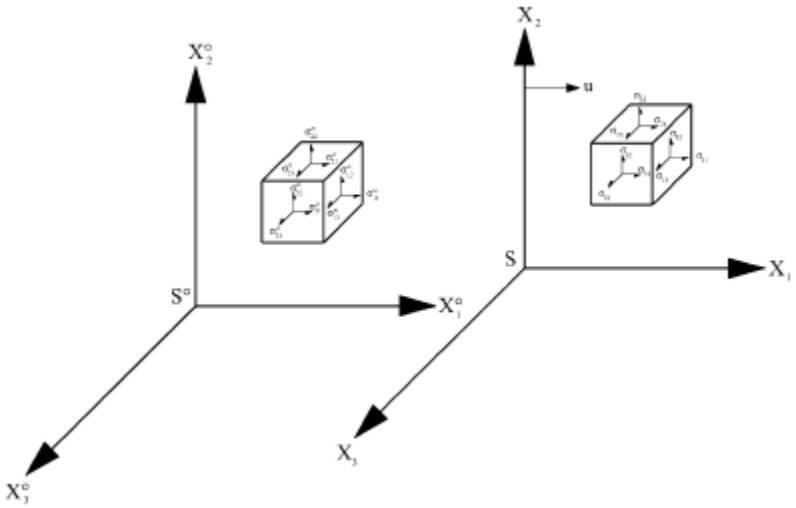

Fig. 2 The state of stress σ_{ik}^{0} in the stationary system S^{0} and σ_{ik} in the airframe system with velocity u parallel to the x_1 - axis.

Besides, the connection between the absolute and relative stress tensors is defined as:

$$\sigma_{ik}^{0} = \sigma_{ik} + g_i u_k, \; i,k = 1,2,3 \tag{5}$$

where g_i are the components of the momentum density $\mathbf{g}$ and u_k the components of the velocity $\mathbf{u}$ of the matter.

The relative stress tensor gives the ***Universal Equation of Elasticity***:

$$\boldsymbol{\sigma} = \begin{bmatrix} \sigma_{11} & \sigma_{12} & \sigma_{13} \\ \sigma_{21} & \sigma_{22} & \sigma_{23} \\ \sigma_{31} & \sigma_{32} & \sigma_{33} \end{bmatrix} = \begin{bmatrix} \sigma_{11}^{0} & \gamma\sigma_{12}^{0} & \gamma\sigma_{13}^{0} \\ \frac{1}{\gamma}\sigma_{21}^{0} & \sigma_{22}^{0} & \sigma_{23}^{0} \\ \frac{1}{\gamma}\sigma_{31}^{0} & \sigma_{32}^{0} & \sigma_{33}^{0} \end{bmatrix} \tag{6}$$

in which γ is given by:

$$\gamma = 1/(1 - u^2/c^2)^{1/2} \tag{7}$$

with c the speed of light.

Additionally, consider the general system of continuously matter, inside which invisible heat conduction can take place. Then the momentum density $\mathbf{g}$ of this system is given by the ***Universal Equation of Thermo-Elasticity:***

$$\mathbf{g} = m\mathbf{u} + \frac{(\mathbf{u},\boldsymbol{\sigma})}{c^2} + \frac{\boldsymbol{\xi}}{c^2} \tag{8}$$

where $\mathbf{u}$ denotes the velocity of the matter at the place and time considered, $\boldsymbol{\sigma}$ the relative stress tensor, $m = E/c^2$ is the total mass density and $\boldsymbol{\xi}$ is given by:

$$\boldsymbol{\xi} = \gamma\left[\mathbf{V} - \mathbf{u}(\mathbf{V},\mathbf{u})/c^2\right] \tag{9}$$

with **V** the four vector.

Furthermore, ***"Universal Mechanics"*** gives the complete theory of mechanics for the whole universe. Then the theories of Special and General Relativity, as were proposed by Albert Einstein are completed for the whole universe by *"Universal Mechanics"*, as proposed by the current author. Hence, by the current author is completed the theory of Albert Einstein for the whole universe regarding mechanics engineering behavior. ***So, this theory could be the leading Theory.***

Table 1 shows the values of γ of relativity theory for some arbitrary values of the velocity u of the moving aerospace structure, where c is the speed of light (300,000 *km/sec*):

Table 1

Velocity u	$\gamma = 1/\sqrt{1-u^2/c^2}$	Velocity u	$\gamma = 1/\sqrt{1-u^2/c^2}$
50,000 *km/h*	1.000000001	0.800c	1.666666667
100,000 *km/h*	1.000000004	0.900c	2.294157339
200,000 *km/h*	1.000000017	0.950c	3.202563076
500,000 *km/h*	1.000000107	0.990c	7.088812050
10E+06 *km/h*	1.000000429	0.999c	22.36627204
10E+07 *km/h*	1.000042870	0.9999c	70.71244596
10E+08 *km/h*	1.004314456	0.99999c	223.6073568
2x10E+8 *km/h*	1.017600788	0.999999c	707.1067812
c/3	1.060660172	0.9999999c	2236.067978
c/2	1.154700538	0.99999999c	7071.067812
2c/3	1.341640786	0.999999999c	22360.67978
3c/4	1.511857892	c	∞

From Table 1 follows that for small velocities 50,000 *km/h* to 200,000

km/*h*, the absolute and the relative stress tensors are nearly the same. On the other hand, for bigger velocities like $c/3$, $c/2$ or $3c/4$ (c = speed of light), the variable γ takes values more than the unit and thus, relative stress tensor is very different from the absolute one. In addition, for values of the velocity for the moving structure near the speed of light, the variable γ takes bigger values, while when the velocity is equal to the speed of light, then γ tends to the infinity.

For the design of the future spacecraft the ***"Universal Stress Intensity Factors"*** are further used. So, as was shown by the current author, the relative first and third mode stress intensity factors are the same for both stationary and moving frames, while the relative second mode stress intensity factor is much different in the above frames. All the relative stress intensity factors (first, second and third) are important for the fracture mechanics analysis of the future spacecraft, as for their fracture mechanics analysis a combination of all the three intensity factors should be used.

The **Universal Stress Intensity Factors** are given by the formulas:

$$K_I = \lim_{x_1 \to 0} \left\{ \sqrt{2\pi x_1}\, \sigma_{22}^0 \right\} \tag{10}$$

$$K_{II} = \lim_{x_1 \to 0} \left\{ \sqrt{2\pi x_1}\, \gamma \sigma_{12}^0 \right\} \tag{11}$$

$$K_{III} = \lim_{x_1 \to 0} \left\{ \sqrt{2\pi x_1}\, \sigma_{23}^0 \right\} \tag{12}$$

Thus, from eqs (10) to (12) follows that the relative first and third mode stress intensity factors are the same for both stationary and moving frames, while the relative second mode stress intensity factor is much different in the above frames. Consequently, because of the above difference of the stress intensity factors, follows that the fracture behavior of the future spacecraft would be much different and thus special materials should be used for their construction. The material which can be used is under investigation.

When the relative stress intensity factors are taken into consideration, then the whole theory is known as ***"Universal Fracture Mechanics".***

As already discussed for experimental approval needs a lot funds by the big Space Administarions.

So we are waiting for the actions of the International Space Administrations.

Reliability of GFR Estimated by Creatinine-Based Formulas in Moderate-to-Severe Proteinuria

by Giuseppe Remuzzi, Member EUAS

Short Biography

Giuseppe Remuzzi completed his medical training at the University of Pavia in 1974 and then received specialty training in Haematology and Nephrology at the University of Milan in 1977 and 1980, respectively. From 1996 until 2013 he was Director of the public-private Department of Immunology and Transplant Medicine (a collaboration between the Ospedali Riuniti of Bergamo and the Mario Negri Institute) and from 1999 until 2018 he has also been Head of the Division of Nephrology and Dialysis. From 2011 until 2015 he was Director of the Department of Medicine of the Azienda Ospedaliera Papa Giovanni XXIII (formerly the Ospedali Riuniti) of Bergamo. In June 2015 he was nominated Chiara Fama Professor of Nephrology at the University of Milan. Alongside his clinical work in hospital, Prof. Remuzzi has dedicated himself to intense didactic and research activities. Since the Mario Negri Institute for Pharmacological Research opened its branch in Bergamo, Prof. Remuzzi has coordinated all of the research that takes place there, and since 1992 he has done the same for the Aldo e Cele Daccò Clinical Research Centre for Rare Diseases in Ranica, Bergamo. Since July 1st 2018 Professor Remuzzi has also taken on the role of Director of the Mario Negri Institute. He has been member of the Consiglio Superiore di Sanità since February 2019. He has been Vice President of the Italian Institute for Planetary Health since 2019. His main research interests include the causes of glomerulonephritis and the mechanisms of progression of kidney diseases. He has also conducted many studies in the field of transplant rejection. With an innovative approach (transplanting two kidneys from older donors into one recipient, after carefully evaluating the condition of the organs), his research has facilitated an increase in the number of transplants conducted. His most recent research concerns the possibility of regenerating tissues and creating organs in the laboratory using
stem cells. Prof. Remuzzi serves on editorial boards of numerous journals and is member of the International Advisory Board of The Lancet. He served as Editorial Board member of the New England Journal of Medicine from 1998-2013. In recognition of his achievements, he has been awarded in 1998 honorary memberships of the Association of American Physicians and the British Royal College of Physicians. In 2005 during the World Congress of Nephrology in Singapore he received the ISN Jean Hamburger Award. In 2007 he received during the annual American Society of Nephrology Congress in San Francisco the prestigious ASN John P. Peters Award and in 2011 he was awarded with the ISN AMGEN Award (World Congress of Nephrology: WCN 2011, Vancouver). In November 2011 he received the Third Edition of the International Award "Luis Hernando" assigned by the Iñigo Alvarez de Toledo Renal Foundation (FRIAT) in Madrid, Spain. From June 2013 until March 2015 he was President of the International Society of Nephrology (ISN). During his tenure he created and launched the global 0by25 project, the goal of which is that "Nobody should die of preventable and treatable Acute Kidney Injury (AKI) by 2025".In April 2018 he was awarded the "Lennox K. Black International Prize for Excellence in Medicine" at the Thomas Jefferson University in Philadelphia. From 2024 he is Corresponding Member of the Academy of the Lincei - Physical, Mathematical and Natural Sciences (Category V: Biological Sciences and Applications - Section D: Physiology, Pharmacology and Neurosciences). In 2022 he was honoured by the Italian President of the Republic with the title of Cavaliere di Gran Croce. Prof. Remuzzi is the author of hundreds of publications in International medical journals and has written several books. He also regularly writes editorials for the Corriere della Sera newspaper.

Clin J Am Soc Nephrol. 2024 Oct 24.

Reliability of GFR Estimated by Creatinine-Based Formulas in Moderate-to-Severe Proteinuria

Giuseppe Remuzzi et al

Key Points:

- GFR estimations are biased in patients with frank nephrotic syndrome, but the problem is uncharacterized in patients with non-nephrotic proteinuria.
- We investigated the bias and accuracy of eGFR formulas in patients with mild-to-moderate proteinuria participating in the ramipril in nondiabetic renal failure 1 and 2 trials.
- The CKD Epidemiology Collaboration 2009 and 2021 and European Kidney Function Consortium equations show no significant bias and sufficient accuracy in moderate-to-severe proteinuria.

Background: Creatinine-based GFR formulas introduce a substantial bias in GFR estimations in patients with frank nephrotic syndrome. The bias and accuracy of creatinine-based GFR estimates (eGFR) in patients with non-nephrotic proteinuria need better characterization.

Methods: We used data from the Ramipril in Nondiabetic Renal Failure (ramipril in nondiabetic renal failure [REIN] 1) and REIN 2 trials involving nondiabetic CKD patients with proteinuria to compare eGFRs derived from the CKD Epidemiology Collaboration formulas (with and without race) and the European Kidney Function Consortium equations with iohexol clearance (a gold-standard GFR measure, measured GFR [mGFR]). Bias was defined as the median difference between eGFR and mGFR while accuracy was assessed using P30 and P15 metrics, which represent the percentage of eGFR values within ±30% and ±15% of mGFR, respectively.

Results: The median bias of the three formulas being compared did not differ, being minimal and in a strict range (0.04–0.05 ml/ml per min per 1.73 m^2) in the REIN 1 trial and (−0.04 to 0.03 ml/min per 1.73 m^2) in the REIN 2 trial. These findings were confirmed in analyses stratified by age and mGFR. The global accuracy of the three formulas regarding P30 % showed sufficient accuracy (P30 >75%) in the REIN 1 trial and all strata in the REIN 2 trial, but the mGFR stratum was <15 ml/min per 1.73 m^2.

Conclusions: The CKD Epidemiology Collaboration (with and without race) and European Kidney Function Consortium equations show no significant bias and sufficient accuracy in patients with proteinuria. These formulas can be safely applied to nondiabetic CKD patients with moderate-to-severe proteinuria.

Front Immunol. 2024 Feb 26:15:1335998.

Bi-specific autoantigen-T cell engagers as targeted immunotherapy for autoreactive B cell depletion in autoimmune diseases

Giuseppe Remuzzi et al

Abstract

Introduction: In autoimmune diseases, autoreactive B cells comprise only the 0.1-0.5% of total circulating B cells. However, current first-line treatments rely on non-specific and general suppression of the immune system, exposing patients to severe side effects. For this reason, identification of targeted therapies for autoimmune diseases is an unmet clinical need.

Methods: Here, we designed a novel class of immunotherapeutic molecules, Bi-specific AutoAntigen-T cell Engagers (BiAATEs), as a potential approach for targeting the small subset of autoreactive B cells. To test this approach, we focused on a prototype autoimmune disease of the kidney, membranous nephropathy (MN), in which phospholipase A_2 receptor (PLA_2R) serves as primary nephritogenic antigen. Specifically, we developed a BiAATE consisting of the immunodominant Cysteine-Rich (CysR) domain of PLA_2R and the single-chain variable fragment (scFv) of an antibody against the T cell antigen CD3, connected by a small flexible linker.

Results: BiAATE creates an immunological synapse between autoreactive B cells bearing an CysR-specific surface Ig^+ and T cells. *Ex vivo*, the BiAATE successfully induced T cell-dependent depletion of PLA_2R-specific B cells isolated form MN patients, sparing normal B cells. Systemic administration of BiAATE to mice transgenic for human CD3 reduced anti-PLA_2R antibody levels following active immunization with PLA_2R.

Discussion: Should this approach be confirmed for other autoimmune diseases, BiAATEs could represent a promising off-the-shelf therapy for precision medicine in virtually all antibody-mediated autoimmune diseases for which the pathogenic autoantigen is known, leading to a paradigm shift in the treatment of these diseases.

Keywords: anti-PLA2R antibodies; autoimmune diseases; autoreactive B cell; bi-specific autoantigen-T cell engagers; membranous nephropathy; targeted immunotherapies.

Cells 2022 Aug 5;11(15):2434.

Add-On Cyclic Angiotensin-(1-7) with Cyclophosphamide Arrests Progressive Kidney Disease in Rats with ANCA Associated Glomerulonephritis

Giuseppe Remuzzi et al

Abstract

Rapidly progressive crescentic glomerulonephritis associated with anti-neutrophil cytoplasmic antibodies (ANCA-GN) is a major cause of renal failure. Current immunosuppressive therapies are associated with severe side effects, intensifying the need for new therapeutic strategies. The activation of Mas receptor/Angiotensin-(1-7) axis exerted renoprotection in chronic kidney disease. Here, we investigated the effect of adding the lanthionine-stabilized cyclic form of angiotensin-1-7 [cAng-(1-7)] to cyclophosphamide in a rat model of ANCA-GN. At the onset of proteinuria, Wistar Kyoto rats with ANCA-GN received vehicle or a single bolus of cyclophosphamide, with or without daily cAng-(1-7). Treatment with cAng-(1-7) plus cyclophosphamide reduced proteinuria by 85% vs. vehicle, and by 60% vs. cyclophosphamide, and dramatically limited glomerular crescents to less than 10%. The addition of cAng-(1-7) to cyclophosphamide protected against glomerular inflammation and endothelial rarefaction and restored the normal distribution of parietal epithelial cells. Ultrastructural analysis revealed a preserved GBM, glomerular endothelium and podocyte structure, demonstrating that combination therapy provided an additional layer of renoprotection. This study demonstrates that adding cAng-(1-7) to a partially effective dose of cyclophosphamide arrests the progression of renal disease in rats with ANCA-GN, suggesting that cAng-(1-7) could be a novel clinical approach for sparing immunosuppressants.

Blood Adv. 2022 Jan 8;6(3):866-881.

C5a and C5aR1 are key drivers of microvascular platelet aggregation in clinical entities spanning from aHUS to COVID-19

Giuseppe Remuzzi et al

Abstract

Unrestrained activation of the complement system till the terminal products, C5a and C5b-9, plays a pathogenetic role in acute and chronic inflammatory diseases. In endothelial cells, complement hyperactivation may translate into cell dysfunction, favoring thrombus formation. The aim of this study was to investigate the role of the C5a/C5aR1 axis as opposed to C5b-9 in inducing endothelial dysfunction and loss of antithrombogenic properties. In vitro and ex vivo assays with serum from patients with atypical hemolytic uremic syndrome (aHUS), a prototype rare disease of complement-mediated microvascular thrombosis due to genetically determined alternative pathway dysregulation, and cultured microvascular endothelial cells, demonstrated that the C5a/C5aR1 axis is a key player in endothelial thromboresistance loss. C5a added to normal human serum fully recapitulated the prothrombotic effects of aHUS serum. Mechanistic studies showed that C5a caused RalA-mediated exocytosis of von Willebrand factor (vWF) and P-selectin from Weibel-Palade bodies, which favored further vWF binding on the endothelium and platelet adhesion and aggregation. In patients with severe COVID-19 who suffered from acute activation of complement triggered by severe acute respiratory syndrome coronavirus 2 infection, we found the same C5a-dependent pathogenic mechanisms. These results highlight C5a/C5aR1 as a common prothrombogenic effector spanning from genetic rare diseases to viral infections, and it may have clinical implications. Selective C5a/C5aR1 blockade could have advantages over C5 inhibition because the former preserves the formation of C5b-9, which is critical for controlling bacterial infections that often develop as comorbidities in severely ill patients. The ACCESS trial registered at www.clinicaltrials.gov as #NCT02464891 accounts for the results related to aHUS patients treated with CCX168.

JAMA. 2022 May 17;327(19):1888-1898.

Effect of Oral Methylprednisolone on Decline in Kidney Function or Kidney Failure in Patients With IgA Nephropathy: The TESTING Randomized Clinical Trial

Giuseppe Remuzzi et al

Abstract

Importance: The effect of glucocorticoids on major kidney outcomes and adverse events in IgA nephropathy has been uncertain.

Objective: To evaluate the efficacy and adverse effects of methylprednisolone in patients with IgA nephropathy at high risk of kidney function decline.

Design, setting, and participants: An international, multicenter, double-blind, randomized clinical trial that enrolled 503 participants with IgA nephropathy, proteinuria greater than or equal to 1 g per day, and estimated glomerular filtration rate (eGFR) of 20 to 120 mL/min/1.73 m2 after at least 3 months of optimized background care from 67 centers in Australia, Canada, China, India, and Malaysia between May 2012 and November 2019, with follow-up until June 2021.

Interventions: Participants were randomized in a 1:1 ratio to receive oral methylprednisolone (initially 0.6-0.8 mg/kg/d, maximum 48 mg/d, weaning by 8 mg/d/mo; n = 136) or placebo (n = 126). After 262 participants were randomized, an excess of serious infections was identified, leading to dose reduction (0.4 mg/kg/d, maximum 32 mg/d, weaning by 4 mg/d/mo) and addition of antibiotic prophylaxis for pneumocystis pneumonia for subsequent participants (121 in the oral methylprednisolone group and 120 in the placebo group).

Main outcomes and measures: The primary end point was a composite of 40% decline in eGFR, kidney failure (dialysis, transplant), or death due to kidney disease. There were 11 secondary outcomes, including kidney failure.

Results: Among 503 randomized patients (mean age, 38 years; 198 [39%] women; mean eGFR, 61.5 mL/min/1.73 m2; mean proteinuria, 2.46 g/d), 493 (98%) completed the trial. Over a mean of 4.2 years of follow-up, the primary outcome occurred in 74 participants (28.8%) in the methylprednisolone group compared with 106 (43.1%) in the placebo group (hazard ratio [HR], 0.53 [95% CI, 0.39-0.72]; P < .001; absolute annual event rate difference, -4.8% per year [95% CI, -8.0% to -1.6%]). The effect on the primary outcome was seen across each dose compared with the relevant participants in the placebo group recruited to each regimen (P for heterogeneity = .11): full-dose HR, 0.58 (95% CI, 0.41-0.81); reduced-dose HR, 0.27 (95% CI, 0.11-0.65). Of the 11 prespecified secondary end points, 9 showed significant differences in favor of the intervention, including kidney failure (50 [19.5%] vs 67 [27.2%]; HR, 0.59 [95% CI, 0.40-0.87]; P = .008; annual event rate difference, -2.9% per year [95% CI, -5.4% to -0.3%]). Serious adverse events were more frequent with methylprednisolone vs placebo (28 [10.9%] vs 7 [2.8%] patients with serious adverse events), primarily with full-dose therapy compared with its matching placebo (22 [16.2%] vs 4 [3.2%]).

Conclusions and relevance: Among patients with IgA nephropathy at high risk of progression, treatment with oral methylprednisolone for 6 to 9 months, compared with placebo, significantly reduced the risk of the composite outcome of kidney function decline, kidney failure, or death due to kidney disease. However, the incidence of serious adverse events was increased with oral methylprednisolone, mainly with high-dose therapy.

J Pathol 2022 Apr;256(4):468-479.

Empagliflozin protects glomerular endothelial cell architecture in experimental diabetes through the VEGF-A/caveolin-1/PV-1 signaling pathway

Giuseppe Remuzzi et al

Abstract

In addition to having blood glucose-lowering effects, inhibitors of sodium glucose cotransporter 2 (SGLT2) afford renoprotection in diabetes. We sought to investigate which components of the glomerular filtration barrier could be involved in the antiproteinuric and renoprotective effects of SGLT2 inhibition in diabetes. BTBR (black and tan, brachyuric) ob/ob mice that develop a type 2 diabetic nephropathy received a standard diet with or without empagliflozin for 10 weeks, starting at 8 weeks of age, when animals had developed albuminuria. Empagliflozin caused marked decreases in blood glucose levels and albuminuria but did not correct glomerular hyperfiltration. The protective effect of empagliflozin against albuminuria was not due to a reduction in podocyte damage as empagliflozin did not affect the larger podocyte filtration slit pore size nor the defective expression of nephrin and nestin. Empagliflozin did not reduce the thickening of the glomerular basement membrane. In BTBR ob/ob mice, the most profound abnormality seen using electron microscopy was in the endothelial aspect of the glomerular capillary, with significant loss of endothelial fenestrations. Remarkably, empagliflozin ameliorated the subverted microvascular endothelial ultrastructure. Caveolae and bridging diaphragms between adjacent endothelial fenestrae were seen in diabetic mice and associated with increased expression of caveolin-1 and the appearance of PV-1. These endothelial abnormalities were limited by the SGLT2 inhibitor. Although no expression of SGLT2 was found in glomerular endothelial cells, SGLT2 was expressed in the podocytes of diabetic mice. VEGF-A, which is a known stimulus for endothelial caveolin-1 and PV-1, was increased in podocytes of BTBR ob/ob mice and normalized by SGLT2 inhibitor treatment. Thus, empagliflozin's protective effect on the glomerular endothelium of diabetic mice could be due to a limitation of the paracrine signaling of podocyte-derived VEGF-A that resulted in a reduction of the abnormal endothelial caveolin-1 and PV-1, with the consequent preservation of glomerular endothelial function and permeability. © 2022 The Pathological Society of Great Britain and Ireland.

Electrocatalysis for Hydrogen Electrode Reactions

by Shichun Mu, Member EUAS

Short Biography

Prof. Mu, State Key Laboratory of Advanced Technology for Materials Synthesis and Processing, Wuhan University of Technology
Shichun Mu is Chair Professor at Wuhan University of Technology, the member of EU Academy of Sciences (2025), the Fellow of the Royal Society of Chemistry (2022), the director of the International Academy of Electrochemical Energy Sciences (2014), the standing director of the Energy Storage Materials and Devices Technology Subcommittee of Energy Storage Technology Committee of IEEE PES China (2020). He received his Ph.D. degree from Chinese Academy of Sciences, China in 2001, and joined the Wuhan University of Technology as a postdoc till 2003. Since then, he has stayed at Wuhan University of Technology and been a full professor since 2006. He was an academic visitor at Inorganic Chemistry Laboratory, University of Oxford in 2007–2008. His research interests focus on carbon materials, water splitting/PEM fuel cell catalysts, and lithium-ion batteries. He has published more than 420 peer reviewed papers.

1. Unveil A Significant Impact of Intrinsic Five Membered Ring (C5) Topological Defects on Electrochemical Reactivity of Carbon Materials

The topological deformation of carbon lattices can regulate charge state of carbon, but evidences are still lacking on promoting electrochemical reactivity of carbon materials. Therefore, we theoretically demonstrated that intrinsic five membered ring (C5) topological defects have a significant impact on the electrochemical reactivity of carbon, as ideal catalytic active centre for oxygen reduction reaction (ORR) and hydrogen evolution reaction (HER). Experimentally, we obtained C5-rich carbon materials for the first time through in-situ chemical etching of C60, and verified that C5 topological defects can significantly enhance the intrinsic ORR (Angew Chem Int Ed 2019, 58, 385) and HER activities (Angew Chem Int Ed 2024, 63, e202411125). We also evidenced positive contribution of C5 topological-defect

carbon on the double-layer-capacitance (Angew Chem Int Ed 2019, 58, 385). The research results point out new research directions for improving the catalytic performance of carbon-based catalysts, and provide new ideas for designing high-performance nanocarbon-based materials, promoting the application of carbon-based materials in energy conversion and storage devices.

2. Propose Compatible Mechanisms for Adsorbate Evolution (AEM) and Lattice Oxygen Oxidation (LOM)

The water oxidation reaction, also known as the oxygen evolution reaction (OER), is a key step in hydrogen production through water electrolysis. Previous studies have shown that although lattice oxygen oxidation mechanism (LOM) can break the thermodynamic limitations of traditional adsorbate evolution mechanism (AEM) and further improve the OER activity of catalysts, it is not conducive to maintaining the structural stability of catalysts due to the involvement of lattice oxygen and the formation and refilling of oxygen vacancies. It has been found that introducing Fe and S as modulator can achieve catalysts with a AEM-LOM compatibility mechanism, wherein Fe serves as active site of the AEM pathway, optimizing adsorption of OER intermediates, while S stimulates lattice oxygen activity, increasing the LOM reaction pathway of OER processes. Under the regulation of Fe and S, the designed R-NiFeOOH@SO_4 system realizes the synergistic catalysis of AEM and LOM pathways, maximizes the utilization of surface metal and oxygen active sites, improving the OER catalytic performance (Nat Commun 2024, 15, 8293).

3. Develop A Series of Pt-Group Metal Compounds for Electrocatalysis

Nano Pt-group metal (PGM) compounds have high catalytic activity, but chemical inertness always limits their synthesis in mild conditions. To this end, we firstly utilized a molten salt assisted method to design and construct a bicontinuous nanoreactor composed of multi-scale defective RuO_2 monomers, with abundant active sites and rapid mass transfer capability for catalytic reactions, demonstrating excellent acidic OER performance (Nature Commun 2024, 15, 3928). With the same method, $IrB_{1.1}$ and OsB_2 compounds were prepared, respectively, with ordered filling of light B atoms in Ir/Os lattices. The strong coupling of Ir-B structural units ensures catalytic stability (Angew Chem Int Ed 2024, 63, e202407577). By filling with light B atoms, the spacing between Os metal atoms can be precisely adjusted, and as the distance between metal atoms increases the hydrogen adsorption distance relationship reverses, promoting the hydrogen evolution reaction (Nano-micro Lett 2023, 15, 168). Additionally, the hydrogen evolution reaction activity trend of PGM silicides (such as IrSi, PtSi, Pd_2Si, RhSi, RuSix) was revealed (ACS Catal 2022, 122623). Due to outstanding contributions in this research field, we had been invited to write a review on the molten salt assisted method (Adv Mater 2024, 36, 2408285). On the other hand, with the strong coordination of green phytic acid, we synthesized a series of nano Pt-group phosphides (PtP_2, RuP_2, IrP_2, RhP_2, Pd_5P_2,

etc.) for the first time in a mild environment (Angew Chem Int Ed 2017, 5611559; Energy Environment Sci 2019, 12952).

4. Unveil Intrinsic Driving Mechanism of Electron Transfer and Charge Balance Effects of Heterogeneous Interfaces by Introducing Work Function (WF)

The work function (WF), as a parameter reflecting the electron escape capability, determines the built-in electric field (BEF) and direction of the charge transfer at the heterostructure interface. By introducing WF into the electrochemical hydrogen evolution reaction at the interface, not only can the intrinsic driving mechanisms of electron transfer and interface equilibrium be fundamentally elucidated, but also the activity origin of heterogeneous electrocatalysts for hydrogen evolution reaction (HER) can be well explained. For the Os-$OsSe_2$ heterostructure, driven by the BEF, Se acts as a controllable charge modulator, promoting bidirectional optimization of the hydrogen bonding energy between Os and $OsSe_2$, accelerating the HER kinetics in both acidic and alkaline media (Angew Chem Int Ed 2022, 61, e202208642). This result can also be applied to the catalytic mechanism analysis of our previous work on Ru/RuS_2 (Angewa Chem Int Ed 2021, 60, 12328), Ru/Ru_2P (InfoMat 2022, 4, e12287) and Os/OsS_2 (ACS Catal 2022, 12, 13312) heterostructure catalysts for water splitting. In addition, we also proposed a strong built-in external electric field between the PdRu@MO_x (M=Fe or Cu) heterostructure interface and the region of the PdRu five-fold local symmetry breaking. The existence of dual electric fields optimized the interface charge density, significantly improving the proton adsorption capacity and accelerating the HER kinetics (Nano Energy 2024,131110, 216).

5. Regulate Interface Characteristics, Coordination Environment, and Electronic Properties of Catalysts by Breaking Their Structural Symmetry

By changing the symmetrical atomic periodic structure in pure phase compounds, it can optimize the electronic configuration and coordination environment near the metal active site, leading to the reduced thermodynamic potential barrier of the rate determining step, achieving synchronous improvement of the electrocatalytic activity and stability of the target catalyst. For example, by introducing the Se atom to partially replace the S atom in RuS_2, the structural asymmetry of $RuSe_2$ was induced, optimizing the electronic configuration and coordination environment near Ru active sites and promoting electron accumulation towards Ru. Also, the introduction of Se enhanced the coupling effect between cations and anions. All these reduce the thermodynamic potential barrier and promote the rapid acid water oxidation kinetics of catalysts (Energy Environment Sci 2024,171885). Additionally, we constructed a defect-rich FeO_x supported Ru cluster (Ru/$RuxFe_{3-}$

$_xO_4$) catalyst with many heterogeneous interfaces and uncoordinated metal sites. Thus, the symmetry of the $Fe_{3-x}O_4$ lattice was broken, the charge distribution at the heterogeneous interfaces was altered, and the electron transfer between Ru clusters and Fe (Ru) O_x was enhanced. Moreover, the dispersion of Ru atoms towards FeO_x interfaces led to electron rearrangement, regulating the adsorption energy of surface active sites and intermediates, and promoting hydrogen evolution/oxidation reactions (Nano Lett 2024,24,2015). This work demonstrates that breaking structural symmetry is an effective way to improve the catalytic performance of catalysts.

6. Achieve Highly Dispersed and Multiscale Pt-Group Metal (PGM) Active Species (Atoms/Clusters/Ultra Small Nanoparticles) by Utilizing Synergistic Effects between PGM Active Species and Metal Single-Atom Sites in The M-N-C System

Choosing a suitable carrier and adjusting the size of the loaded PGM species through strong carrier metal interaction (SMSI) is a simple and effective method for preparing efficient PGM-based catalysts. In the process of catalyst synthesis and applications, active PGM nanoparticles often undergo severe aggregation due to Oswald ripening or lack of constraints, resulting in a decrease in the number of active sites and catalytic efficiency. Therefore, how to improve the atomic utilization efficiency of PGM remains a great challenge. According to our prediction, due to the strong interaction between single atom M sites on the M-N-C framework and PGM (PGM@M-N-C), the overgrowth and aggregation of PGM species will be effectively suppressed, resulting in the ideal size and distribution for PGMs. To this end, we used the MOF-derived single atom M-N-C system as a substrate to anchor active PGM species. Thanks to the strong anchoring effect of highly dispersed MN_4 single atom sites (M) on PGM species, the aggregation of PGM species is effectively inhibited. It had been shown that there was electron transfer and strong interaction between the single atom M site and the loaded PGM species, and the obtained PGM@M-N-C catalysts have multiple active centres, ultra-low PGM loading, and suitable size from single atoms, clusters to nanoparticles, exhibiting excellent ORR, HER or HOR performance in acidic/alkaline media (Nano Energy 2024, 121, 109247; ACS Catal 2023, 134, 012; J Energy Chem 2022, 65, 48; Nano Energy 2021, 88, 106221; Nano Energy 2019, 59472).

7. Extract Carbon Atoms from Transition Metal Carbides (M_xc_y) for The First Time

Although conventional carbide-derived carbon (CDC) can be achieved by replacing transition metal (M) in carbides, it is difficult to extract carbon atoms from carbides. This is mainly because the principle of reaction thermodynamics and kinetics for carbon-atom extraction is still unclear. Therefore, we attempted to finely regulate the thermodynamic parameters of the chlorinated carbide reaction, and found that if

the χ value (the chlorine-to-carbide molar ratio) is significantly reduced and the reaction temperature is controlled for incomplete chlorination reaction, carbon atom can be extracted from carbides. Taking tungsten carbide (WC) as an example, when the χ value is reduced to 1.3 (reaction temperature of 1000 ℃, reaction time of 4h), the carbon atoms can be extracted from tungsten carbide (WC), thereby obtaining a metal tungsten/tungsten carbide (W/WC) heterostructure composed of homologous metal atoms. The constructed W/WC heterostructure material exhibits high hydrogen evolution and photocatalytic performance. This study realizes the carbon extraction of carbides by a chlorination method and provides innovative ideas for the in-situ preparation of metal/metal carbide heterostructure materials through the chlorination of carbides (Nanoscale Horiz 2019, 4,19).

8. Develop A New Method to Obtain Graphene and Homologous Transition Metal Doped Carbon Materials through Chlorinating Carbides

First, we thoroughly removed the M component from two-dimensional crystalline metal carbides (M_xC_y) through chlorination reaction under ambient pressure, rapidly converting them into graphene featured with controllable graphene layers, low cost, few defects, and high quality (Adv Funct Mater 2017271604904). In addition, amorphous carbides (a-M_xC_y) such as SiC and TiC can be rapidly converted into graphene under medium to low temperature (200-1000 ℃) and atmospheric pressure conditions using a complete chlorination method (Sci Rep UK 2013,31148; Sci Rep UK 2014,45494; ZL201410289271.3; ZL201210419348.5). This universal method breaks the traditional thinking that only crystalline carbides can be used to synthesize graphene. On the basis of the above research, a series of carbide-derived multifunctional carbon materials can obtained through a non-complete chlorination method, that is, by controlling the amount of Cl_2 to regulate the chlorination reaction process of carbides and intentionally retain some M components, the controllable homologous M self-doped graphene, carbon nanotubes and other nano carbon materials can be achieved, which solves the scientific puzzle of metal doping of graphene due to the mismatch between metal atoms and carbon atom radii in graphene. Additionally, it can also retain some M_xC_y to obtain a novel core-shell structure M_xC_y@CDC nanocomposite materials. (Adv Funct Mater 2017, 27, 1604904; ACS Energy Lett 2017, 3184; Nano Energy 2017, 36374; Carbon 2018, 1391144; ZL201611209424.4).

Representative Publications

1. T. T. Liu, C. Chen, Z. H. Pu, Q. F. Huang, J. D. Jiang, M. Han, W. Chen, G. T. Yu, Y. Z. Sun, S. Y. Huang, Q. J. Chen, A. M. Al-Enizi, A. Nafady, X. Q. Mu, S. C. Mu. Ultrafast Synthesis of Nanoscale Metal Borides for Efficient Hydrogen Evolution. Angewandte Chemie International Edition, 2025, 64, e202425257.

2. S. J. Zhang, Z. P. Li, Y. X. Zhang, X. P. Wang, P. Y. Dong, S. H. Lei, W. H. Zeng, J. Wang, X. B. Liao, X. Chen, D. Q. Li, Sh. C. Mu. Moderate Li^+-Solvent Binding for Gel Polymer Electrolytes with Stable Cycling toward Lithium Metal Batteries. Energy & Environmental Science, 2025, 18,

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3. Y. X. Zhang, Z. P. Li, S. J. Zhang, J. H. Li, S. H. Lei, P. Y. Dong, W. H. Zeng, J. Wang, X. Y. Chen, D. Qi Li, S. C. Mu. High-elastic Flame-retardant Polyacrylate-based Gel Polymer Electrolyte by Dual-phase Fluorination for Highly Stable Lithium Metal Batteries. Nano Letters, 2025, 25, 4930-4938.
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11. X. Q. Mu, X. Y. Zhang, Z. Y. Chen, Y. Gao, M. Yu, D. Chen, H. Z. Pan, S. L. Liu, D. S. Wang, Shichun Mu. Constructing symmetry-mismatched $Ru_xFe_{3-x}O_4$ heterointerfaces supported Ru clusters for efficient hydrogen evolution/oxidation reactions. Nano Letters, 2024, 24(3), 1015–1023.
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Origin of Self-ignition in Transient Release of Pressurized Hydrogen into a Rectangular Tube: Flow Visualization and Numerical Research

by Jinhua Sun, Member EUAS

Short Biography

Education and Positions

2022~ Chair Professor, University of Science and Technology of China
2019~ Chairman, Sub-Academic Advisory Committee of USTC
2004~2019 Vice Director of State Key Laboratory of Fire Science of China, CHINA
2014~ Director of Energy Fire Safety Institute, SKLFS, CHINA
2002~ Professor, University of Science & Technology of China, CHINA
1999~2002 Research Professor, Japan Science and Technology Agency, JAPAN
1996~1999 Ph.D., The University of Tokyo, JAPAN
1988~1996 Associate Professor, Anhui University of Science & Technology, CHINA
1986~1988 M. Sc., Nanjing University of Science and Technology, CHINA
1983~1986 Assistant Professor, Anhui University of Science & Technology, CHINA
1979~1983 B. Sc., Nanjing University of Science and Technology, CHINA

Professional Activities

Fellow Selection Committee Member, The Combustion Institute (2024~)
Executive Officer Nomination Committee, The Combustion Institute (2023)
Vice-chairman of Electrical Fire Protection Committee, CFPA (2021~)
Vice-Presidents of Asia-Oceania Association for Fire Science and Technology (2007~2020)
Committee Member of the International Association for Fire Safety Science (2008~2017)
Committee Member of the National Science and Technology Award (2010~)
Vice-chairman of Chemical Safety Committee, CIESC (2017~)
Vice-chairman of Building Fire Protection Committee, CFPA (2008~2022)
Experts of the first national emergency response expert group for work safety (2015~)
Experts of the fifth national work safety expert group (2014~)
Academic Committee Member of University of Science and Technology of China (2009~)
Safety expert committee Anhui Province, Civil blasting group leader (2009~)
Member of Science and Technology Award Committee, Ministry of Public Security (2007~)
Member of Academic Committee of urban safety and disaster prevention, Urban Planning Society of China (2005~2015)
Evaluation expert in international scientific and technological cooperation program, Ministry of Science and Technology of China (2005~)
Executive director of Anhui Fire Protection Association (2005~)
Associate Editorial or Editorial Board of six International Journals (2010~)

Editorial Board of nine national Journals (2003~)
Academic Committee Member of China Fire Protection Association (2003~2020)
Honors and Awards
Serving-the-people Award, USTC (2024)
Science and Technology Award, First-class Award, Anhui Province (2024)
Fellow of The Combustion Institute (2023)
Model Research Worker Award, Anhui Province, China (2022)
Science and Technology Award, Second-class Award, Anhui Province (2022)
Moral Model of Teacher Award, Anhui Province, China (2021)
Lifetime Contribution Award of AOAFST (2021)
Science and Technology Progress Award, First-class Award, CAPS (2021)
Special government allowance of the State Council, The State Council of the P. R. China (2019)
Science and Technology Innovation Award, First-class Award, CFPA (2018)
Science and Technology Progress Award, First-class Award, China Highway and Transportation Society (2018)
Zhu Li Yuehua excellent teacher Award, Chinese Academy of Sciences (2017)
Excellent graduate student supervisor Award, Chinese Academy of Sciences (2017)
Zhu Li Yuehua excellent teacher Award, Chinese Academy of Sciences (2014)
Excellent graduate student supervisor Award, Chinese Academy of Sciences (2014)
Teaching Award of Anhui Province, First-class Award, Anhui Province (2010)
Beijing Science and Technology Award, Third-class Award, Beijing (2008)
Science and Technology Award for Young Scientist, Anhui Province (2006)
Safety Science and Technology Award of State Administration of Work Safety, Second-class Award (2006)
National Science and Technology Progress Award, Second-class Award, China (2006)
Outstanding Member of Hundred Talent Program, Chinese Academy of Sciences (2005)
Member of Hundred Talent Program, Chinese Academy of Sciences (2001)
National Science and Technology Progress Award, First-class Award, China (1993)

Professor Sun Jinhua has long been devoted to academic research and education in the area of fire science and fire protection. He has made substantial accomplishments in a number of fields in fire safety science and engineering, including fire risk assessment, performance-based fire protection design, building fire safety, industrial fire safety, fire safety in new energies. He led as a PI more than 20 important national research projects, such as the National “973 Program”, key projects funded by National Natural Science Foundation of China (NSFC), the “11th Five-Year plan” and the “13th Five-Year Plan” national key R&D program, the sixth Framework Project of the EU International Cooperation Program in Science and Technology, general projects of NSFC, and “Outstanding Talents” project funded by the Chinese Academy of Sciences.

Prof. Sun has published more than 450 papers in peer-reviewed journals, including Progress in Energy and Combustion Science, Combustion and Flame, Renewable and Sustainable Energy Reviews, et al, which have been cited more than 25,000 times (Web of Science). Contributions have also been recorded in 11 academic books or book chapters and over 60 keynote or invited talks at national or international conferences. In addition, Prof. Sun has supervised over 60 PhD students.

Major Research Areas

1. Theories and methods of fire prevention for new energies
2. Methods for fire risk assessment and safety design of buildings and urban areas
3. Theory of fire dynamics, fire prevention and control for buildings
4. Industry fire dynamics and fire prevention

Selected Publications in 2025

1. **Guangbo Jiang, Yiming Jiang, Qiangling Duan*, Songlin Zhang , Huahua Xiao , Kaiqiang Jin , Jinhua Sun*. Origin of self-ignition in transient release of pressurized hydrogen into a rectangular tube: Flow visualization and numerical research, Combustion and Flame 280 (2025) 114361.**

   Self-ignition events during the transient release of pressurized hydrogen into a length of tube have been reported. Understanding the underlying mechanism is crucial for both process control and risk mitigation. This study combines flow visualization and a three-dimensional numerical simulation to investigate the origin of self-ignition within a smooth rectangular tube. The experiments eliminate the influence of tube-wall discontinu-ities caused by sensor arrangements in previous studies, while the simulations implement a realistic multi-step diaphragm opening scheme. The present experimental study clearly captures the boundary layer behind the leading shock within the tube in the scope of self-ignition. This finding is significant as it provides direct experimental evidence that self-ignition originates from the boundary layer. The contact surface at the head of the jet is difficult to accumulate high temperatures due to flow divergence, and the wall center is filled with a high concentration of hydrogen, making them unlikely locations for ignition initiation. The contact surface and post-shock high temperatures are stretched along the wall corners of the rectangular tube. The low-velocity flow at the wall corner promotes the accumulation of oxidizer and the mixing of cold hydrogen and hot air. Self-ignition originates from the overlapping boundary layers at the wall corner. Thin flames propagate down-stream along the wall corner under limited turbulent mixing and fuel supply.

2. **Zheng Fang, Zhenwei Wu , Wei Zeng, Elza Bontempi , Qiangling Duan, Jinhua Sun*, Qingsong Wang**. Exploring the viability of cryogenic freezing for safe pretreatment in lithium-ion battery recycling. Renewable Energy 252 (2025) 123481, Renewable Energy 252 (2025) 123481.**

   Recycling of massive spent lithium-ion batteries (LIBs) is urgently required with the development of electric vehicles and energy storage industries. However, due to their complex composition and uncertain state, spent LIBs pose significant fire hazards during the recycling process. In this work, liquid

nitrogen (LN) and dry ice (DI) were utilized as refrigerants to investigate the inerting mechanism and thermal stability of spent LIBs. Post-mortem and thermal analyses indicated that when spent LIBs are subjected to low temperatures (below -60℃), the solidification of the electrolyte and the separation of internal components cause an increase in internal resistance, leading to a drop in terminal voltage where it cannot deliver energy. Nail penetration tests demonstrated that cryogenic freezing effectively suppresses thermal runaway, reducing peak internal battery temperatures from 921.2℃ to below 150℃, with a temperature rise rate suppressed to under 3℃/s. Additionally, DI exhibited a more sustained cooling effect than LN and is proposed as a safer and more cost-effective alternative for enhancing safety in LIBs recycling.

3. **Haowen Wang, Peiyu Duan, Jiamin Tian, Qiangling Duan, Kaiqiang Jin*, Jinhua Sun*. Synergistic effect of bimetallic Au-Pt functionalized In_2O_3 nanoflowers for ppb-level hydrogen detection, Sensors & Actuators: B. Chemical 426 (2025) 137082.**

The synergistic effects and distinctive properties make bimetal an anticipated catalyst in gas sensing field. Herein, Au-Pt functionalized In_2O_3 nanoflowers is proposed for ppb-level hydrogen detection. The microstruc-ture and surface chemical composition of materials were systematically studied. The specific surface area of modified material was enlarged to 63.24 m^2/g, which was twice of pure In_2O_3. And the proportion of adsorbed oxygen was increased according to XPS analysis. The introduction of Au led to the shift of Pt peaks, which demonstrated the charge transfer between Au and Pt, thus indicating the synergistic effect of Au-Pt bimetallic catalyst. The modified material exhibited a notable enhancement in hydrogen sensing properties at a lower operating temperature of 240 ℃. The 5.0Au-1.0Pt-In_2O_3 sensor showed a 17-fold improvement in response and a 78.41 % reduction in response time than pure In_2O_3. Especially, the limit of detection was tested to be 50 ppb, providing a potential application for trace-level hydrogen detection. All the sensors in this work exhibited favorable linearity response, reversibility, and long-term stability. The significant enhancement in hydrogen sensitivity could be attributed to the synergistic effect of Au-Pt bimetallic catalyst and Schottky barriers at the interface between In_2O_3 and Au-Pt particles. This work demonstrates that the specific bimetallic catalyst can greatly improve hydrogen sensing properties of In_2O_3, especially in detection limit. The advantages of facile synthesis, favorable sensitivity and selectivity make this Au-Pt functionalized material a competent candidate for the design of ppb-level hydrogen sensors.

More Developments in Ion-Solid Interactions

by William J. Weber, Member EUAS

Short Biography

Professor Emeritus, Department of Materials Science and Engineering, The University of Tennessee – Knoxville, USA

Prof. William J. Weber received his PhD in Nuclear Engineering from the University of Wisconsin - Madison, USA. He joined Pacific Northwest National Laboratory (PNNL) in 1977 as a research scientist and was appointed Laboratory Fellow in 1997. During 1983, he was a visiting scientist at the Institute for Transuranium Elements in Karlsruhe, Germany, He is currently Professor Emeritus in the Department of Materials Science and Engineering at the University of Tennessee. He retired as Professor and Director of the Ion Beam Materials Laboratory in January 2023. From 2010 through 2020, he was the Governor's Chair Professor for Radiation Effects in Materials at the University of Tennessee, with a joint appointment at Oak Ridge National Laboratory. His research has encompassed the fundamental aspects of radiation-solid interactions, radiation effects in materials, ion beam modification and analysis of materials, and defects and defect processes in materials. Much of his current research emphasizes the coupling of electronic and atomic energy dissipation processes and their role on radiation effects, defect evolution, formation of novel nanostructures, creation of new functionalities, and the response of materials to extreme environments. He is a member of the EU Academy of Sciences (2016), Fellow of the American Ceramic Society (2000), Fellow of the American Association for the Advancement of Science (2006), Fellow of the Materials Research Society (2008), Fellow of the American Physical Society (2010) and Fellow of the Ion Beam Society of India (2016). He is the recipient of the MRS Woody White Service Award from the Materials Research Society (2023); the Radiation Effects in Insulators Award from the International Committee on Radiation Effects in Insulators (2023), the James I. Mueller Award from the American Ceramic Society (2020); Lee Hsun Lecture Award (2015); the Outstanding Young Alumni Award (1983) and the Distinguished Alumni Award (2009) from the University of Wisconsin - Oshkosh; the PNNL Laboratory Director's Award for Individual Lifetime Achievement in Science & Technology (2009); the PNNL Laboratory Director's Award for Scientific and Engineering Excellence (1995); the PNNL Chester L. Cooper Mentor of the Year Award (2005); and the U.S. Department of Energy's Materials Science Award for Research with Significant Implication for DOE Related Technologies (1995). He has over 740 peer-reviewed publications and 14 book chapters. Based on the Web of Science, his publications have over 32,300 citations, with an h-index of 86; based on Scopus, his publications have over 34,500 citations, with an h-index of 87; based on Goggle Scholar, his publications have over 43,000 citations, with an h-index of 97.

The interaction of energetic ions with a solid is well known to result in inelastic energy loss to electrons and elastic energy loss to atomic nuclei in the solid. However, the coupled effects of these energy loss pathways and the critical role of energy dissipation processes on defect production and the evolution of defects, nanostructures and phase transformations under far from equilibrium conditions in materials are complex and not well understood. Particularly challenging are the dynamics of energy transfer processes to electrons and the exchange of energy between electrons and the atomic nuclei via electron-phonon coupling. In general, the electrons along the ion path undergo a high degree of excitation and electron–electron scattering, and they subsequently transfer much of their energy, via electron–phonon coupling, to atoms in the same region, causing a highly-localized thermal spike. Following thermalization of the electrons and recombination of electrons and holes, a high density of localized electronic defects (trapped electrons, holes and excitons) may remain. This partitioning of energy deposition and energy dissipation on the electronic and atomic structures are important to the control of ion beam modification methods to create defects and nanoscale structures that tailor materials properties or create new functionalities, as well as the development of radiation-tolerant materials and devices. Predicting and modeling such complex processes, which are temporally and spatially coupled, are grand challenges that demand fundamental understanding of materials processes at the level of electrons and atoms over several orders of magnitude in time scale, from femtoseconds to nanoseconds. The decoupling these processes experimentally with sequential dual-beam ion irradiations has advanced the understanding of the complex interactions between ionization energy dissipation and pre-existing defects that may be created from displacement events, as highlighted in a recent review on ion irradiation effects in $KTaO_3$.

Damage evolution and phase stability in defective β-Ga_2O_3 and an irradiation-induced γ-Ga_2O_3 surface layer have been studied under ionizing irradiation at 300 K. By exploring athermal nonequilibrium processes in β-Ga_2O_3, a self-healing mechanism has been identified that enables recovery of pre-existing defects, characterized by a recovery cross-section of ~0.17 nm^2. This study further demonstrated that the crystallinity of the irradiation-induced γ-Ga_2O_3 surface layer improves under ionizing irradiation. More importantly, X-ray diffraction analysis reveals that the highly-strained γ -phase transforms into a highly-crystalline structure without film disintegration, in contrast to behavior reported under isochronal annealing at 1000 K. Inelastic thermal spike calculations have provided insights into the important effects of energy transfer to electrons in reordering the local atomic arrangement of both defective β- Ga_2O_3 and γ-Ga_2O_3. This behavior suggests

a pathway for low-temperature crystallization, offering a promising strategy for fabricating ultrahigh-speed non-volatile memory devices.

Thermally activated annealing in semiconductors faces inherent limitations, such as dopant diffusion. A non-thermal pathway for a complete structural restoration has been demonstrated in pre-damaged germanium via ionization-induced athermal recovery. By combining experimental and modeling approaches, this study revealed that the energy transfer of only 2.4 keV nm^{-1} from incident ions to target electrons can effectively anneal pre-existing defects and restore the original crystalline structure at room-temperature. Furthermore, this study revealed that the irradiation-induced crystalline-to-amorphous transformation in Ge is reversible, a phenomenon previously considered unattainable without additional thermal energy imposed during irradiation. For partially damaged Ge, the overall damage fraction decreases exponentially with increasing ion fluence. This study provides new insights on reversing the c/a transformation in Ge using highly-ionizing irradiation and has broad implications across materials science, radiation damage mitigation, and fabrication of Ge-based devices.

Ionoluminescence measurements of $SrTiO_3$ have been conducted from 30-100 K using 3 MeV H^+ and 19 MeV Si^{6+} ions. Analysis of the emission spectra over this temperature range yielded spectral kinetics curves that exhibited sharp qualitative and quantitative changes around 65 K. The behavior of the 2.0 eV emission, associated with V_O-T^{3+} centers, was correlated with a large anomalous increase in electronic conductivity at temperatures below 65 K. The center of this emission band was observed to undergo a shift to higher energy with decreasing temperature. This blue shift may be related to the crossing of soft antiferrodistortive and ferroelectric phonon modes at 65 K. The intensity of the 2.0 eV emission band increased with increasing ion fluence, which was attributed to oxygen vacancy production through elastic ion-atom collisions. This growth phase was followed by a decay stage in which irradiation-induced non-radiative recombination sites quench the light emission. The vacancy production cross sections extracted from the data for these two ions agree quantitatively with predictions based on binary collision calculations. The intensity of the 2.8 eV emission band, which is associated with an excited self-trapped exciton, followed Arrhenius behavior below 65 K with an activation energy of 25 meV. The same activation energy was measured in thermal quenching curves for the 2.0 eV emission band and the 2.5 eV emission band that is associated with the ground state of the self-trapped exciton. This indicates the critical role that the excited state of the self-trapped exciton plays in thermal quenching.

Improved understanding and predictive models of materials performance in high radiation environments are essential for societal needs in energy

conservation and production, a clean environment, and national security. Ion beams have been employed to study the irradiation resistance of concentrated solid-solution alloys and high-entropy alloys. The thermal stability and high-temperature evolution of He bubbles within the structure of WTaCrV, a refractory concentrated solid solution alloy considered for nuclear fusion applications, has been investigated. The nanometer-sized bubbles were stable up to temperatures of 1075 K and only exhibited limited growth at 1275 K. Molecular dynamics simulations revealed that the low diffusivity of He-vacancy clusters is responsible for the limited coarsening of the helium bubbles at elevated temperatures.

Select Publications Related to This Research

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4. M. L. Crespillo, J. T. Graham, F. Agulló-López, and W. J. Weber, Dielectric Anomalies in $SrTiO_3$ at High Electronic Excitation Rates and Cryogenic Temperatures, *Materials Today Chemistry* **44**: 102599 (2025).
5. D. Kalita, A. Esfandiarpour, I. Jóźwik, Y. Zhang, J. Byggmästar, M. J. Alava, Ł. Kurpaska, W. J. Weber, P. D. Rack, and J. Jagielski, High temperature He bubble evolution and thermal stability of the WTaCrV refractory concentrated solid solution alloy, *Materials & Design* **252**: 113751 (2025).
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Ingress and Egress through Rim Seals between Stator and Rotor Disks in Gas Turbines

by Tom I-P. Shih, Member EUAS

Short Biography

DR. TOM I-P. SHIH is professor of aeronautics and astronautics at Purdue University, where he served as the head of the School of Aeronautics and Astronautics from 2009 to 2019. Prior to joining Purdue, he was a mechanical engineer at NASA Lewis (now Glenn) Research Center and served on the faculties of the Univ. of Florida, Carnegie Mellon Univ., Michigan State Univ., and Iowa State Univ. (chair of the Dept. of Aerospace Engineering, 2003–2009). Currently, he is the editor-in-chief of the AIAA Journal and serves on the advisory boards of the Dept. of Mechanical Engineering at The Univ. of Michigan and the Dept. of Mechanical, Materials, and Aerospace Engineering at West Virginia Univ. Previously, he has served on the Aeronautics Committee of the NASA Advisory Council (2018-21) and chaired the AIAA Committee on Higher Education (2016-23) and the Aerospace Department Chair Association (2005-06). Dr. Shih started his undergraduate education at West Virginia Univ., but completed his B.S. at the National Cheng Kung Univ. in Taiwan. His M.S.E. and Ph.D. degrees are from The Univ. of Michigan at Ann Arbor. He is a Fellow of the American Institute of Aeronautics and Astronautics (AIAA) and the American Society of Mechanical Engineers (ASME) and received the 2010 Distinguished Engineering Educator Award from the Engineers' Council of San Fernando Valley, the 2015 AIAA Energy Systems Award, the 2020 AIAA Thermophysics Award, Mechanical Engineering Alumni Merit Award from The University of Michigan in 2023, and the NCKU Distinguished Alumni Award from National Cheng Kung University in 2023.

Research Interests

Dr. Shih's research interests are in fluid mechanics, heat transfer, and numerical methods and their application to problems in aerodynamics (airfoils and wings with ice accretion, shock-wave/boundary-layer interactions with bleed, and mixed-compression inlets); energy, power, and propulsion systems (gas turbines, piston and rotary engines, automotive torque converters, automotive clutches, liquid-ring vacuum pumps, thermoelectric power generators); and two-phase flows (electrodeposition; particle/particle and particle/fluid interactions). Current research is on the development of generalizable reduced-order models for the design of turbine cooling that satisfy physical constraints and embed higher dimensional effects; automatic grid generators that embed human intelligence (HI); and thermal management of gas turbines and turbine-integrated rotating-detonation combustors.

In gas turbines, the hot gas exiting the combustor can have temperatures as high as 2,000 ^{o}C, and some of this hot gas enter into the space between the

stator and rotor disks (wheelspace). Since the entering hot gas could damage the disks, its ingestion must be minimized or prevented to ensure that the temperature of disks never exceed the maximum permitted for reliable operation. This is accomplished by installing seals (referred to as rim seals) and by introducing cooling air from the compressor into the wheelspace (referred to sealing flow). Ingress into and egress from the wheelspace through the rim seal are driven by (1) the rotor disk and its rotation, (2) the pressure variation about the stator vanes' trailing edges, and (3) stagnation pressure induced by the rotor and its blades. It is important to understand how each of those three drivers affect ingress and egress through the rim seals. Studies based on steady RANS with the SST turbulence model and large-eddy simulations (LES) with the WALE subgrid model were performed to understand the mechanisms that drive ingress and egress.[1,2]

Key findings from reference 1 for a configuration without stator vanes and without rotor blades show how the rotor and its rotation create ingress and egress – referred to as rotationally-induced ingress and egress:

- Interaction between the hot gas flow in the axial direction and the boundary-layer flow in the azimuthal direction induced by the rotating rotor causes Kelvin–Helmholtz instability (KHI) to form.
- The Kelvin-Helmholtz instability creates a wavy boundary layer in the azimuthal direction with a corresponding wavy displacement thickness that produces alternating regions of high and low pressures about the rotor side of the seal.
- The alternating regions of high and low pressures formed by the Kelvin-Helmholtz instability cause ingress into the seal to start on the rotor side.
- Vortex shedding occurs at the stator side of the seal and gets convected in the azimuthal direction by the rotating rotor. The shedding also creates alternating regions of high and low pressures on the rotor side of the seal when shed vortices impinge there. The shed vortices also entrain hot gas into the seal.
- Regions of high and low pressures on the rotor side of the seal created by Kelvin-Helmholtz instability and by impingement of the shed vortices were found to be statistically stationary and do not rotate with the rotor.
- Hot-gas flow over the seal with vortex shedding and the rotating rotor create a large "pulsating" spiraling recirculating flow in the clearance of the seal, which induces additional vortical structures deeper in the clearance of the seal and in the wheelspace.
- Not all hot-gas ingested into the seal reach the wheelspace because the motion induced by the spiraling recirculating flow entrain them back out into the hot-gas path.

- On egress, it starts on the rotor side because of "disk pumping" in the wheelspace. However, once reaching the clearance of the seal, it gets entrained by the recirculating flows there and exits from the stator side.
- Though RANS with the SST model was able to predict regions of high and low pressures about the rotor-side of the seal, it was unable to predict ingress. LES with the WALE model could predict regions of high and low pressures about the rotor-side of the seal and the ingress that they create.
- Under conditions where ingress is dominated by the rotor and its rotation, then the seal geometry should be designed to weaken features that create and magnify the strength of the alternating regions of high and low pressures that induce ingress. Also, the pulsating spiraling flow in the seal induced by the hot-gas flow over the seal and by rotation of the rotor should be modified to minimize entrainment of hot gas and to eject entrained gas back to the hot-gas flow.

Key findings from reference 2 for a configuration with stator vanes but without rotor blades show how the pressure differences vanes create induce ingress and egress – referred to as externally-induced ingress and egress:

- Both LES with the WALE and steady RANS with SST model could accurately predict the pressure coefficient, C_p, on the stator platform upstream of the rim seal.
- LES could predict ingress and accurately predict the sealing effectiveness.
- Steady RANS could not predict ingress and could not predict the sealing effectiveness.
- Since steady RANS could accurately predict C_p but could not predict ingress, this indicates that C_p by itself is inadequate in quantifying ingress.
- LES predicts a much higher pressure drop in the axial direction about the seal region with much higher levels of turbulent kinetic energy than RANS, which produced a much higher pressure difference across the seal in the radial direction to drive ingress into the wheelspace.
- For LES to correctly predict ingress, the grid size and time-step size must be small enough to resolve the small-scale structures created by the interaction between the hot-gas flow in the axial direction, the boundary-layer flow induced by rotation in the azimuthal direction, and the shedding of vortices in the seal clearance.
- On ingress induced by the stator vanes, it starts in the middle of the seal and later deflected onto the stator side. Once in the wheelspace, the flow is entrained by the vortical structures in the wheelspace.
- On egress, it flows along the rotor side of the wheelspace and exits on the rotor side of the seal.

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1. Nketia, S., Shih, T.I-P., Bryden, K.M., Dalton, R., and Dennis, R., "Large-Eddy Simulation of Rotationally-Induced Ingress and Egress about an Axial Seal between Rotor and Stator Disks," *Energies*, Vol. 16, Issue 11, 2023.
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Aerodynamic Losses and Heat Transfer of As-Built, Machined, Electropolished, and Chemical Polished Turbine Alloy Blades

by Phil Ligrani, Member EUAS

Short Biography

Eminent Scholar in Propulsion, Professor of Mechanical and Aerospace Engineering, Department of Mechanical and Aerospace Engineering, Propulsion Research Center, 5000 Technology Drive, University of Alabama at Huntsville, Huntsville, AL 35899 USA.

PROFESSIONAL PREPARATION

University of Texas at Austin	*Mechanical Engineering*	*Bachelor of Science*
Stanford University	*Mechanical Engineering*	*Master of Science*
Stanford University	*Mechanical Engineering*	*Doctor of Philosophy*

APPOINTMENTS

2014 – present Eminent Scholar in Propulsion, Professor of Mechanical and Aerospace Engineering, Propulsion Research Center, Department of Mechanical and Aerospace Engineering, University of Alabama at Huntsville

2010 – 2014 Oliver L. Parks Endowed Chair, Professor of Aerospace and Mechanical Engineering, Parks College, Saint Louis University

2010 – 2013 Director of Graduate Programs, Parks College, Saint Louis University

2006 – 2009 Statutory Professor, Department of Engineering Science, University of Oxford, Donald Schultz Professor of Turbomachinery

2006 – 2009 Director, Rolls-Royce UTC (University Technology Centre) in Heat Transfer and Aerodynamics, University of Oxford

ARCHIVAL JOURNAL PUBLICATIONS AND RELATED ITEMS.

As of December 2025, Dr. Ligrani is author or co-author of more than 238 publications in archival journals, including the International Journal of Heat and Mass Transfer, the ASME Transactions-Journal of Turbomachinery, the ASME Transactions-Journal of Engineering for Gas Turbines and Power, the ASME Transactions-Journal of Heat Transfer, the ASME Transactions-Journal of Fluids Engineering, the International Journal of Thermal Sciences, Nature - Scientific Reports, the Journal of Fluid Mechanics, the AIAA Journal, Experiments in Fluids, Physics of Fluids, the AIAA Journal of Heat Transfer and Thermophysics, the International Journal of Rotating Machinery, Separation Science and Technology, Sensors and Actuators A: Physical, Measurement Science and Technology, Applied Thermal Engineering, and the Journal of Microcolumn Separations. He is also author of 11 book chapters, and about 167 conference presentations and publications. A number of these are invited conference presentations at international meetings, at locations which include Korea, France, the Ukraine, Croatia, Germany, England-United Kingdom, and Belgium. From 1994 to 2023, he has also presented approximately 207 lectures at different institutions and establishments, including many invited lectures. From 2006 to 2025, he presented or is scheduled to present 11 Invited Keynote Papers, 18 Invited Papers, and 12 Invited Plenary Papers at different international conferences. ● Current SCOPUS Reference Citation H-INDEX is 53. ● Current GOOGLE SCHOLAR Reference Citation H-INDEX is 59. ● GPS Scholar ranking in the top 22/100ths of one percent internationally in mechanical engineering and the top 8/100ths of one percent internationally in heat transfer. ● From evaluation of over 30 million ScholarGPS profiles, 19 ranking in Turbine Blade, 46 ranking in Turbomachinery, 137 ranking in Heat Transfer, and 384 ranking in Turbine. ● AD Scientific Index ranking of number 1 out of 9 scientists in mechanical engineering at the University of Alabama in Huntsville, and number 1 out of 59 scientists in engineering and technology at the University of Alabama in Huntsville.

EDITOR ACTIVITIES.

From 1998 to 2000, Dr. Ligrani served as Guest Editor for a Special Topical Issue for Measurement Science and Technology. He has also served as Associate Editor for the ASME Transactions-Journal of Heat Transfer from 2003 to 2006, and from 2010 to 2014, and for the ASME Transactions-Journal of Fluids Engineering from 2005 to 2008. He also served as Associate Editor, ASME Transactions-Journal of Journal of Engineering for Gas Turbines and Power from 2018 to 2021 and from 2021 to 2024. Current editorial responsibilities include: (i) Member, Distinguished Editorial Review Board, Advances in Transport

Phenomena, Book Series, Springer Publishing Corporation, (ii) Academic Editor, International Journal of Rotating Machinery, (iii) Editorial Board Member, International Journal of Aeronautical Science and Aerospace Research, (iv) Associate Editor, AIAA Journal of Thermophysics and Heat Transfer, (v) Editorial Advisory Board, International Journal of Heat and Fluid Flow.

RESEARCH FUNDING AWARDS

Dr. Ligrani has a strong past and present record of performing sponsored, fundamental and applied research for a variety of funding agencies, including ones in the USA and Europe. As such, he has successfully managed a wide variety of research programs, for different industrial, foundation, and government sponsors. As of December 2025, research funding awards have been received from the following organizations: U.S. Air Force Research Laboratory - Aerospace Systems Directorate, CFDRC – Computational Fluid Dynamics Research Corporation, NASA – Marshall Space Flight Center (MSFC), Alabama State Innovation Program Fund, University of Alabama in Huntsville Endowment for Eminent Scholar in Propulsion, University of Alabama in Huntsville Start-Up Funds, AEDC – Arnold Engineering Development Center of Arnold Air Force Base, National Science Foundation, Honeywell Aerospace Corp., The Boeing Company, IHI Corporation, the Henry Luce Foundation, South Carolina Institute for Energy Studies (SCIES-AGTSR) of the Department of Energy, U. S. Army Aviation Research and Technology Activity-AVSCOM, NASA-Ames Research Center, NASA-Lewis Research Center, Hispanic Research Center-Arizona State University, Turbo and Power Machinery Research Center-Seoul National University, Solar Turbines Incorporated, UCON U.S.-Japan Center-Weber State University, General Electric Corporate Research and Development Center, Pratt & Whitney Corporation-Florida, the North Atlantic Treaty Organization (NATO), Pratt & Whitney Corporation-Canada Corp., the Gas Technology Institute, Intel Corporation, HEET-High Efficiency Engines and Turbines Program - South Carolina Energy Research and Development Center, Invesys Corp. - Foxboro Company, Ceramatec Advanced Materials and Electrochemical Technologies Corp., CISCO Systems Inc., SEEDA-South East England Development Agency, EPSRC – Engineering and Physical Sciences Research Council of Great Britain, ISIS Innovation, John Fell Fund, European Community Sixth Framework Programme, Korea Institute of Geoscience and Mineral Resources - KIGAM, Lockheed Martin UK, The Royal Academy of Engineering, Rolls Royce PLC, Science and Engineering Research Council (SERC) Engineering Board of Great Britain, Office of Naval Research, Naval Postgraduate School Res

CURRENT AND RECENT RESEARCH FUNDING AWARDS

As of December 2025, current and recent research sponsors at the University of Alabama in Huntsville include: (1) Solar Turbines, Inc. of San Diego, California, USA (multiple research contracts), (2) IHI Corp. (Ishikawajma Harima Heavy Industries), of Tokyo, Japan (multiple research contracts), (3) National Science Foundation, CBET Thermal Transport Processes, Division of Chemical, Bioengineering, Environmental, and Transport (CBET) Systems, Arlington, Virginia, USA (multiple funding awards), (4) the Alabama Innovation Fund, Research Program, Montgomery, Alabama, USA, (5) Office of the Vice President for Research and Economic Development, University of Alabama in Huntsville, Huntsville, Alabama, USA, (6) AEDC – Arnold Engineering Development Center, Arnold Air Force Base, Tullahoma, Tennessee, USA (high pressure tank donation), (7) U.S. Air Force Research Laboratory, SBIR/STTR Program, Aerospace Systems Directorate, Wright-Patterson Air Force Base, Ohio, USA, (8) NASA – Marshall Space Flight Center (MSFC), Huntsville, Alabama, USA (multiple funding awards).

RESEARCH AREAS AND EXPERTISE

Dr. Ligrani has a strong past and present record of working with many different collaborators and co-workers, from many locations throughout the world. Additional information on selected, currently active research projects is provided within sections which follow. **(i) Traditional Heat Transfer and Fluid Mechanics Investigations** involving electronics cooling, heat transfer augmentation, drag reduction, turbulent boundary layers, flows in channels with dimpled surfaces, flows in curved channels, elastic turbulence, slot impingement cooling, and macro-scale pumps and pump flows. Also included are **aerodynamics investigations with *high-speed, compressible flows at***

transonic and supersonic Mach numbers, including SWBLI – Shock Wave Boundary Layer Interactions. Related projects involve **transonic and supersonic experimental testing**. Research interests also include experimental diagnostics in high speed flows, and air breathing propulsion. **(ii) Air Breathing Engines - Gas Turbine Heat Transfer, Cooling, and Aerodynamics Losses**, including internal cooling, film cooling, impingement cooling, cooling of extremities, aerodynamic performance including aerodynamic losses, and transonic turbine flows and heat transfer. This subject area includes the effects of uses of bio-fuels, synthetic fuels, and renewable energy sources in relation to gas turbines and gas turbine heat transfer and cooling technologies. Note that an important area of turbomachinery research interest involves heat transfer and aerodynamics investigations with *high-speed, compressible flows at transonic and supersonic Mach numbers*, including linear cascade studies. **(iii) Micro-Fluidics and Millimeter-Scale-Fluidics**, including micro-pump flows, and the effects of slip phenomena on gas and liquid flows in micro-scale passage flows with and without surface roughness, including the effects of hydrophobic surfaces and elastic turbulence. **(iv) Experimental Techniques**, including development of millimeter-scale multiple-hole pressure probes, subminiature hot-wire anemometry, infrared thermography, and particle image velocimetry.

Tip Gap and Coolant Mass Flux Ratio Effects on Film Cooling Effectiveness, Coefficients of Convection, and Net Heat Flux Reduction Along a Transonic Turbine Airfoil.

Considered are coefficient of convection, adiabatic effectiveness, and net heat flux reduction characteristics for the extremity end of a transonic turbine airfoil with a squealer rim and coolant films. A cascade that is linear is employed to mount the airfoil along with four additional airfoils. Subsonic conditions are present along the concave side of each considered turbine airfoil, and transonic conditions are present along the convex side of each considered turbine airfoil. Included are spatially-resolved and line-averaged variations of surface heat transfer characteristics, which are given along the concave surface at bigger radial locations and along the extremity end of the turbine airfoil. Film coolant is supplied by two sources which are installed at upstream and downstream positions within the airfoil, such that the ratio of mass flux for the downstream coolant supply BRd is varied, as the ratio of mass flux for the upstream coolant supply BRu is approximately constant. Provided for tip gap TG values of 1.20 mm and 2.00 mm are local and line-averaged variations of coefficient of convection ratio, adiabatic film cooling effectiveness, and net heat flux reduction data for specific locations within the

recess region, trailing edge region, and upper concave surface region of the airfoil. Associated variations of these surface heat transfer characteristics are related to local levels of turbulent mixing and turbulent shear stress, and to coolant concentrations along and near to the airfoil extremity end surfaces. Resulting coefficient of coefficient ratios, film effectiveness, and net heat flux reduction are often higher for TG=1.20 mm, relative to the TG=2.00 mm environment, when compared at the same ratio of mass flux for the downstream coolant supply BRd, and the same airfoil extremity end location.

Aerodynamic Losses and Heat Transfer of As-Built, Machined, Electropolished, and Chemical Polished Turbine Alloy Blades.

Because of the scarcity of research that indicates how post-processing surface enhancement methods for additive manufactured alloys affect the aerodynamic behavior of turbine blades, the present comparative study considers electro-polishing and chemical polishing surface enhancement methods, as compared to as-built and machined surfaces. The first three of these are comprised of the GRX-810 alloy, whose textures are characterized using scanning laser microscopy. A transonic linear cascade test section and traverse apparatus are employed to obtain measurements of downstream aerodynamic loss characteristics and blade surface static pressure distributions. Included are discussions of the associated analysis procedures for determination of aerodynamic loss characteristics and other parameters which characterize wake regions produced by different surface finishes. Of particular significance are different aerodynamic losses as these relate to different overall average roughness element size and character, and alterations of blade shape profiles when surface enhancement post processing procedures, such as electro-polishing and chemical polishing, are employed. A key roughness characteristic is the uniformity and regularity of roughness elements as these are distributed along blade surfaces. The benefit of a high degree of roughness element uniformity is illustrated by the as-built blade, without any surface enhancement, because of relatively smaller downstream aerodynamic losses, even though the arrangement is associated with the largest value of mean roughness height.

Unsteady Separation Region Characteristics Within a Normal Shock Wave - Lambda Foot Structure.

Within the present shock wave/boundary layer interaction study, considered are the unsteady behavior of the flow separation zone within a normal shock wave and the associated lambda foot structure. Also provided are correlation and time lag data for this separation zone length relative to the

normal shock wave, as well as relative to other phenomena at other flow locations. Employed for the study is a test section with an inlet Mach number of 1.54, where shock waves are visualized with a shadowgraph visualization arrangement along with simultaneous acquisition of time-resolved surface static pressure data. Resulting instantaneous separation zone length variations are then compared to other flow phenomena and sensor data using Magnitude Squared Coherence (MSC) and Time Lag (TL) analysis. Considered are both high and low inlet Mach wave intensity distributions at the test section entrance, denoted HMWI and LMWI. Overall data trends indicate that separation length flow events at different frequencies are generally more strongly correlated with unsteady surface static pressure and with the instantaneous tracked normal shock wave location with HMWI, relative to the LMWI arrangement. With HMWI, results for the lowest frequencies considered indicate that unsteady flow events propagate from the separation zone to the normal shock wave location, and then to the Kulite surface location beneath the flow separation zone. In contrast, with LMWI, results for the lowest frequencies indicate that unsteady flow events propagate from the normal shock wave location to the Kulite surface location beneath the flow separation zone, and then, to the separation zone.

Second Law Aerodynamic Losses From Symmetric Turbine Blades With and Without Film Cooling.

Experimental results are presented which illustrate magnitudes of second law losses, including spatial-averaged global exergy destruction, which are a result of aerodynamic losses generated from a symmetric turbine blade with film cooling and without film cooling. The approach is unique and different because irreversibilities, which result from different physical phenomena, are presented on the same global exergy destruction basis, providing means for quantitative comparisons regarding relative second law loss contributions from different physical mechanisms. Film cooling results are provided for two configurations: CDH or conical diffused holes, and RCH or round cylindrical holes, with ratios of coolant Mach number to local mainstream Mach number as high as 0.74. Data are also included for three airfoil Mach number distributions (with two subsonic arrangements and one transonic arrangement), three values of turbulence intensity at the test section inlet (on a percentage basis) of 0.9, 5.5, and 16.2, and surfaces with three different levels of roughness, quantified by ratios of equivalent sand grain roughness to blade chord length ks/c of 0.0, 0.00069, and 0.00164. Relative to a smooth, symmetric blade at low freestream turbulence intensity and low Mach number, which is also without coolant films, the greatest increases in local entropy creation distributions and exergy destruction are associated with

larger Mach numbers, and increased roughness along surfaces. Results also indicate that exergy destruction overall values and local entropy creation increases, which are associated with coolant films, are generally significantly smaller than magnitudes linked with larger roughness on blade surfaces. In addition, the dependences of overall exergy destruction magnitudes, and local entropy creation distributions, on main flow Mach number and inlet intensity of turbulence intensity, change significantly as the magnitude surface roughness along the symmetric turbine blade is altered.

Coherence and Time Lag Data Analysis Within Compressible Shock Wave Flow Environments.

Physically-representative correlation data are considered in regard to phenomena associated with an oblique shock wave. The associated data are acquired and processed to avoid effects leading to physically incorrect results. For example, the beginning of data acquisition occurs after wind tunnel start-up transients are present, and the end of data acquisition occurs before wind tunnel shut-down transients are present. Time intervals for data acquisition are 3.59 seconds and 2.58 seconds, which are long enough for adequate resolution of data at lower frequencies. Acquisition sampling frequency is 6.25 kHz, which is large enough to capture high frequency content up to about 3.0 kHz. This acquisition rate, the overall time interval for data acquisition, the use of Welch's approach, and the use of 5 segments for ensemble averaging then give frequency resolution values which are appropriate for the flow environment. According to the shadowgraph image data, locations for flow analysis are in reasonable proximity to each other. Each local shock wave signature is also reasonably well defined with relatively sufficient contrast within gray-scale images for each line sampling location. Resulting unsteady signals within shadowgraph time sequences are then also reasonably well defined as time-varying data are acquired for Fourier correlation analysis.

Short Background of Embankment Dam Engineering History

by Pedro Pinto, Member EUAS

Short Biography

Pedro Sêco e Pinto is licentiate in Civil Engineering and holds a Master Engineering degree and Specialist in Geotechnics degree (PhD level).
He was an ISSMGE (International Society for Soil Mechanics and Geotechnical Engineering) Board member(2017-2022).
He is a member of European Union Academy of Sciences.
He is a Fellow of Portuguese Institute of Engineers.
He is a former Director of Reserch of National Laboratory of Civil Engineer (LNEC).
He is an ISSMGE Past President.
He was ISSMGE Vice President for Europe.
He was Chairman of ISSMGE of "Earthquake Geotechnical Engineering" Technical Committee.
He was a Full Professor of Geotechnical Engineering at Coimbra University and has supervised several master's and doctoral theses.
He has worked as World Bank Consulting.
He has worked as United Nations Consulting.
He has presented more than 350 State-of-the Art Lectures and Special Lectures in 80 countries of the 5 Continents.
He was a Editorial in Chief of 2 International Journals.
He is a member of 7 Editorial Board and Reviewer of International Journals.
He is Editor or Co-Editor of 6 Conference Proceedings.
He was a member of Advisory Committee of more than 130 International Conferences.
He has participated in several European Research Programmes and has contributed for Eurocode 7 and Eurocode 8.
He is author or co-author of 600 Technical and Scientific Reports, and more than 185 papers for National and International Conferences and Journals and has contributed for 15 Books.
He has received more than 50 International Awards including 3rd Victor de Mello Lecture, 3rd Braja Das Lecture, American Biographical Institute USA, "Special Volume for the Contributors of Earthquake Engineering", Nagadi Lecture by Indian Geotechnical Society, Széchy Lecture by Hungarian Academy of Sciences, Nonveiller Lecture by Croatia Geotechnical Society, Sukle Lecture by Slovenia Soil Mechanics Society, Chin Lecture by Huanzhou University (China), Qian Jia Huan Lecture by Hohai University (China) and Chin Fung Kee Memorial Lecture by Institute of Engineers of Malasia.
As a Consulting Engineer he has worked on more than 450 major projects in Dams, Power plants, Bridges, Special Foundations, Tunnels, Highways, Landslides, Dykes, Airports and Quay Walls, in 23 countries of Europe, Africa, Asia and South America.

1. SHORT BACKGROUND OF EMBANKMENT DAM ENGINEERING HISTORY

History does not record exactly when irrigation systems and dams were first constructed. Study of ancient Egypt, China, India and Iran dams reveals that such work in these lands was begun thousands of years ago and provided lifelines on which their civilizations depended. Menes, the first Pharaoh of Egypt, ordered irrigation works to draw from the River Nile. In China, construction of impressive dams was accomplished on the Min River for flood control and diversion of water to nearby farm lands. The sacred books of India cite the very early operation of dams, channels, and wells, evidence that this land may have been the birthplace of the art.

Many of the outstanding waterworks of antiquity eventually declined into disuse because the knowledge of their designers and builders was not preserved by the generations who inherited them.

The ruins of the Sadd-el-Kafara embankment dam were discovered over 100 years ago in the Garawi ravine in Egypt. The dam was built around 2600 BC and was 14 m high and 113 m along the crest (Figure 1). It is the oldest dam of such size known in the world. The purpose of the dam was to retain the water from rare but violent floods.

The grossly overdesigned cross section of the dam was due to inexperience. Unfortunately, there was no channel or tunnel to divert the river around the dam site while it was being built. As a result, the dam was destroyed while still under construction during one of the rare floods it was intended to control. The consequences of the dam's failure must have been so grave that the Egyptian engineers refrained from further dam construction for about eight centuries.

About 5000 years ago, Chinese people started to build earth dikes and embankments for flood prevention. The dykes to form large plain reservoirs were always long, with irregular shapes, but small in width and height. One example is the Shaobei, now called Anfengtang reservoir, with a dyke of 24.3 km (Figure 2).

In southern of India the embankments used gravelly materials and so the outer slopes were considerably steeper. An extreme example was Motitalav dam located north of the city of Mysore with 24 m of high and upstream face protected by ashlar blocks with 1:1.5 slope and a downstream face sloped 1:1 (Figure 3).

Modern cross sections were adopted around 1213 for Anantha dam.

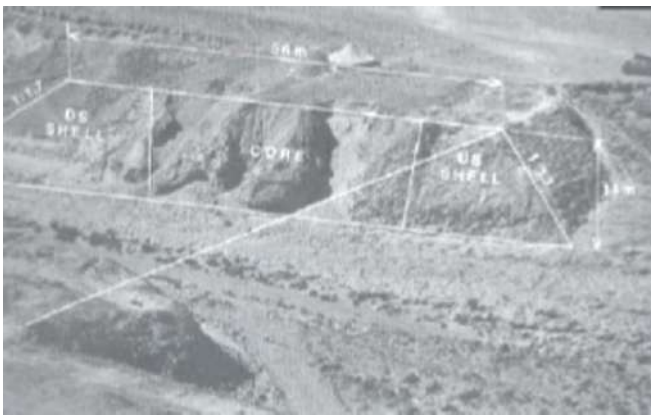

Figure 1. The Sadd-el-Kafara Damphoto (from Schnitter courtesy of A.A. Balkema)

Figure 2. Anfengtang reservoir dyke (courtesy ICOLD, 2007)

It is interesting to mention that at near Anantha dam an inscription dated 1369 states twelve essential requisites for the construction of a good reservoir (ICOLD, 2007):

1. A king (i.e. owner or client) endowed with righteousness, rich, happy and desirous of acquiring fame;
2. A person well versed in hydrology;
3. A reservoir bed or hard soil;
4. A river conveying sweet water from a distance of about 40 Km;
5. Two projecting portions of hills in contact with the river;
6. Between these protecting portions of hills a dam built of compact stone, not too long but firm;
7. The two extremities of the hills to be devoid of fruit-bearing land (i.e. humus);
8. The bed of the reservoir to be extensive and deep;
9. A quarry containing straight and long stones;
10 Fertile low and level (i.e. irrigable) area in the neighborhood;
11 A watercourse having strong eddies in the mountain region; and
12 A group of men skilled in the art of dam construction.

The inscription also mentioned that the following six faults should be avoided:

1. Oozing water from the dam;
2. Saline soil;
3. Site at the boundary of two kingdoms;
4. High ground in the middle of the reservoir;
5. Scantly water supply and an extensive area to be irrigated;
6. Too little land to be irrigated and excessive supply of water.

The Shadorvan Dam-Bridge is an outstanding historical remain of Shoshtar, built nearly 1700 years ago and one of the most important historical dams in Iran and of the world. It is about 500 m long, 10 m high, with 40 original gates, but only 8 gates remain in northern section and 15 gates in the southern section (Figure 4).

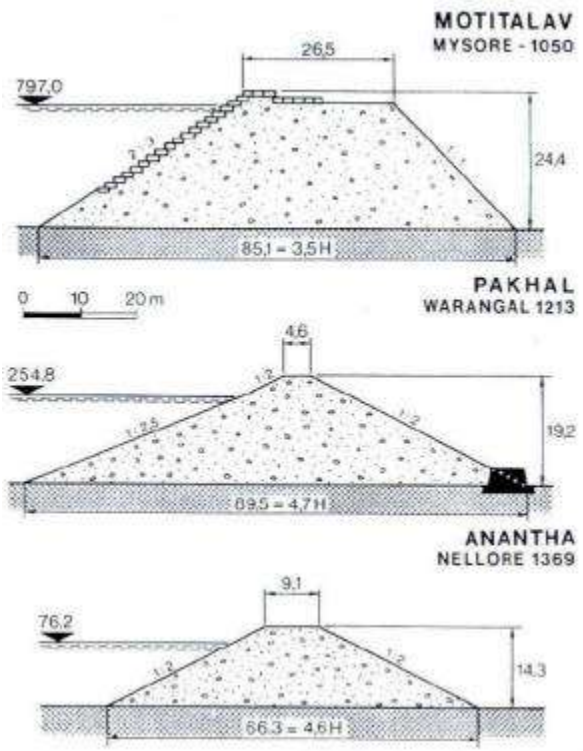

Figure 3. Cross sections of three South-Indian embankment dams (after ICOLD, 2007)

The dam is 6 m wide and is made of rubble stone and lime mortar.

The Amir dam is a multi purpose dam located on the Kur river, 37 Km northeast of Shiraz, 104 m long, 15 m high and 5 m wide and its construction dates back to 1000 years ago (Figure 5). Dam toe is built in the shape of a pillow forming a stilling basin to mitigate river-bed erosion.

The dam is made of rubble stone and lime mortar, the three major purposes of the project were:

- spanning the river as a bridge;
- diverting water into irrigation canals;
-running the water mills with the energy of river water.

These dams built in Egypt, China, India and Iran can be considered jewelry fashioned by the hand from the pure gold of the intellect.

Figure 4. Shadorvan dam–bridge in Iran (courtesy, ICOLD, 2007).

Figure 5. Amir dam in Iran (courtesy ICOLD, 2007)

2. ICOLD-World Register Dams

In 1928, several countries considered that dam experience play an important role and so decided to join the efforts to create a worldwide association, ICOLD.
ICOLD-World Register Dams, updated December 2024, takes into account 62 339 dams.

2.1. Definition of a "Large Dam"

A dam with a height of 15 meters or greater from lowest foundation to crest or a dam between 5 meters and 15 meters impounding more than 3 million cubic meters.
The World Register is widely recognized as the best data basis on dams worldwide (Figure 6). But despite all the efforts of ICOLD, some data are lacking. In using the data basis for calculations, one should stay aware that those calculations are made based on the available data. Therefore, and for a specific field, the dams for which the data are lacking are ignored.

2.2. Purposes of dams

Runoff waters are a natural resource for nations. For developing countries, storing water is often vital and in any case, the only means to develop economically this natural resource.
Water reservoirs mainly give them the guarantee of water supply for irrigation, domestic and industrial use during droughts and reduce the negative impacts of floods.
Statistics are established for 62 339 dams registered in the register, the "Role" field being significant for 42 825 dams.
Demand for water is steadily increasing and will reach 2-3 percent per year over the coming decades.
With their present aggregate storage of about 8 989 km^3, dams make a significant contribution to the efficient
management of finite water resources that are unevenly distributed and subject to large seasonal fluctuations.
Earth dams predominate for some 67 % of all reported dams. This is of course the oldest

type and there are traces or earth dams in the remains of the most ancient civilizations. Furthermore, this type of dam can accommodate a wide range.
Many more dams need to be built to ensure proper use of this resource, in accordance with ICOLD policy set out in the “Position Paper Dams and Environment”.

2.3. Dam types

Referenced dams can be broken into two main categories:

- single-purpose dams (31 473) or 50,5 % dams.
- multipurpose dams (11 352) or 18,2 % dams.

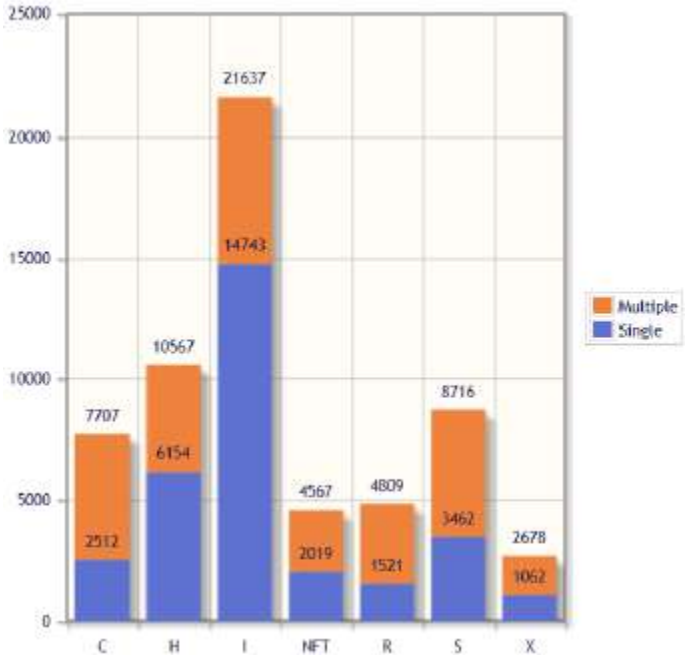

Figure 6. Statistics of dams with single and multiple purposes (after ICOLD, 2024)

Legend

Code	Description	Dams with this sole purpose	Multiple-purpose dams with this purpose
C	Flood control	2512	5195
F	Fish farming	63	1864
H	Hydropower	6154	4413
I	Irrigation	14743	6894
N	Navigation	79	601
R	Recreation	1521	3288
S	Water supply	3462	5254
T	Tailing	1877	83
X	Others	1062	1616

Number and Purposes of registered dams

a) <u>single - purpose dams</u>**:**

Figure 7 illustrates the statistics of dams with single purposes

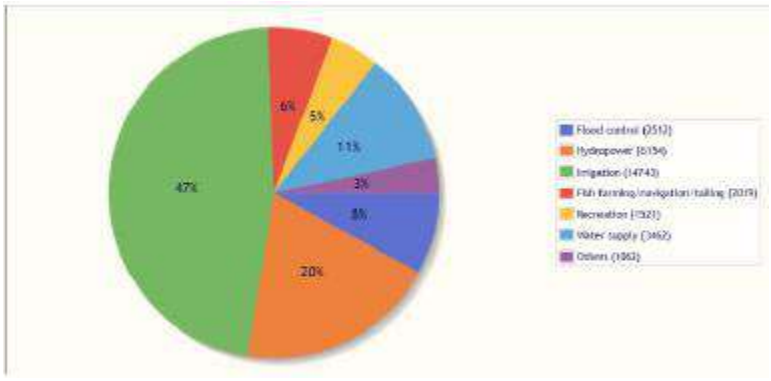

Figure 7. Statistics of dams with single purposes (after ICOLD, 2024)

a) <u>multipurposes dams</u>

Figure 8 shows the statistics of dams with multiple purposes

The distribution of dams for the different types shows that earth dams predominate for some 67 % of all reported dams (see Figure 9).
Table 1 summarizes the TOP 20 -Highest Dams.
Table 2 presents the TOP 20- Oldest Dams.

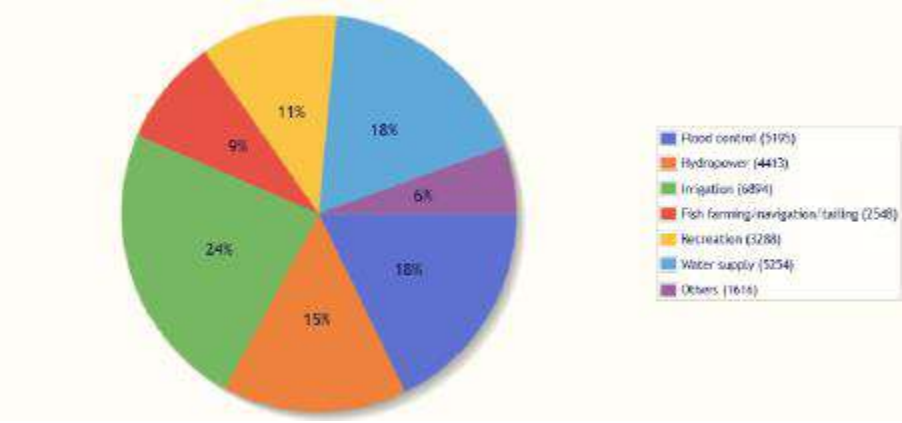

Figure 8. Statistics of dams with multiple purposes (after ICOLD, 2024)

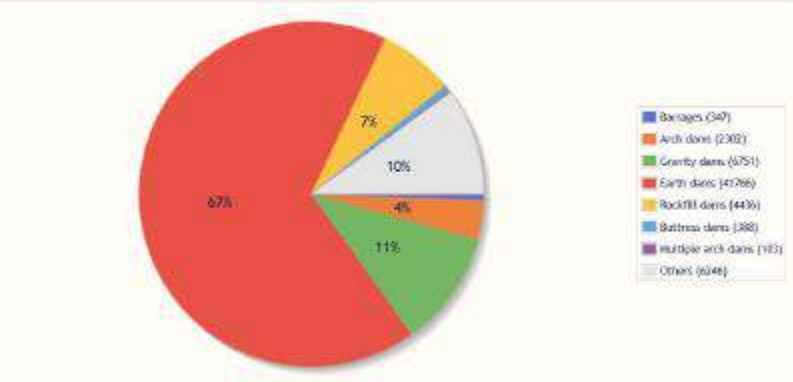

Figure 9. Distribution of dams for the different types (after ICOLD, 2024)

Table 1. TOP 20 -Highest Dams (ICOLD, 2024)

Dam name	Height (m)	Purposes	Country
ROGUN (C)	335	HI	Tajikistan
SHUANGJIANGKOU (C)	312	H	China
JINPING 1	305	HC	China
NUREK	300	IH	Tajikistan
LIANGHEKOU	295	H	China
XIAOWAN	294	HCIN	China
BAIHETAN	289	H	China
XILUODU	286	HCN	China
GRANDE DIXENCE	285	H	Switzerland
BR SANTA FELICIDADE	284	T	Brazil
GUANJINGKOU	282		China
BAKHTIYARI (C)	275	HC	Iran
YUSUFELI	270	H	Türkiye
DIAMER BHASHA (C)	272	HIS	Pakistan
ENGURI	272	HI	Georgia
WUDONGDE	270	H	China
CERRO VERDE/LINGA	265	T	Peru
NUOZHADU	262	HCN	China
VAJONT	262	H	Italy
MANUEL MORENO TORRES	261	H	Mexico

Table. 2. TOP 20 - Oldest dams (ICOLD, 2024)

Dam name	Year	Country
PROSERPINA	130	Spain
CORNALVO	144	Spain
ICHIBANIKE	400	Japan
SUMIYOSHIKE	400	Japan
KAERUMATAIKE	887	Japan
SAYAMAIKE	918	Japan
MANNOIKE	700	Japan
FURUTANIKE	900	Japan
KUMAMOTOIKE	900	Japan
MINENOIKE	900	Japan
NAGAYUKIKE	1000	Japan
THONNUR TANK	1000	India
SHINTARO	1260	Japan
MACHOVO JEZERO	1272	Czech Republic
KEBAR	1300	Iran
SARKHAB	1316	Afghanistan
MARUYAMA(YAMAGUCHI)	1346	Japan
OIKE	1360	Japan
DVORISTE	1363	Czech Republic
OTANIKE	1470	Japan

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ICOLD (2007). *"Historical Review on Ancient Dams"*. Bulletin nº 143.
ICOLD (2024). *"World Register of Dams"*.

Recent Research on Pathogenesis and Chemoprevention of Cancer

by Zigang Dong, Member EUAS

Short Biography

Position:*Professor, Vice President of Zhengzhou University and Dean of Medical College*

Education

1978 – 1983 *M.D., Department of Medicine, Henan Medical University, P.R. China*

1983 – 1986 *M.S., Department of Pathophysiology, Henan Medical University, P.R. China*

1987 – 1991 *Dr. P.H., Mailman School of Public Health, Columbia University, New York*

Positions and Honors

1991 – 1995 *Postdoctoral Fellow, PRI/DynCorp, NCI-Frederick Cancer Research & Development Center, Frederick, MD*

1992 – 1995 *Group Leader, PRI/DynCorp, NCI-Frederick Cancer Research & Development Center, Frederick, MD*

1995 – 1997 *Assistant Professor, The Hormel Institute, University of Minnesota, Austin, MN*

1998 – 1999 *Associate Professor, The Hormel Institute, University of Minnesota, Austin, MN*

1997 – 2019 *Full Member, Cancer Center, University of Minnesota, Minneapolis, MN*

2001 – 2019 *Executive Director, The Hormel Institute, University of Minnesota, Austin, MN*

2000 – 2019 *Full Professor, The Hormel Institute, University of Minnesota, Austin, MN*

2009 – present *Professor with tenure, Department of Biochemistry, Molecular Biology and Biophysics, University of Minnesota*

2019 – present *Dean of College of Medicine, Zhengzhou University, Zhengzhou, Henan, China*

2020 – present *Vice president, Zhengzhou University, Zhengzhou, Henan, China*

Awards, Honors and Other Special Scientific Recognition

1999 *The Gallo Award, The Cancer Institute of New Jersey*

2000 *Alice Hamilton Award, Biological Science category, National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention (CDC) for research presented in JBC 274: 30611-30616, 1999 (Publication # HI 1442)*

2001 – 2019 *Hormel/Knowlton Professor, The Hormel Institute, University of Minnesota*

2006 – 2019 *University of Minnesota McKnight Presidential Professor in Cancer Prevention*

2008 – 2014 *National Institutes of Health Merit Award*

2010 – 2019 *Internal Advisory Committee, Center for Translational Science Activities, Mayo Clinic*

2010 *World Class Professor, Seoul National University, South Korea*

2011 – 2015 *External Steering Panel for the Division of Cancer Prevention, NCI, NIH*

2011 *Oh Dang Award, The Pharmaceutical Society of Korea, South Korea*

2012 *Stars in Nutrition and Cancer Lecturer Award, Division of Cancer Prevention, NCI, NIH*

2013 – 2019 *I.J. Holton Professor, The Hormel Institute, University of Minnesota*

2013 *International Science and Technology Collaboration Award, Hunan, China*

2014 *Yellow River Friendship Award, China*

2016 *Outstanding Achievement Award, Society of American Asian Scientists in Cancer Research*

2020 *The 8th Overseas Chinese Contribution Award, China*

2020 *Science and Technology Collaboration Award, Henan, China*

2023 *Foreign Full Member, Academician of the Russian Academy of Engineering*

Editorial Work

2004 – 2008	*Carcinogenesis: Editorial Board member*
2003 – 2010	*Journal of Biochemistry and Molecular Biology: Overseas Editor*
2005 – present	*Molecular Carcinogenesis: Associate Editor*
2003 – present	*Biofactors: Editorial Board member*
2006 – present	*International Journal of Biological Sciences: Editorial Board member*
2007 – 2013	*Cancer Research: Editor*
2008 – 2015	*Cancer Prevention Research: Editorial Board member*
2015 – present	*Cancer Prevention Research: Senior Editor*
2010 – 2014	*Carcinogenesis: Editorial Board member*
2011 – 2019	*The Journal of Biological Chemistry, Editorial Board member*
2014 - 2019	*EBioMedicine Editorial Board member*
2016 – 2019	*Nature Partner Journal: Precision Oncology: Editor-in-Chief*

Professor Zigang Dong has long been engaged in research on the pathogenesis and chemoprevention of cancer, and has original achievements with international influence in the field of carcinogenic mechanisms and chemoprevention of physical and chemical carcinogens. He is a leader in cancer chemoprevention research in the world. Professor Dong has published over 580 articles in journals such as Nature, Nature Reviews Cancer, Nature Cell Biology, Nature Structure and Molecular Biology, and Science Signaling, with a total citation of over 46000 times, H-index is 116. Serving as an editorial board member or deputy editor in chief of various authoritative journals in the field of cancer research, such as Cancer Research、Cancer Prevention Research and Carcinogenesis. Professor Dong has signed a contract with Nature Publishing Group to establish the magazine 'npj Precision Oncology'. He has received the highest honor of McKnight Chair Professor at the University of Minnesota. Professor Dong won Gallo Award in 1999 and the Merit Award from the National Institutes of Health in 2008. In 2012, he received the Nutrition and Cancer Star Award from the American Cancer Institute. In 2013, he was awarded the I. J. Holton Chair Professor at the University of Minnesota. In 2014, Professor Dong won the Yellow River Friendship Award from the Henan Provincial Government. In 2016, he was awarded the Outstanding Contribution Award by the Asian American Cancer Society. In 2020, he won the 8th China Overseas Chinese Contribution Award and the Henan Province Science and Technology Cooperation Award. In 2021, he was selected as the "Top 100000 Scientists in the World", ranking the third in clinical medicine in Chinese Mainland and the first in all scientific fields in Henan Province. In the same year, he was selected as professor in national level. In 2023, elected as a foreign academician of the Russian Academy of Engineering. In 2024, elected as a member of the European Academy of Sciences. In the same year, he was invited to attend the National Day reception celebrating the 75th anniversary of the founding of the People's

Republic of China. Professor Dong has been selected multiple times for the "Top 2% Global Scientists List", and in 2024, he was selected for the "career-long impact Scientists", ranking first in all scientific fields in Henan Province.

Professor Dong is a world leader in cancer prevention and molecular carcinogenesis. He conducted pioneering work in elucidating physical and chemical carcinogen-induced signal transduction pathways as molecular targets for chemopreventive agents in carcinogenesis. He has systematically and innovatively studied the molecular targets and mechanisms of cancer chemopreventive drugs and established the models or crystal structures for the binding of drugs to their target molecules, which drove the design and clinical trials of new cancer preventive drugs through theoretical breakthroughs. Professor Dong's research group has multiple drugs undergoing phase 0 to IV clinical trials. The National Cancer Institute of the United States highly praises Professor Dong's research work on its website, believing that Professor Dong has pioneered the application of high-tech in the study of carcinogenic mechanisms, cancer treatment target molecules, and cancer prevention drugs. In 2009, Professor Dong was invited to publish a paper titled "Cancer Prevention Research - Then and Now" in Nature Reviews Cancer, systematically elaborating on the progress and research focus of cancer chemoprevention, and becoming a key recommended article on the Nature website.

Professor Dong's group was the first to identify protein kinases including p38, ERKs, JNKs, Fyn, MLTK and RSK as p53 protein kinases that phosphorylate p53 at different amino acid residues. p53, known as the "molecular police," is the most well-known tumor suppressor to date. Professor Dong conducted the first study on the phosphorylation modification of different sites of p53 and its role in cell cycle, apoptosis, and carcinogenesis, and discovered 18 different upstream protein kinases that modify p53 phosphorylation. Invited to publish a review article titled "Post translational modification of p53 in tumor genesis" in Nature Reviews Cancer, it is one of the most cited papers in the field of molecular biology and genetics worldwide from 2003 to 2009 by Thomson Reuters Science Watch.

For the limitation that a single cause cannot explain the occurrence of cancer, Professor Dong proposed a new theory of "1+X" that the main carcinogenic cause combined with multiple carcinogenic factors leads to the occurrence of cancer. He pointed out that the injury of esophageal epithelium caused by hot food and hot drink may be the main reason for the occurrence of esophageal cancer. The prevention strategy based on this theory has been popularized and applied in the high incidence areas of esophageal cancer. In

recent years, the incidence rate of esophageal cancer has declined year by year. This theory was published in the authoritative journal of Cancer Research of the American Cancer Society, and is expected to become a global guideline for cancer prevention. In addition, Professor Dong's team used spatial transcriptomics analysis to sequence specific areas of esophageal squamous epithelial precancerous lesions, and found that the stage of esophageal squamous precancerous lesions was in an immunosuppressive state. The use of machine learning methods to screen and study confirmed that the expression of TAGLN2 significantly increases during the progression of esophageal cancer, while the expression level of CRNN decreases. Further research confirms that TAGLN2 promotes the progression of esophageal cancer, while CRNN inhibits the progression of esophageal cancer. This study suggests that early intervention should be carried out in high-risk populations with abnormal expression of TAGLN2 and CRNN in esophageal precancerous lesions. The research results were published in Nature Communications and were named one of the top 50 papers of 2023 by the journal.

For a long time, H. pylori infection has been considered as the main cause of gastric cancer. However, so far, there is not enough experimental evidence to support this argument. Professor Dong proposed a new theory of "emotional illness" in the occurrence of gastric cancer: Helicobacter pylori infection alone is not enough to cause the occurrence of gastric cancer, the biological factors of Helicobacter pylori infection, chronic stress, alcohol consumption, and other factors work together to lead to the occurrence of gastric cancer. The proposal of this academic idea has attracted widespread attention in the academic community since its publication, and is expected to provide new theoretical basis for exploring the etiology and molecular mechanisms of gastric cancer.

Professor Dong's team further revealed that long-term negative emotional states, particularly chronic stress, significantly promote the development of upper gastrointestinal cancers, like esophageal cancer and gastric cancer. Accordingly, they proposed that chronic stress-related emotional disturbances may represent the "fourth major category of carcinogenic factors" in humans, following physical, chemical, and biological factors (Molecular Cancer, 2025). The study elucidated that chronic stress activates the "cortisol - glucocorticoid receptor (GCR) - HMGB2 - LDLR" signaling axis, disrupts cholesterol metabolism, and thereby drives the initiation and progression of esophageal cancer (PNAS, 2025).

What is Light, and how does it Interact with Matter?

by Claude Fabre, Member EUAS

Short Biography
Born in 1951 in Paris.
claude.fabre@lkb.upmc.fr
Laboratoire Kastler-Brossel, Sorbonne Université, Paris, France
Present position : Emeritus Professor at Sorbonne Université
wikipedia page: https://fr.wikipedia.org/wiki/Claude_Fabre

Scientific Career

1970-1974 Graduate student at the École Normale Supérieure and Sorbonne Université (Paris)
1975-1986 Full time research position at the CNRS
1981 Ph D
1984-1985 Visiting Scientist at IBM California
1986-1998 Part time associate professor at the Ecole Polytechnique
1986-1996 Research Director at the CNRS
1996-2003 Professor at Sorbonne University
2001-2007 Director of Physics Doctoral School of Paris area
Visiting scientist in different universities in China
2007-2010 Chair of the French National examination "Agrégation"
2003-2017 Full Professor at the Sorbonne Université
Visiting Scientist at the Shanxi University (China), Max Planck Institute (Germany), ANU University (Australia), NIST Gaithersburg (USA) and Ottawa (Canada)
2017- Emeritus Professor at Sorbonne University

Awards and honors

1991 Fabry De Gramont prize of the French Optical Society (SFO)
1999 Honorary professor at the Shanxi University, Taiyuan (China)
2004 Fellow of the Optical Society (OSA)
2007-2017 Senior member of the Institut Universitaire de France
2009 Fellow of the European Optical Society (EOS)
2014 Honorary professor at the East China Normal University, Shanghai (China)
2013 Arnulf-Françon prize of SFO for the book Introduction to Quantum Optics
2015 Recipient of "Knight of Légion d'Honneur" distinction (highest in France)
2018 Honorary professor at the National Time Service Center, Xi'an (China)
2018 Great Prize Leon Brillouin of SFO, attributed to "a world famous optician

for his whole career"

Service to the Optical Sciences community

1995-2004 Member of the board of the Quantum Electronics and Optics Division (QEOD) of the European Physical Society (EPS)
Member of the steering committee of the series of EQEC/IQEC onferences (Nice, Glasgow,Hamburg, Munich), co-organized by EPS/QEOD and OSA
Program chair (2003), then general chair (2005) of the CLEO-EQEC conferences in Munich
2004-2010 Member of the International Advisory Board of the OSA
2006-2011 Member of the steering committee of CLEO-EQEC Munich conferences
2008-2012 Editor in chief of the European Physical Journal D
2007-2009, 2011-2013 Vice-president of the French Optical Society
2009-2011 President of the French Optical Society
2009-2017 Founding member and treasurer of the F2S (French Federation of Scientific Societies)
2013-2017 "Chargé de mission", commissioned the French Minister of Research and Higher Education, in charge of the coordination of the reform of teachers training in France
2016-2018 Member of the European Research Council selection panel

Bibliometry

181 refereed papers, 23 review papers and book chapters, 113 invited talks, 34 invited courses in summer schools, 222 seminars and colloquia, 3 textbooks, 26 outreach eminars According to Google Scholar: 18500 citations, h-index 74. Most cited paper: 954 citations.

Research Domain

Throughout his research career Claude Fabre has investigated the multiform properties of light and has always sought, by theoretical and experimental investigations, to answer the question: what is light, and how does it interact with matter? This search began by the study of the interaction between microwaves and highly excited atoms, then continued by the study of the interaction between quantized light and various devices such as atoms, mirrors, nonlinear crystals... Claude Fabre has put in evidence and characterized the quantum properties of light under all its possible forms, first in simple systems: light beams, optical resonators, lasers, nonlinear oscillators, then in multimode quantum optical systems such as optical images and recently in trains of ultra-short light pulses. To treat quantum light in its more general perspective, he has been led to develop an original approach of multimode quantum optics. He has applied this knowledge to develop "quantum technologies", namely to optimize high precision optical measurements at the quantum level and recently to perform quantum information processing operations.

Main Scientific Achievements

In 1986, with E. Giacobino and S. Reynaud, he created one of the first research groups devoted to the study of quantum fluctuations and correlations in the amplitude of the electric field of light. He made soon an important world premiere, namely the first generation of "twin beams", i.e. bright beams of light which have correlated intensity fluctuations which cannot be explained classically, which was one of the first manifestations in optics of a quantum correlation. These beams were produced by intracavity parametric down-conversion, which led him to study in great detail the classical and quantum properties of Optical Parametric Oscillators: theoretical prediction of complex dynamics and chaos theoretical analysis of quantum fluctuations using a semi-classical approach theoretical study of quantum noise reduction near a self-pulsing bifurcation point. On the experimental side, he made the first generation of sub-Poissonian light using electronic feedforward on twin beams, the first observation of a delayed bifurcation in OPOs and showed evidence of quantum-enhanced spectroscopy using twin beams, one of the first experimental implementations of quantum metrology. In 1992, he was asked to make a review about squeezed states of light at the Solvay meeting.

He also investigated the quantum noise properties of lasers: first observation of laser action in a cloud of cold and trapped atoms, theoretical study of quantum fluctuations in lasers and of the influence of pump noise study of the "superradiant laser". in the now flourishing domain of quantum opto-mechanics, he showed theoretically that it is possible to reduce the quantum fluctuations of light in a cavity with a movable mirror. He then turned most of his interest to the study of optical images at the quantum level: he was the first to observe optical patterns and transverse instabilities in OPOs and studied the influence of quantum noise on optical resolution and the ways to improve it beyond quantum limits. He made the first theoretical proposal of the use of squeezed light in tailored modes to improve position measurements, followed by its experimental implementation by surpassing the quantum limit in the measurement of 1D and 2D displacements. This led him to propose a general multimode analysis of quantum noise processing in optical images.

He still contributed to the advancement of the study of quantum correlation and entanglement: he realized the first non-classical state generation by a conditional measurement on Continuous Variables optical systems and measured a world-record quantum noise quantum noise reduction and entanglement. He made the first theoretical prediction of tripartite entanglement (pump-signal-idler) in above threshold OPOs, which was then experimentally demonstrated by a Brazilian group. In collaboration with

solid-state physicists, he showed that it is possible to use two-photon absorption in semi-conductors to measure intensity correlations at the femtosecond scale. He showed the interest of using a retrodictive approach of quantum states in the understanding of quantum measurements and conducted various studies in quantum theory of continuous variable systems: first direct ab initio determination of the temporal mode of a single photon, proof that Homodyne Detection gives only partial information about quantum light, proof that entanglement cannot replace a real interaction between atoms in two-atom excitation quantum analysis of the quantum fluctuations of the width of a focussed optical beam. In a collaboration with researchers from Thalès company he investigated the use of ring semi-conductor lasers for gyrometric applications. He also investigated the possibility of building miniature OPOs directly coupled to single mode fibers.

He recently devoted the main part of his research to the study of quantum aspects of parametrically generated ultrashort pulses and of the quantum properties of optical frequency combs: first theoretical study of such a multimode quantum light, first experimental measurements of quantum frequency correlations in an Optical Frequency Comb, first determination of the quantum noise eigenmodes and evidence for highly multipartite entanglement between frequency modes theoretical analysis of mode-selective photon subtraction to generate non-Gaussian multimode states of light This led him to stress the importance of a modal analysis of quantum effects. In particular he found the optimum shape of the mode in which to put squeezed light in order to reduce as much as possible the quantum uncertainty of space, time and frequency measurements He studied also another important application of this kind of multipartite entangled light, which is Measurement Based Quantum Computation where approriate modes of light are the nodes of the “cluster state” which is the basic ingredient of this newly explored kind of quantum computation

New Tools and Methodologies for Biomass Characterization

by Arthur Ragauskas, Member EUAS

Short Biography

Dr. Arthur Ragauskas held the first Fulbright Chair in Alternative Energy and is a Fellow of the American Association for the Advancement of Science, the International Academy of Wood Science, and TAPPI. In 2014, he assumed a Governor's Chair for Biorefining based in the University of Tennessee's Department of Chemical and Biomolecular Engineering, with a complementary appointment in the UT Institute of Agriculture's Department of Forestry, Wildlife, and Fisheries and serves in the Energy and Environmental Sciences Directorate, Biosciences Division, at ORNL. His research program is directed at understanding and exploiting innovative sustainable bioresources for the circular economy. This multifaceted program is targeted to develop new and improved applications for nature's premiere renewable biopolymers for biofuels, biopower, and bio-based materials and chemicals. His research program has been sponsored by NSF, USDA, DOE, GA Traditional Industry Program, a consortium of industry partners, and several fellowship programs which are summarized in ***725 peer-reviewed*** *publications. His Fulbright-sponsored activities at the Chalmers University of Technology, Sweden were focused on forest biorefinery and new biofuel conversion technologies for lignocellulosics. Currently, Dr. Ragauskas manages a research group of graduate students, postdoctoral research fellows, a research scientist, and visiting scientists. He is the recipient of the 2014 TAPPI Gunnar Nicholson Gold Medal Award, the 2014 ACS Affordable Green Chemistry Award, the 2017 AIChE Green Processing Award, the 2017 Academia Distinguished Service Award, 2019 AIChE Chase Award and 2022 RSC Environment, Sustainability, and Energy Division open award: Environment Prize. In addition, his students and postdocs have won several awards, including the ACS graduate research award, the ORNL UT-Battelle Award, and the ORNL Supplementary Performance Award.*

Dr. Ragauskas is an Associate Editor for Biofuels, Bioproducts and Biorefining, Biofuels, BioEnergy Research, Industrial Biotechnology, Taiwan Journal of Forest Service, TAPPI J., Holzforschung, Journal of Biobased Materials and Bioenergy, Journal of Petroleum Technology and Alternative Fuels, The Open Biotechnology Journal, Current Biotechnology, and J. Wood Chemistry and Technology. He is an editorial board member of Sustainability and the Journal of Chemical Technology and Biotechnology. Dr. Ragauskas has served on several advisory boards and review panels including the Austrian Science Fund, European Commission Research Directorate, National Science Academy, J. Paul Getty Trust, NSF, USDA, DOE, ARAPA-E, NSERC, TAPPI Research Management Committee, Netherlands Organization for Scientific Research (NWO), Swedish Foundation for Strategic Research, Swedish VINN Excellence Center, Swedish Knowledge Foundation, VTT Technical Research Centre of Finland, ERA Chemistry, Swiss National Science Foundation, Finnish Academy of Science Norway Research Council, The Technology Foundation STW, Agence Nationale de la Recherche and Singapore Agency for Science, Technology, and Research. Dr. Ragauskas has been an invited visiting professor at Universidade da Beira Interior, Portugal; Chalmers University of Technology, Sweden; Royal Institute of Technology/ STFi, Stockholm, Sweden; and Southeast University, China, and South China University of Technology,

China.

Summary Statement: Ragauskas' Governor's Chair in Biorefining

Ragauskas heads a multifaceted program to understand and exploit the fundamental structure of municipal waste and bioresources to develop new and improved conversion pathways for sustainable fuels, power, materials, and chemicals within the circular economy while educating the next generation of leaders. The program leverages the unique research infrastructure and expertise located on the campuses of the Oak Ridge National Laboratory (ORNL), University of Tennessee, Knoxville (UTK), and the University of Tennessee Institute of Agriculture (UTIA). Ragauskas' research thrusts focus on four central overlapping focus areas:

- Fundamental investigation of the structure of lignocellulosics and their relationship to biological biorefining of biomass to biofuels
- Valorization of biomass components for bio-derived materials
- Development of new tools and methodologies for biomass characterization
- Upcycling of societal waste streams.

Ragauskas assumed the ORNL-UTK Governor's Chair in Biorefining in June 2014 and was renewed in October 2019. This UTK faculty position, jointly funded by UTK and ORNL, was envisaged to develop a fundamental research and academic program for sustainable biomass biorefining. His research-educational thrusts are pursued and developed within the boundaries of a circular economy.

Figure 1: Overview of Ragauskas' ORNL, UTK, and UTIA Governor Chair in Biorefining.

Historically, the bio-economy was frequently viewed from the "lens of biorefining bioresources from forest and agricultural resources" to serve society's needs, which by default are centered in major metropolitan centers. Over the last decade, this vision of producers and consumers has evolved, as captured by the circular economy (see **Fig. 1**), in which products are manufactured to be used, recycled, and reused. Thus, the bio-economy and Ragauskas' studies have been

broadened to utilize virgin biomass resources and waste streams from industry and the general population. The outcomes of Ragauskas studies over the past 4.5 years have been documented in +239 publications, three patent filings, +60 conference presentations, and the graduation of four UTK Ph.D. students. Reflective of these studies, Ragauskas has a Google H-Index of 128 and was the 2022 awardee of the *RSC Environment, Sustainability, and Energy Division open award: Environment Prize*.

Significant Research Contributions: To address evolving research and educational challenges in biorefining-circular economy, Dr. Ragauskas has developed a dynamic, internationally recognized ORNL-UTK-UTIA research team in the field of fundamental (i) biorefining of lignocellulosics, (ii) green chemistry/engineering, (iii) material science of bio-derived materials, and (iv) valorization of modern societal waste streams.

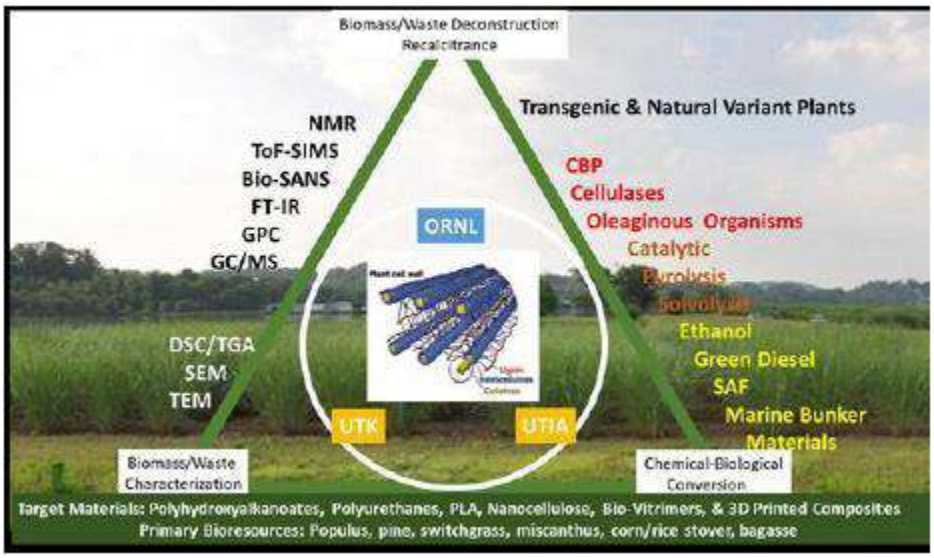

Figure 2: Ragauskas' biorefining studies.

Figure 2 demonstrates a strong emphasis on advanced analytics and biofuel research, which is consistent with Ragauskas' contributions to the Center of Bioenergy Innovation (CBI) and Science Focus Area (SFA, titled' Visualization of Solvent Disruption of Biomass and Biomembrane Structures in the Production of Advanced Biofuels and Bioproducts') DOE-funded programs centered at ORNL. As shown in **Figure 3**, our circular economy studies are primarily directed at upcycling waste streams for sustainable generation of chemicals, fuels, and materials. Both focus areas leverage ORNL, UTK, and UTIA research infrastructure and expertise. (NB: our coal material studies are directed at providing value-added alternatives to the combustion of coal)

Figure 3: Ragauskas' circular economy studies.

ORNL Focused Activities*:* Five selected publications representing Ragauskas' 2020-2024 Governor's Chair research efforts at ORNL are summarized below:

1. Economics and global warming potential of a *commercial*-scale delignifying biorefinery based on cosolvent-enhanced lignocellulosic fractionation to produce alcohols, sustainable aviation fuels, and biomass co-products. Klein, Bruno Colling; Scheidemantle, Brent; Hanes, Rebecca J.; Bartling, Andrew W.; Grundl, Nicholas J.; Clark, Robin J.; Biddy, Mary J.; Tao, Ling; Trinh, Cong T.; Guss, Adam M.; Wayman, Charles E.; Ragauskas, Arthur J.; Webb, Erin G.; Davison, Brian H.; Cai, Charles M., *Energy & Environmental Science* (2024), 17(3), 1202-1215.
2. Characterization and molecular simulation of lignin in cyrene pretreatment of switchgrass. Wang, Yun-Yan; Wang, Yunxuan; Liang, Luna; Smith, Micholas Dean; Meng, Xianzhi; Pu, Yunqiao; Mazarei, Mitra; Agarwal, Rupesh; Rukmani, Shalini J.; Davison, Brian H.; Ragauskas, Arthur J. *Green Chemistry* (2024), 26(6), 3170-3182
3. Novel candidate genes for lignin structure identified through genome-wide association study of naturally varying *Populus trichocarpa.* Bryant, Nathan; Zhang, Jin; Feng, Kai; Shu, Mengjun; Ployet, Raphael; Chen, Jin-Gui; Muchero, Wellington; Yoo, Chang Geun; Tschaplinski, Timothy J; Pu, Yunqiao; Ragauskas, Arthur J. *Frontiers in Plant Science* (2023), 14, 1153113.
4. Deconstruction of biomass enabled by local demixing of cosolvents at cellulose and lignin surfaces. Pingali, Sai Venkatesh; Smith, Micholas Dean; Liu, Shih-Hsien; Rawal, Takat B.; Pu, Yunqiao; Shah, Riddhi; Evans, Barbara R.; Urban, Volker S.; Davison, Brian H.; Cai, Charles M.; Ragauskas, Arthur J.; O'Neill, Hugh, M.; Smith, Jeremy; Petridis, Loukas. *Proceedings of the National Academy of Sciences of the United States of America* (2020), 117(29), 16776-16781.
5. Tensile properties of 3D-printed wood-filled PLA materials using poplar trees. Bhagia S; Lowden RR; Erdman D; Rodriguez M; Haga BA; Solano IRM; Gallego NC; Pu Y; Muchero W; Kunc, V; Ragauskas AJ. *Applied Materials Today* (2020) 21, 100832.

UTK/UTIA Focused Activities: In addition to these activities, Ragauskas has developed several UTK-UTIA research thrusts leveraging ORNL capabilities, as summarized in five representative publications presented below:

1. 3D printed lignin/polymer composite with enhanced mechanical and anti-thermal-aging performance. Zhang, Shuyang; Meng, Xianzhi; Bhagia, Samarthya; Ji, Anqi; Dean Smith, Micholas; Wang, Yun-yan; Liu, Bo; Yoo,

Chang Geun; Harper, David P.; Ragauskas, Arthur J. *Chemical Engineering Journal* (2024), 481, 148449.
2. Catalytic cascade upcycling single-use natural rubber glove wastes into fuels via a two-stage pressurized fixed-bed reactor. Wang, Jia; Jiang, Jianchun; Meng, Xianzhi; Lam, Su Shiung; Ragauskas, Arthur J.; Wang, Yanqin. *Fuel Processing Technology* (2022), 238, 107490.
3. Upcycling disposable face masks into fuel range iso-alkanes through hydropyrolysis coupled with vapor-phase hydrocracking. Wang, Jia; Jiang, Jianchun; Zhang, Yiyun; Meng, Xianzhi; Ragauskas, Arthur J. *Energy* (2023), 263(Part_B), 125843.
4. A facile strategy to fabricate a lignin-based thermoset alternative to formaldehyde-based wood adhesives. Shi, Xiaoyu; Gao, Shishuai; Jin, Can; Zhang, Daihui; Lai, Chenhuan; Wang, Chunpeng; Chu, Fuxiang; Ragauskas, Arthur J.; Li, Mi. *Green Chemistry* (2023), 25(15), 5907-5915.
5. Influence of plasticizers on thermal and mechanical properties of biocomposite filaments made from lignin and polylactic acid for 3D printing. Wasti, Sanjita; Triggs, Eldon; Farag, Ramsis; Auad, Maria; Adhikari, Sushil; Bajwa, Dilpreet; Li, Mi; Ragauskas, Arthur J. *Composites, Part B: Engineering* (2021), 205, 108483.

Research Projects and Five-Year Plan: Our research activities are forward-looking and directed at developing fundamental science and engineering to advance next-generation biorefining operations that address circular economy challenges. We have leveraged critical assets on the ORNL, UTK, and UTIA campuses to develop unique solutions and understanding of biomass and its conversion to biofuels, bio-based chemicals, and materials. These advances have come due to our partnerships with researchers from several departments, including:

- ORNL: Neutron Sciences, Chemical Sciences, BioSciences Division, Computational Systems Biology, and Manufacturing Demonstration Facility
- UTK: Chemical Biomolecular Engineering, Department of Plant Sciences
- UTIA: Center for Renewable Carbon

We remain one of the leading groups in biomass characterization and valorization of cellulose and lignin, both nationally and internationally. Based on our past accomplishments and ongoing research efforts, two Center proposals have been submitted to (1) NSF: Global Center for Sustainable Bioproducts and (2) DOE: Assessment of CORE-CM Resources in Eastern Coastal U.S. Waste Streams. We have been and will continue to strongly support ORNL's SFA and CBI's research mission, working with plant scientists and deconstruction teams to characterize and understand the key plant cell wall features that contribute to recalcitrance. In addition, as our nanocellulose/lignin and related material studies at UTK/UTIA mature, we anticipate leveraging ORNL's SNS, computational science, and plant science expertise in joint proposals. Indeed, recent and future RFPs/FOAS from DOE, USDA, and NSF are highly aligned with our current research programs.

Educational Mission

Although Ragauskas' current position does not require a teaching component, a core value of his academic mission is that a professor can only be as successful as the students he educates, mentors, and graduates. As such, Ragauskas' academic mission has been and remains a cornerstone of his career objectives. These career objectives include the following.

- Develop a challenging and enriching educational and research experience that facilitates the intellectual development of UTK/UTIA students and

postdoctoral fellows and supports the mission of the Department of Chemical and Biomolecular Engineering and the Center for Renewable Carbon.

- Recruit, educate, and develop the next generation of scientists who will be nationally and internationally recognized leaders in biorefining, green chemistry/engineering of biofuels, bio-derived materials, chemicals, and circular economy chemical processes.

Concluding Statement

In summary, since the beginning of Ragauskas' Governor's Chair position in the summer of 2014, his professional vision has been to leverage his past academic research accomplishments in lignocellulosic chemistry to develop a nationally and internationally recognized program for fundamental sustainable green chemistry engineering of (1) bio-renewables for Biorefining biomass to biofuels, bio-derived materials, chemicals, and (2) Circular Economy studies involving upcycling plastics, REE recovery, and utilization of coal as a material, at ORNL, UTK, and UTIA. His accomplishments to date attest to his success in accomplishing these goals.

Artificial Intelligence-Driven Reconstruction of Traditional Chinese Medicine: Integration, Challenges, and Future Prospects

by Fuji Ren, Member EUAS

Short Biography

Fuji Ren received his Ph. D. degree in 1991 from the Faculty of Engineering, Hokkaido University, Japan. From 1991 to1994, he worked at CSK as a chief researcher. In 1994, he joined the Faculty of Information Sciences, Hiroshima City University, as an Associate Professor. Since 2001, he has been a Professor of the Faculty of Engineering, Tokushima University. He is a Chair Professor of University of Electronic Science and Technology of China from 2022. His current research interests include Natural Language Processing, Artificial Intelligence, Affective Computing, Emotional Robot. He is the Academician of The Engineering Academy of Japan and EU Academy of Sciences. He is a senior member of IEEE, Editor-in-Chief of International Journal of Advanced Intelligence, a vice president of CAAI, and a Fellow of The Japan Federation of Engineering Societies, a Fellow of IEICE, a Fellow of CAAI. He is the President of International Advanced Information Institute, Japan.

Abstract

This paper systematically explores the potential pathways, practical applications, and future directions for the deep integration of artificial intelligence (AI) technology with Traditional Chinese Medicine (TCM). As a medical system centered on holism and syndrome differentiation (Bian Zheng Lun Zhi), TCM faces contemporary challenges such as the tacit nature of knowledge transmission, subjectivity in diagnosis, and difficulties in textual excavation of ancient literature. AI technologies—particularly machine learning, natural language processing (NLP), and knowledge graphs—offer new methodological opportunities for the modernization and scientization of TCM due to their strengths in complex data modeling, pattern recognition, and knowledge inference. Beginning from a discussion of theoretical compatibility, this paper analyzes the intrinsic alignment between AI and TCM in holistic thinking, fuzzy concept processing, and small-sample learning. It further elaborates how AI is reconstructing the TCM diagnostic–therapeutic chain from perception to decision-making in concrete scenarios such as objective quantification of the "Four Diagnostic Methods," AI-assisted syndrome

differentiation, ancient text mining, and herbal formula analysis. Finally, the paper prospects future research paradigms of "Digital–Intelligent TCM," ethical challenges, and the vision of human–AI collaboration. This study aims to provide systematic reflection and pathways for the inheritance, innovation, and development of TCM in the era of artificial intelligence.

Keywords: Artificial Intelligence; Traditional Chinese Medicine Modernization; Objective Quantification of the Four Diagnostic Methods; Syndrome Differentiation and Treatment; Knowledge Graph; Human–AI Collaboration

1. Introduction: When Ancient Wisdom Meets Modern Algorithms

Traditional Chinese Medicine, crystallizing millennia of Chinese health wisdom, is a theoretical system rooted in philosophical concepts such as Yin–Yang and the Five Elements, Zang–Fu organ theory, and meridian networks. It emphasizes "harmony between humans and nature" and "treatment based on syndrome differentiation," employing the "Four Diagnostic Methods"—observation, listening/smelling, inquiry, and palpation—for diagnosis and therapy. However, amidst the rapid advancement of modern science and healthcare systems, the inheritance and development of TCM face a series of structural challenges:

1. Individualization and Tacit Nature of Experience Transmission: The clinical expertise of master TCM practitioners heavily relies on personal experience and insight, making it difficult to transmit on a large scale.
2. Complexity and Subjectivity of Syndrome Differentiation: Diagnosis is influenced by practitioners' experience and subjective perception, lacking objective and quantifiable standards.
3. Difficulties in Textual Mining of Ancient Literature: Vast amounts of classical texts and medical records exist in unstructured forms, hindering efficient knowledge extraction.
4. Demand for Evidence within Modern Evidence-Based Medical Standards: Efficacy evaluation of TCM requires stronger data support and scientific interpretation.

Concurrently, artificial intelligence—especially deep learning, natural language processing (NLP), graph neural networks (GNNs), and multimodal learning—has made significant breakthroughs in modeling complex systems, processing unstructured information, and learning from small samples. This offers unprecedented technological potential to systematically address TCM's developmental challenges. The integration of AI and TCM is not merely a superficial application of tools, but a profound reconstruction based on deep-level complementarity in their cognitive logics. This paper aims to systematically elucidate the theoretical foundations, practical pathways, and future directions of AI-empowered TCM, promoting the formation of a new "Digital–Intelligent TCM" paradigm.

2. TCM and AI: Theoretical Alignment and Empowerment Logic

2.1 **Resonance in Cognitive Models**

Multiple points of convergence exist between TCM and AI at the foundational level of thinking:

Holistic and Relational Thinking: TCM emphasizes the interconnectedness of the human body and its environment, as well as among organs and meridians. Technologies like knowledge graphs and GNNs can structurally model the complex "disease–syndrome–formula–herb" relationships, building a computable and inferable TCM knowledge network.

Fuzzy and Probabilistic Processing: TCM concepts such as "Qi deficiency" and "blood stasis" possess fuzzy characteristics. Fuzzy logic, probabilistic graphical models, and uncertainty quantification methods provide mathematical tools for representing such concepts.

Experience and Data-Driven Learning: TCM clinical experience can be viewed as high-quality, small-sample data. AI methods like transfer learning and meta-learning enable model generalization from limited samples, facilitating the digital preservation and transmission of master physicians' expertise.

2.2 **The Empowering Role of AI**

AI does not aim to replace the philosophical core of TCM (the "Dao"), but rather to enhance its methodological system of diagnosis and treatment (the "Shu"). Its goal is to serve as a "smart external brain" and "super assistant" for TCM practitioners, expanding their capabilities in information perception, syndrome analysis, and therapeutic decision-making.

Therapeutic Chain

3.1 **Intelligent Perception and Objectification of the Four Diagnostic Methods**

Diagnostic Method	AI Technologies Employed	Functional Implementation
Observation (Wang Zhen)	Computer Vision, Image Recognition	ongue image analysis (coating, texture, fissures), facial diagnosis, quantitative feature extraction
Listening/Smelling (Wen Zhen)	Voiceprint Recognition, Audio Signal Processing	Feature extraction from cough, breath, and heart/ lung sounds to assist in assessing Qi dynamics
Inquiry (Wen Zhen)	Natural Language Processing, Dialog Systems	Intelligent inquiry, structured symptom extraction, automated medical history summarization
Palpation (Qie Zhen)	Signal Processing, Time-Series Models	Pulse waveform feature analysis, classification of pulse

		types (e.g., wiry, slippery, thin, hesitant)

3.2 **Intelligent Syndrome Differentiation and Decision Support**

Based on multimodal information fusion, AI can construct syndrome classification models, outputting syndrome patterns with confidence levels and linking them to classical formulas or similar medical cases. Using "formula–herb–syndrome" knowledge graphs, systems can provide personalized modification suggestions and predict potential herb–herb interactions or adverse reactions by integrating network pharmacology.

3.3 **"Preventive Treatment of Disease" and Health Management**

Leveraging data from wearable devices and daily monitoring, AI can build dynamic models of individual health status, enabling early warning of disease risks and recommending personalized interventions such as dietary adjustments, physical exercises (Daoyin), or herbal teas. This promotes the practical application of TCM's "preventive treatment" philosophy.

4. Directions for Scientific Innovation: Towards a "Digital–Intelligent TCM" Paradigm

4.1 **Mining Ancient Wisdom and Building Knowledge Bases**

Utilizing NLP techniques for entity recognition, relationship extraction, and semantic analysis of classical TCM texts to construct large-scale, structured ancient knowledge graphs, supporting intelligent retrieval and knowledge discovery.

4.2 **Decoding the Complex System of Herbal Formulae**

Integrating network pharmacology and multi-omics data with GNNs and generative models to analyze the "multi-component, multi-target, multi-pathway" mechanisms of herbal formulas, providing computational support for modern formula research.

4.3 **Real-World Studies and Generation of Evidence**

Aggregating multi-center electronic medical records and employing AI for comparative effectiveness analysis, identification of TCM's advantageous disease areas, and summarization of clinical patterns, thereby contributing to the optimization of clinical guidelines and the generation of high-level evidence.

4.4 **Cross-Modal Correlation Analysis for TCM–Western Medicine Integration**

Using multimodal learning to uncover hidden correlations between TCM syndromes and modern medical indicators (imaging, biochemical, genomic data), providing data-driven decision support for integrative medicine.

5. Future Outlook: The Era of Human–AI Collaboration in TCM

5.1 **Vision for Development**

Future TCM practice will feature a "human–AI collaboration" model: AI handles information integration, preliminary screening, and suggestions, while TCM practitioners focus on comprehensive judgment, doctor–patient communication, and personalized treatment adjustment. This synergy enhances the precision and accessibility of healthcare services.

5.2 **Key Challenges**

Data Foundation: Establishing high-quality, standardized, and shareable TCM clinical and textual datasets is crucial.

Algorithm Interpretability: Developing explainable AI that aligns with TCM theoretical logic is essential for building clinical trust and acceptance.

Ethics and Agency: Clarifying AI’s Auxiliary Role, Preserving the Primacy of the Physician and the Humanistic Dimension of TCM.

6. Conclusion

The deep integration of artificial intelligence and Traditional Chinese Medicine constitutes a systematic endeavor to equip an ancient medical system with "digital lenses" and "intelligent wings." This process involves not only technological application but also theoretical innovation, paradigm shift, and interdisciplinary collaboration. Adhering to the principle of "preserving the essence while embracing technology," we must promote the creative transformation and innovative development of TCM in the digital age, ultimately contributing a more inclusive and insightful medical paradigm to global human health and well-being.

Inverse Reinforcement Learning of Differential Games

by Frank Lewis, Member EUAS

Short Biography

Dr. Frank L. Lewis was born in Würzburg, Germany, subsequently studying in Chile and Gordonstoun School in Scotland. He obtained the Bachelor's Degree in Physics/Electrical Engineering and the Master's of Electrical Engineering Degree at Rice University in 1971. He spent six years in the U.S. Navy, serving as Navigator aboard the frigate USS Trippe (FF-1075), and Executive Officer and Acting Commanding Officer aboard USS Salinan (ATF-161). In 1977 he received the Master's of Science in Aeronautical Engineering from the University of West Florida. In 1981 he obtained the Ph.D. degree at The Georgia Institute of Technology in Atlanta, where he was employed as a professor from 1981 to 1990. He moved to UTA in 1990. He is Moncrief-O'Donnell Endowed Chair Professor of Electrical Engineering at The University of Texas at Arlington.

Ranked #1 scholar in the world in Optimal control, #1 in Reinforcement learning, #2 in Control theory, #4 in Neural networks, #8 in Intelligent control, #14 in Multi-agent systems. Optimal Control Rankings

Google Scholar page is

https://scholar.google.com/citations?user=rMRit3UAAAAJ&hl=en&oi=sra

Lewis is Ranked as number 22 of all scientists in the world and 12 in the USA in Electronics and Electrical Engineering by Research.com. Ranked number 5 in the world in the subfield of Industrial Engineering and Automation according to a Stanford University Research Study in 2021.

Awarded Andrew P. Sage Best Transactions Paper Award in the IEEE Trans. on Systems, Man, and Cybernetics: Systems. 2025

Awarded Top 10 Inspiring Leaders of 2024 by Impact Entrepreneur Magazine.

Recognized as a Top 1% Highly Top Cited Researcher by Clarivate Web of Science every year during 2019-2025.

Graduated 60 PhD students. Fellow, National Academy of Inventors. Life Fellow of the IEEE, Fellow of IFAC, Fellow of the U.K. Institute of Measurement & Control, Fellow European Union Academy of Sciences, Fellow American Association for the Advancement of Sciences, Member of the New York Academy of Sciences. Registered Professional Engineer in the State of Texas and Chartered Engineer, U.K. Engineering Council. Published 527 Refereed Journal Papers. 108,264 Google citations, h-index 145. Published 35 books. Awarded 8 US Patents. Charter Member (2004) of the UTA Academy of Distinguished Scholars. UTA Academy of Distinguished Teachers 2012. IEEE Control Systems Society Distinguished Lecturer 2012-1014. Founding Member of the Board of Governors of the Mediterranean Control Association 1992. Invited as Fulbright Fellow Professor at Democritus University in Greece 1988. Founded International Symposium on Autonomous Systems (ISAS) in Southeast Asia in 2017. Invited for research visits at Hong Kong University of Science and Technology, Bristol University UK, Chinese University of Hong Kong, City University of Hong Kong, National University of Singapore, Nanyang Technological University Singapore, and elsewhere.

Received IEEE Computational Intelligence Society Neural Networks Pioneer Award 2012, AIAA Intelligent Systems Award 2016, John Ragazzini Education Award 2018 from American Automatic Control Council. Received Fulbright Research Award 1988, American Society of Engineering Education F.E. Terman Award 1989, Int. Neural Network Soc. Gabor Award 2009, U.K. Inst Measurement & Control Honeywell Field Engineering Medal 2009, three Sigma Xi Research Awards, UTA Halliburton Engineering Research Award, UTA Distinguished Research Award, ARRI Patent Awards, numerous International Best Paper Awards, IEEE Control Systems Society Best Chapter Award (as Founding Chairman of DFW Chapter), and National Sigma Xi Award for Outstanding Chapter (as President of UTA Chapter). Received Outstanding Service Award from the Dallas IEEE Section and selected as Engineer of the year by Ft. Worth IEEE Section. Listed in Ft. Worth Business Press Top 200 Leaders in Manufacturing. Appointed to NAE Committee on Space Station in 1995 and IEEE Control Systems Society Board of Governors in 1996. Received the 2010 IEEE Region 5 Outstanding Engineering Educator Award and the 2010 UTA Graduate Dean's Excellence in Doctoral Mentoring Award. Texas Regents Outstanding Teaching Award 2013.

Current interests include autonomous systems, unmanned aerial vehicles, distributed cooperative control on graphs, reinforcement learning, AI Artificial Intelligence. Nonlinear systems, intelligent control, process control, and neurological systems. Received 8 U.S. patents, Wrote 527 journal papers, 52 chapters and encyclopedia articles, 527 refereed conference papers, and 35 books including the internationally acclaimed textbooks Optimal Control, Optimal Estimation, Applied Optimal Control and Estimation, Aircraft Control and Simulation, Control of Robot Manipulators, Neural Network Control, High-Level Feedback Control with Neural Networks and the IEEE reprint volume Robot Control.

Editor of Taylor & Francis Book Series on Automation & Control Engineering. Served as Editor for the flagship journal Automatica. Served/serves on many Editorial Boards including International Journal of Control, Neural Computing and Applications, Optimal Control & Methods, and Int. J. Intelligent Control Systems. Recipient of NSF Research Initiation Grant and continuously funded by NSF since 1982. He has received $17 million in funding from NSF, ARO, ONR, AFOSR and other government agencies, including significant DoD SBIR and industry funding. His SBIR program was instrumental in ARRI's receipt of the US SBA Tibbets Award in 1996.

1. Inverse Reinforcement Learning of Differential Games (book chapter)

In Encyclopedia of Systems and Control Engineering
Volume 2, 2026, Pages 598-605
Lian, Bosen | Xue, Wenqian | Lewis, Frank L.
Elsevier (2026)
10.1016/B978-0-443-14081-5.00073-8

Abstract

This article is an application of AI to feedback control systems for aircraft and robotic systems. It discusses model-free inverse reinforcement learning (RL) of differential games captured by multiplayer systems (MPSs) and multiagent systems (MASs) described as continuous-time differential equations. In both MPS and MAS cases, an expert system and a learner system are considered, where the expert system is modeled with optimal control inputs associated with underlying cost functions. The presented learning schemes reconstruct the cost functions of the expert system for the learner without using system

dynamics of the learner and expert, thereby the learner having the expert's control policy and behavior. We first formulate off-policy integral inverse RL for MPS and then extend that to MAS with graphical connections.

2. Neuroadaptive Control With Enhanced Stability and Reliability (journal article)
Xiang, Kaili | Ming, Ruotong | Chen, Siyu | Lewis, Frank L.
IEEE Transactions on Neural Networks and Learning Systems, volume 36, issue 8, pages 15413-15423 (2025).
10.1109/TNNLS.2025.3542551

Abstract

This article is an application of AI to feedback control systems for aircraft and robotic systems. Specific results are developed for Neural Networks in automatic feedback control. The performance of neural network (NN)-driven control systems hinges on the reliability and functionality of the NN unit in the controller. This article introduces a constraint transformation-based design method that ensures excitation signals always originate from a fixed region, regardless of initial conditions. By meeting the compactness condition required by the universal approximation theorem, this approach safeguards the functionality of the NN-driven control unit. To further ensure robust operation even if the NN underperforms due to an insufficient number of neurons or violation of the compact set condition, a new control strategy is developed based on the worst-case behavior of NNs. This “fail-secure” mechanism significantly enhances the reliability of the NN-based control scheme. The effectiveness and benefits of the proposed method are confirmed through numerical simulations, demonstrating its potential to substantially improve the robustness and performance of NN-driven control systems.

3. Inverse Value Iteration and Q -Learning: Algorithms, Stability, and Robustness (journal article)
Lian, Bosen | Xue, Wenqian | Lewis, Frank L. | Davoudi, Ali
IEEE Transactions on Neural Networks and Learning Systems, volume 36, issue 4, pages 6970-6980 (2025).
10.1109/TNNLS.2024.3409182

Abstract

This article proposes a data-driven model-free inverse Q-learning algorithm for continuous-time linear quadratic regulators (LQRs) for automatic

feedback control. Using a system's trajectories of states and optimal control inputs, the algorithm reconstructs performance that captures the same trajectories. This article first poses a model-based inverse value iteration scheme using the agent's system dynamics. Then, an online model-free inverse Q-learning algorithm is developed to recover the agent's cost function only using the demonstrated trajectories. It is more efficient than the existing inverse reinforcement learning (RL) algorithms as it avoids the repetitive RL in inner loops. This is an improvement of AI techniques in feedback control of automated systems such as aircraft, unmanned aerial vehicles (UAV), and robots. The proposed algorithms do not need initial stabilizing control policies and solve for unbiased solutions. The proposed algorithm's asymptotic stability, convergence, and robustness are guaranteed. Theoretical analysis and simulation examples show the effectiveness and advantages of the proposed algorithms.

Diluted Swine and Aquaculture Wastewater Enhance Carbon Sequestration and Nutrient Removal by the Red Seaweed Agardhiella Subulata

by Peter H. Santschi, Member EUAS

Short Biography

Dr. Peter H. Santschi is a Regents Professor of Oceanography and Marine Sciences at the Texas A&M University, Galveston, TX, USA. He received his training in Geochemistry and Oceanography during his post-graduate work at L-DEO at Columbia University, N.Y., after graduating from the University of Bern, Switzerland, with a Ph.D. in Chemistry. Dr Santschi's research interests include Marine Chemistry, Environmental Chemistry and Environmental Radiochemistry; trace element interactions with natural organic matter; Tracer applications in natural water systems using stable and radioactive isotopes. Since 2000, he is associate editor of the journal Marine Chemistry. He is an author of well over 300 journal articles and 45 book chapters on these subjects, which, over the years, have received more than 15,000 citations. More on his research can be found at https://www.tamug.edu/mars/faculty-bios/PeterHSantschi.html and https://scholar.google.com/citations?user=ZKGyOTsAAAAJ&hl=en&oi=ao.

*His total of 400+ peer-reviewed publications, according to the ISI Web of Science (all databases as of August 3, 2020), attest to his productivity, while his citation record is a testimony of his impact. Santschi's record is thus not only of quantity alone but predominantly of quality. Metrics establishing scientific impact are difficult to come by, but if the citation count and other indexes (e.g., h-index from ISI, all databases) may serve as a measure of scientific impact, then his 400+ publications have been cited over 17,000 times, with an average citation per publication of over 42. Other indexes for his publications (ISI h-index = 71 and productivity m-index = $h/\Delta t$ = **1.51** with Δt = 47 years since the 1st publication in 1974; g-index = 137; and Google Scholar h-index = 87 and i-10 index = 293, with well over 25,000 citations) are exceptional.*

Peter H. Santschi received ***numerous national and international awards****, e.g., he was elected Member of the European Union Academy of Sciences (EUAS) (2020), Geochemical Fellow of the Geochemical Society and the European Association of Geochemistry (2017); Fellow of the American Geophysical Union (2014), which are given annually to only 0.1% of the 60,000 members; received the Distinguished Achievement Awards in Graduate Student Mentoring (2013) from Texas A&M's Association of Former Students; Regents Professor of Texas A&M University (2009), and received the Association of Former Student Distinguished Achievement Award for Research from Texas A&M University (2004). These awards were not possible without many collaborative and/or supportive scientists.*

His international pre-eminence *is not only demonstrated by the prestigious awards that he received, but also by the fact that he was invited as a member of Academic Advisory or Review Panels, as well as a Visiting Professor at national and international Universities, e.g., at Lamont-Doherty Earth Observatory of Columbia University (1982-1988), University of Rhode Island, School of Oceanography (1986), Dept. of Geology and Dept. of Chemistry, University of Geneva, Geneva, Switzerland (1996), Dept. of Chemistry and Biochemistry, University of Bern, Bern, Switzerland (2002), Dept. of Chemistry, University of Geneva, Geneva, Switzerland (2003), Swiss Institute of Technology, ETH, Zurich, Switzerland (2003), National Taiwan University, Taipei, Taiwan (2003), and Hong Kong University of Science and Technology (2004), National Center for Oceanographic Research, NCOR (2008).*

Summary of Accomplishments in Environmental Science. *During his 45-plus year career in environmental science, Santschi has gained and communicated novel insights into some of the blueprints of the aquatic*

environment, spanning from rain water, rivers and lakes to groundwater, from surface to deep ocean. During his long research career, he, together with 40+ graduate students, post-doctoral fellows and scientists all over the world, was able to pioneer new concepts and approaches that were truly ***transformational****. The unifying theme of his research has been the* ***study of the self-cleansing capacity of natural aquatic systems****: in particular, the importance of natural organic matter compounds for particle, radionuclide, and trace element cycling in aquatic systems. The importance of natural organic matter was not obvious in aquatic chemistry, as for many decades, the dogma was that metal behavior is mostly controlled by inorganic ligand interactions. His research involves the main agents that can ameliorate impact (e.g., toxicity, mobility) of potential pollutants to aquatic biota, i.e., microbially produced macromolecular substances that occur in the colloidal phase. This phase is mostly composed of nano-sized exopolymeric substances, as well as terrestrially derived humic substances, both of which can, at times, greatly help to control the efficiency of the self-cleansing capacity of aquatic systems. Natural colloids in aquatic systems are thus, to a large extent, derived from biological production and degradation of natural particles. Therefore, Peter's main contributions and impacts in environmental geochemistry are on the role of macromolecular natural organic matter, trace metal, and radionuclide speciation, transport, and cycling.*

Dr. Santschi's ***seminal contributions*** *to science, more specifically to the field of environmental biogeochemistry and radiochemistry, have thus included major* ***transformational*** *breakthroughs, e.g., the Colloidal (or Brownian) Pumping Concept that led to paradigm shifts in aquatic science (see below), and sustained impact, with his most cited papers providing unifying chemical and physic-chemical concepts explain pollutant behavior in aquatic environments, including articles published from the 1980s, 1990s, and 2000s. This transformational "Colloidal or Brownian Pumping Model" was able to simulate observations of apparent particle concentration effects on both the widely observed particle-water distribution coefficients and the model kinetic constants of trace element and radionuclide uptake onto natural particles, given the observed colloidal fractions of trace metals and radionuclides. His work then stimulated many other researchers to build on these novel concepts. Over the years following this transformational work, he tackled the challenging question of macromolecular organic compounds that occur in the colloidal phase and act as carrier molecules for specific trace elements and radionuclides. Due to the numerous difficulties in finding such compounds at relevant but trace levels in the midst of thousands of other compounds, selective separation and purification chemistry had to be thoroughly tested, before state-of-the-art instrumentation can be applied.*

Abstracts of Recent Publications 2025

Weerakkody, W.Sanjaya, Hsieh, H-H., Abedneko, V.G., Ling, K.H., Chung, T-C., Wang, Z-Y., Shih, Y-Y., Lee, T-M., Xu, C., Santschi, P.H., Hung, C-C. 2025. Diluted swine and aquaculture wastewater enhance carbon sequestration and nutrient removal by the red seaweed Agardhiella subulata, Bioresource Technology

Abstract

Swine wastewater poses significant environmental challenges, and conventional microalgae treatments often leave high residual nutrients while consuming substantial freshwater. This study explored the potential of the saltwater macroalgae Agardhiella subulata for nutrient removal and carbon assimilation under varying salinity and ammonium

concentrations. Using diluted swine and aquaculture wastewater, A. subulata achieved ammonium and phosphorus removal efficiencies of up to 93 % and 68 %, respectively, within 24 h. It also removed CO_2 at rates five times higher than the global forest average and enhanced dissolved oxygen levels, reducing the environmental impact of nutrient-rich wastewater while minimizing freshwater demand. Notably, A. subulata effectively utilized swine wastewater with ammonia concentrations up to 600 μM under salinity conditions of 27–34 ppt. These results demonstrate the potential of A. subulata for large-scale nutrient removal and CO_2 reduction, providing a sustainable solution to the environmental impacts of the livestock industry.

Improved Modeling of Fluid Flow in Porous Media

by Russell Johns, Member EUAS

Short Biography

Russell T. Johns is recently retired from Penn State University and is now serving as faculty on a special project at the Harold Vance Department of Petroleum Engineering at Texas A&M University. He is the past George E. Trimble Chair of Energy and Mineral Sciences at the Department of Energy and Mineral Engineering at Penn State. He served as interim Head of the John and Willie Leone Family Department of Energy and Mineral Engineering from 2023 – 2024, managing over 60 faculty, 10 staff, and 1000 affiliated undergraduate and graduate students. Prior to that, he served as Chair of the Petroleum and Natural Gas Engineering Program from 2015 to 2018, Distinguished SPE Lecturer for 2019–2020, and Editor-In-Chief for all SPE technical journals from 2018–2020. He was director of the Enhanced Oil Recovery consortium in the EMS Energy Institute at Penn State until 2020.

Before Penn State, he served on the petroleum engineering faculty at The University of Texas at Austin from 1995 to 2010. He also has nine years of industrial experience as a petrophysical engineer with Shell Oil and as a hydrogeologist for Colenco Power Consulting in Baden, Switzerland. He holds a B.S. degree in electrical engineering from Northwestern University and M.S. and Ph.D. degrees in petroleum engineering and water resources from Stanford University. He has over 300 publications in enhanced oil recovery, thermodynamics, and phase behavior, unconventional gas engineering, multiphase flow in porous media, and well testing. Johns received the SPE Ferguson medal in 1993, the Society of Petroleum Engineers (SPE) Distinguished Member award in 2009, the SPE Faculty Pipeline award in 2013, the 2016 SPE international award in Reservoir Description and Dynamics, the Wilson Excellence in Research award from the College of Earth and Mineral Sciences in 2018, the prestigious IOR Pioneer Award from SPE in 2022, and the highest technical award from SPE in 2023, the Anthony F. Lucas Gold medal.

The research group of Dr. Johns is noted for its development of the first flash calculation algorithm for microemulsion phases where all Winsor regions (single, two, and three-phase) are modelled simultaneously. His group is also recently recognized as developing state function theory of relative permeability to fit experimental data and predict relative permeabilities away from that data set. As a part of that research, they developed an analytical function that includes connectivity (Euler number) in the relative permeability model. Finally, his group has been recognized as a leader in developing miscibility theory for gas injection applications such as injection of carbon dioxide into oil reservoirs. They developed analytical theory for solving hyperbolic equations to predict the minimum miscibility pressure (MMP) for any number of components.

Dr. Johns currently teaches a required undergraduate course in advanced reservoir dynamics, along with a required graduate course in energy thermodynamics, which couples phase behavior and chemical reactions. He also teaches elective graduate courses in gas and chemical flooding for enhanced oil recovery. He is a member of numerous Penn State and professional committees. Selected abstracts from publications this year from his group are included below, along with a brief publication list.

Modeling of Relative Permeability Hysteresis Using Limited Experimental Data and Physically Constrained ANN

Mukherjee, S., and Johns, R.T., *Transport in Porous Media* (2025)

We developed a relative permeability (k_r) model using an artificial neural network (ANN) that can simultaneously fit one or more drainage and imbibition experimental scans while also predicting relative permeability and residual saturations for other scans. The ANN model uses saturation and phase connectivity and is constrained to giving continuous and physical values for any hysteresis path. The new model can estimate continuous k_r values even when saturations move outside residual saturation limits owing to vaporization or solubilization. To demonstrate the approach, we fit one measured drainage and imbibition k_r curve from gas–water experimental data to develop contours of k_r in saturation-connectivity space. Relative permeability is then predicted as paths, described by simple functions, are traversed. The results show that residual saturations vary automatically as small k_r values are encountered and increase with increasing initial saturation without the use of Land's model. The ANN model simultaneously fits all experimental data, unlike current empirical Corey or hysteresis models. Once tuned, the ANN model accurately predicts other measured hysteresis scans not used in tuning. Key highlights:

- Unlike traditional relative permeability models, the ANN model can fit drainage and imbibition data simultaneously.
- The developed model predicts relative permeability and residual saturations for any hysteresis cycle using limited experimental field datasets. Residual saturations increase naturally with initial saturations without using Land's model.
- The model ensures scalability and integration into reservoir simulators for CO_2 storage and other applications.

Microemulsion Flash Calculations using an HLD-NAC Based Equation of State

Johns, R.T. and Magzymov, D., Chapter 18 in *Surfactant Formulation Engineering Using HLD and NAC*, 2025

Hydrophilic-lipophilic deviation and net-average curvature (HLD-NAC) theory is a practical way to model surfactant-oil-water (SOW) systems. We incorporate HLD-NAC to develop flash calculations like those using the physics-based van der Waals cubic equations-of-state (EoS). Primary inputs to the EoS are overall composition, temperature, and pressure, while the

outputs are phase compositions and saturations. The flash methodology described follows the seminal paper by Khorsandi and Johns (2016) but is also modified for variable characterization length in the three-phase region (Magzymov and Johns, 2022).

Properties of the pseudocomponents are specified prior to flash calculations. There can be numerous components, including alcohols (cosolvents), various brine cations and anions, multiple surfactants, hydrocarbon, and nonhydrocarbon components. These components must be lumped into three pseudocomponents prior to a flash calculation. The surfactant pseudocomponent is anionic here, although other moieties can be used with some modification. Salinity and equivalent alkane carbon number (EACN) characterize the water and oil pseudocomponents.

Khorsandi and Johns (2018) outline the transformation of a multicomponent system to three pseudocomponents. This transform could be done once, or multiple times as needed, for example, after new components are added to the SOW system. If the components are well defined (fixed oil composition, brine at fixed salinity, and fixed surfactant composition), then no transform is needed.We developed a relative permeability (k_r) model using an artificial neural network (ANN) that can simultaneously fit one or more drainage and imbibition experimental scans while also predicting relative permeability.

Selected Journal Publications (Last Five Years)

1. Mukherjee, S., Johns, R.T. Modeling of Relative Permeability Hysteresis Using Limited Experimental Data and Physically Constrained ANN. *Transp Porous Med* **152**, 39 (2025).
2. Yoga, H. F., Gasimli, N. R., and Johns, R. T., Reliable Equivalent Alkane Carbon Number Determination for Dead and Live Crudes in Microemulsion Systems, SPE Journal 29 (09), 4935-4949, 2024
3. Purswani, P., Johns, R. T., and Karpyn, Z. T., Relationship Between Residual Saturations and Wettability Using Pore-Network Modeling. *SPE J.* 29 (2024): 2004–2013.
4. Purswani, P., Johns, R. T., & Karpyn, Z. T. (2024). Impact of wettability on capillary phase trapping using pore-network modeling. Advances in Water Resources, 184, 104606.
5. Yoga, H.F., Johns, R.T., and Prakash P., Predictive Model for Relative Permeability Using Physically-Constrained Artificial Neural Networks, SPE Journal, 29 (02), pp. 928-942. 2024.
6. Mukherjee, S., Johns, R.T., Foroughi, S., and Blunt, M.J., Fluid-Fluid Interfacial Area and Its Impact on Relative Permeability: A Pore Network Modeling Study, SPEJ, 28(02), pp 653-663. 2023

7. Magzymov, Daulet, Johns, Russell T., Hashim, Hafsa, and Birol Dindoruk. "Modeling of High-Pressure and High-Temperature Microemulsion Experiments using HLD-NAC-Based Equation of State." SPE J. 28(03) (2023): 1202–1215.
8. Magzymov, D., Ratnakar, R. R., Dindoruk, B., & Johns, R. T. (2022). Evaluation of machine learning methodologies using simple physics based conceptual models for flow in porous media. Journal of Petroleum Science and Engineering, 219, [111056].
9. Tawfik, M. S., Karpyn, Z. T., & Johns, R. T. (2022). Effect of oil chemistry on the performance of low-salinity waterflooding in carbonates: An integrated experimental approach. Fuel, 329, [125436].
10. Mukherjee, S., & Johns, R. T. (2022). Sensitivity Analysis of Fluid–Fluid Interfacial Area, Phase Saturation and Phase Connectivity on Relative Permeability Estimation Using Machine Learning Algorithms. Energies, 15(16), [5893].
11. Magzymov, D., & Johns, R. T. (2022). Inclusion of variable characteristic length in microemulsion flash calculations. Computational Geosciences, 26(4), 995-1010.
12. Magzymov, D., Purswani, P., Karpyn, Z. T., & Johns, R. T. (2022). Modeling the Effect of Reaction Kinetics and Dispersion during Low-Salinity Waterflooding. SPE Journal, 26(5), 3075-3093.
13. Tawfik, M. S., Adishesha, A. S., Hsi, Y., Purswani, P., Johns, R. T., Shokouhi, P., Huang, X., & Karpyn, Z. T. (2022). Comparative Study of Traditional and Deep-Learning Denoising Approaches for Image-Based Petrophysical Characterization of Porous Media. Frontiers in Water, 3, [800369].
14. Duffy, T. S., Gamwo, I. K., Johns, R. T., & Lvov, S. N. (2021). Modeling Contact Angle vs. Temperature for the Quartz-Water-Decane System. SPE Journal, 26(6), 3668-3680.
15. Dindoruk, B., Johns, R., & Orr, F. M. (2021). Measurement and modeling of minimum miscibility pressure: A state-of-the-art review. SPE Reservoir Evaluation and Engineering, 24(2), 367-389.
16. Magzymov, D., Clemens, T., Schumi, B., & Johns, R. T. (2021). Experimental analysis of alkali-brine-alcohol phase behavior with high acid number crude oil. SPE Reservoir Evaluation and Engineering, 24(2), 390-408.
17. Duffy, T. S., Li, J., Johns, R. T., & Lvov, S. N. (2021). Capillary contact angle for the quartz-distilled water-normal decane interface at temperatures up to 200 °C. Colloids and Surfaces A: Physicochemical and Engineering Aspects, 609, [125608].
18. Khorsandi, S., Li, L, and Johns, R.T., A New Way of Compositional Simulation Without Phase Labeling, SPE J., 26 (02), pp. 940-958. 2021.
19. Purswani, P., Johns, R. T., Karpyn, Z. T., & Blunt, M.. Predictive Modeling of Relative Permeability Using a Generalized Equation of State. SPE Journal, 26(01), pp. 191-205, 2021.
20. Cronin, M., Emami-Meybodi, H., & Johns, R. T. Multicomponent Diffusion Modeling of Cyclic Solvent Injection in Ultra-Tight Reservoirs. SPEJ 26 (03), pp. 1213-1232, 2021.
21. Khodaparast, P., and Johns, R.T., A Continuous and Predictive Viscosity Model Coupled to a microemulsion Equation of State, doi:10.2118/190278-PA, SPEJ, 25(03), pp. 1070-1081, 2020.
22. Zhang, K., Nojabaei, B., Ahmadi, K., and Johns, R. T., Effect of Gas/Oil Capillary Pressure on Minimum Miscibility Pressure for Tight Reservoirs. Society of Petroleum Engineers., *SPEJ*, 25(02), pp. 820-831, 2020.
23. Purswani, P., Tawfik, M.S., Karpyn, Z.T. and Johns, R.T., On the development of a relative permeability equation of state. *Comput Geosci*, 24(2), pp. 807-818, 2020.

Recent in Situ Experimental & Theoretical Advances in Severe Plastic Deformations, Strain-induced Phase Transformations & Microstructure Evolution under High Pressure

by Valery I. Levitas, Member EUAS

Short Biography

Valery I. Levitas
Anson Marston Distinguished Professor in Engineering
Vance Coffman Faculty Chair Professor
Department of Aerospace Engineering & Department of Mechanical Engineering
Iowa State University, Ames, Iowa 50011-2161

Education and Training:
Kiev Polytechnic Institute, Kiev, USSR Mechanical Engineering M.S. (Honors), 1978
Institute for Superhard Materials, Kiev, USSR Materials Science Ph.D., 1981
Ins. Electronic Machinebuilding, Moscow, USSR Continuum Mechanics Dr. of Sci., 1988
University of Hannover, Germany Continuum Mechanics Doctor-Engineer habil., 1995

Appointments

08.08-present	*Anson Marston Distinguished Professor in Engineering (2018, permanent); Vance Coffman Faculty Chair Professor (17-), Schafer 2050 Challenge Professor (08-17), Dept. Aerospace Engineering, Dept. Mechanical Engineering; Dept. Material Science and Engineering, Iowa State University; Faculty Scientist, Ames Labor.*
08.02-present	*Associate Professor (99-02), Professor (02-08) Lubbock, TX, Department of Mechanical Engineering.*
08.14-12.14	*Visiting Scholar, NIST and Geophysical Lab., Carnegie Institution of Washington.*
01.05-05.05	*Visiting Scholar, Los Alamos National Labs, Los Alamos, NM.*
08.93 -08.99	*Humboldt–Research Fellow (93-95), Visiting & Research Professor (95-99), University of Hannover, Inst. Structural & Computational Mechanics, Hannover, Germany.*
04.78–08.94	*Engineer (78-81), Junior Researcher (81-84), Senior Researcher (84–88), Leading Researcher (89–94); Leader of research group (82–94), Ins. for Superhard Materials of the Ukrainian Academy of Sciences, Kiev, Ukraine.*

Consultant: Los Alamos National Labs; NIST; Geophysical Laboratory, Carnegie Institution of Washington; Ins. for Superhard Materials (Kiev); Seyeon E&S corporation (Daejeon, South Korea).
Products: *494 publications, including 308 refereed journal papers, 3 books, 11 book chapters and 11 patents; 15, H-index - 74.*
Selected Awards and Honors
- The best paper of the Journals of Alloys and Compounds award in 2024.
- Board Member of the American Council of the International Association of Advanced Materials (IAAM).
- 2024 ScholarGPS Highly Ranked Scholar in area of Phase Transitions: #5 lifetime and #12 prior

5 years.
- Elected to the European Academy of Sciences and Arts (2023).
- Fellow of the International Association of Advanced Materials (IAAM), Sweden (2023).
- Elected to the EU Academy of Sciences (2022).
- Paper "Levitas V.I. High-Pressure Phase Transformations under Severe Plastic Deformation by Torsion in Rotational Anvils. Material Transactions, 2019, Vol. 60, No. 7, 1294-1301" is recognized as the most cited paper in Material Transactions during 2016-2022.
- Phase transformations and other structural changes in materials: special issue of the International Journal of Plasticity in Honor of Professor Valery I. Levitas; Editorial: Liming Xiong, International Journal of Plasticity, 2021, Vol. 139, 102948. - Symposium on Phase Transformations and other Structural Changes in Materials in honor of Khan's Medal Awardee Prof. Valery Levitas at 25th International Conference on Plasticity, Damage & Fracture 2019, Panama, 1/3/19-1/9/19.
- Khan International Medal Award for outstanding contributions to the field of plasticity (2018).
- Symposium on Structural Changes in Materials in honor of Prof. Valery Levitas at 23rd International Conference on Plasticity, Damage & Fracture 2017, Puerto Vallarta, Mexico, 1/3/17-1/9/17.
- ISU Award for Outstanding Achievement in Research (2016).
- Lifetime Achievement Award for outstanding achievements in engineering, science, and education (Int. Biog. Centre, 2011).
- Honorary Doctor of the Institute for Superhard Materials, Kiev, Ukraine (2011).
- ASME Fellow (2007).
- Barnie E. Rushing Faculty Distinguished Research Award (TTU, 2005).
- Best Professor Award (TTU, Fall'01).
- Richard von Mises Award of GAMM (Society of Applied Mathematics & Mechanics, 1998).
- Int. J. Eng. Sciences Best Paper Award (1995).
Alexander von Humboldt Foundation Fellowship, Germany (1993 – 95, 2012).

Recent in Situ Experimental & Theoretical Advances in Severe Plastic Deformations, Strain-induced Phase Transformations & Microstructure Evolution under High Pressure

Here, we summarize selected in situ experimental and theoretical studies of coupled severe plastic deformation (SPD), strain-induced phase transformations (PTs), and microstructure evolution under high pressure under compression in diamond anvil cell (DAC) or compression and torsion in rotational diamond anvil cell (RDAC) (Fig. 1) published in 2025.

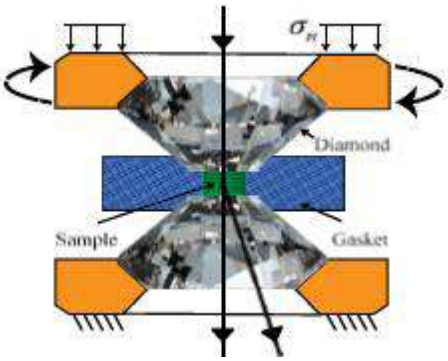

Fig. 1. Schematic of RDAC. Two diamond anvils compress the sample within or without a gasket, like in traditional DAC, to high pressure. Then torque is applied, leading to the superposition of large shear-dominated straining on compression. The X-ray beam is directed along the axial direction.

1. New rules of high-pressure phase and nanostructure evolution during severe plastic flow [1]

The main problem in studying plasticity, plastic strain-induced PTs, structural changes, and contact friction is that they depend on five components of the plastic strain tensor $\boldsymbol{\varepsilon}_p$ and its entire path $\boldsymbol{\varepsilon}_p^{path}$, making an unspecifiable number of combinations of independent parameters. This leaves a little hope of fully comprehending and characterizing these phenomena and finding some general rules. We applied traditional smooth diamond anvils (smooth-DA) with asperities height of 10 nm and newly developed rough-DA with asperities height of 400 nm to compression of severely pre-deformed Zr. Rough-DA intensify all occurring processes. The first in-situ X-ray diffraction (XRD) study of the evolution of the crystallite size and dislocation density in phases during plastic strain-induced PT is performed utilizing α-ω PT in strongly pre-deformed commercially pure Zr as an important example. The main rule is found that *during α-ω PT, the crystallite size and dislocation density in ω-Zr depend solely on the volume fraction of ω-Zr and are independent of pressure, plastic strain tensor, its path, and initial nanostructure.*

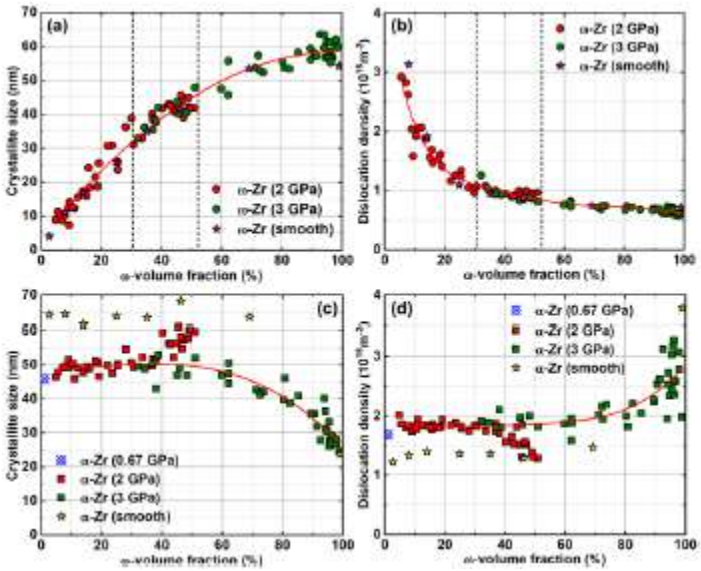

Fig. 2. (a) Crystallite size and **(b)** dislocation density in ω-Zr versus volume fraction of ω-Zr at 2 and 3 GPa steps with rough-DA and smooth-DA. For rough-DA, points from 2 and 3 GPa steps overlap within dash lines. **(c)** Crystallite size and **(d)** dislocation density in α-Zr versus volume fraction of ω-Zr at 2 and 3 GPa steps with rough-DA and smooth-DA. Results in **(a)** and **(b)** represent a remarkable rule for ω-Zr: the *existence of the unique curves for the crystallite size and dislocation density solely depending on c during α-ω PT, which are independent of pressure,* $\boldsymbol{\varepsilon}_p$ *and* $\boldsymbol{\varepsilon}_p^{path}$*, the same for rough- and smooth-DA and different nanostructures of α-Zr at the initiation of PT.* For α-Zr in **(c)** and **(d)**, one sees the existence of the unique curves for the crystallite size and dislocation density solely depending on *c* during α-ω PT, which are independent of pressure, $\boldsymbol{\varepsilon}_p$ and $\boldsymbol{\varepsilon}_p^{path}$, except for region 0.4<c<0.5, where some scatter is observed. Results for α-Zr obtained with rough-DA and smooth-DA are different due to different initial microstructure at the beginning of PT.

Crystallite size in ω-Zr increases from 5 to 60 nm during the PT, while dislocation density reduces from $3\times10^{15}/m^2$ to $0.6\times10^{15}/m^2$. Rough-DA produce a steady nanostructure in α-Zr before PT with smaller crystallite size and larger dislocation density than smooth-DA, leading to a reduction of the minimum pressure for α-ω PT to a record value 0.67 GPa, 9 times smaller than under hydrostatic loading and 5.1 times lower than the phase equilibrium pressure. A *surprising time-dependence of the kinetics of the strain-induced PT is revealed*, which confronts the conventional view that strain-induced PTs do not occur at fixed plastic strain. This result was qualitatively rationalized by utilizing previous phase-field solutions and by the fact that at a record low PT pressure the time-dependent part of the kinetics is getting slow enough to be detected by in-situ experiments. This opens a *new field of study of combined plastic strain- and stress-induced PTs*. Also, the strain-controlled part of the kinetics is zero order, in contrast to the first-order kinetics with smooth-DA. The obtained results open a new window for understanding the mutual effects of nanostructure evolution and PT during severe plastic flow in various technological and natural processes. They may bring up economic strategies for producing nanocomposites and single-phase nanostructured materials with optimal properties.

Indeed, instead of severe plastic straining by high-pressure torsion of a large-grain material (e.g., at 6 GPa and 5 anvil turns for Zr in literature), at the beginning one can reach one of the steady nanostructures by severe straining at normal pressure (e.g., by equal channel or other types of extrusion or rolling) in a much larger sample and then achieve PT at much lower pressure and smaller plastic strain being imposed, even by compression with DAC or metallic/ceramic anvils without torsion, and more uniformly. While under compression, we completed the PT at 3 GPa, we expect to achieve completion of the PT and reaching steady dislocation density and crystallite size at ~ 1 GPa by high-pressure torsion and larger plastic strain. Thus, strain-induced PT of strongly pre-deformed under normal pressure materials is a much more effective and economical way to refine grain than just severe plastic flow under high pressure. In addition, for a small volume fraction of ω-Zr, the crystallite size is much smaller, and the dislocation density is larger than that after PT completion. This gives an idea of designing α-ω Zr composites with increased strength due to strong ultrafine-grained ω-Zr and sufficient plasticity from ductile α-Zr by optimizing parameters using Fig. 6.

2. Severe Strain-induced Olivine-Ringwoodite Transformation at Room Temperature: Key to Enigmas of Deep-Focus Earthquake [2]

Developed rough-DA produced by laser ablation, methods of determination of the radial distributions of the microstrain, crystallite size, and dislocation density, and determination of the strain-controlled PT kinetics have been applied to PTs in a strong mineral olivine not only to resolve an important geophysical problem, but to study important material phenomena relevant to the current project.

Deep-focus earthquakes that occur at 350–660 km are presumably caused by olivine-spinel PT. However, there are many existing puzzles:

(a) What are the mechanisms for jumping from geological 10^{-17}-10^{-15}/s to seismic 10-10^3/s strain rates? Is it possible without phase transformation?

(b) How does olivine, which does not transform for over a million years, suddenly transform in seconds?

(c) How to connect shear-dominated seismic signals with volume-change-dominated transformation strain?

In the paper [Levitas V.I. Resolving puzzles of the phase-transformation-based

mechanism of the deep-focus earthquake. Nature Communications, 2022, Vol. 13, 6291], we introduced a combination of several novel concepts that resolve the above puzzles quantitatively. We treated the transformation in olivine like plastic strain-induced (instead of pressure/stress-induced) and found an analytical 3D solution for coupled deformation-transformation-heating in a shear band. This solution predicted conditions for severe (singular) transformation-induced plasticity (TRIP) and self-blown-up deformation-transformation-heating process due to positive thermomechano-chemical feedback between TRIP and strain-induced transformation. This process leads to temperature in a band, above which the self-blown-up shear-heating process in the shear band occurs after finishing the PT. Without PT and TRIP, significant temperature and strain rate increase is impossible. These findings changed the main concepts in studying the initiation of the deep-focus earthquakes and PTs during plastic flow in geophysics in general.

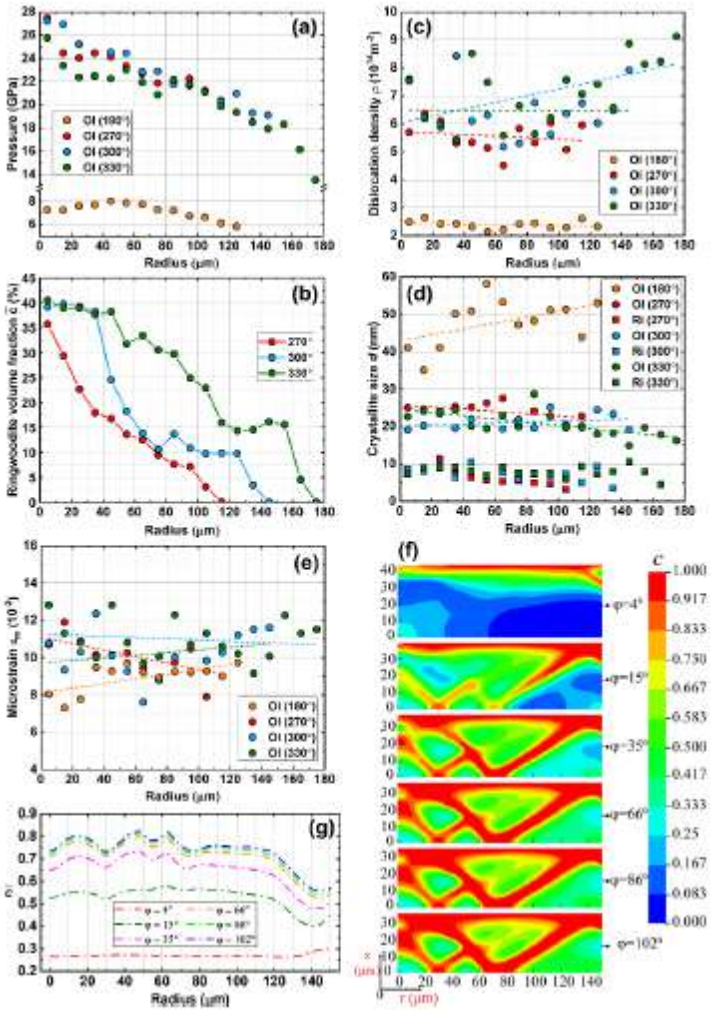

Fig. 3. Radial distributions of various parameters in the samples after different compression-shear loadings in dRDAC. **(a)** Pressure, **(b)** volume fraction of the ringwoodite, **(c)** dislocation density, **(d)** crystallite size, and **(e)** microstrain. Results from the FEM analysis under a constant compressive force with increasing rotation angle ϕ. **(f)** Radial distribution of the volume fraction of the weaker ringwoodite c within the central part of the sample, demonstrating formation of the shear-transformation bands. **(g)** Radial distribution of the volume fraction of the ringwoodite $\bar{c}$ averaged over the sample thickness. The uncertainties of all parameters in Figs. **(a)-(e)** are smaller than the symbols.

However, there was not even experimental proof of the existence of strain-induced PT for olivine or any geological material. In [5], we introduced dRDAC with rough diamond anvils to impose SPD on San Carlos olivine. While olivine never transformed to spinel at room temperature at any pressure, we *obtained for the first time reversible olivine-ringwoodite PT under SPD at 15-28 GPa within tens of seconds*, which is clearly attributed to the effect of plastic strain. Hereby, this is a new strain-induced transformation mechanism, distinguished from a traditional pressure/temperature-induced one. The rate of strain-induced phase transformation is proportional to the plastic strain rate (in addition to the pressure overshoot), and a high strain rate leads to a high transformation rate. Olivine transforms directly to ringwoodite without involving wadsleyite. The PT pressure linearly reduces with increasing dislocation density, microstrain, plastic strain, and decreasing crystallite size. During pressure release, ringwoodite completely transforms back to olivine at 2 GPa, which affects the interpretation of the results of ex-situ studies. The main rules of the coupled SPD, PT, and microstructure evolution are found: after high-pressure SPD, the crystallite sizes and microstrain of olivine and crystallite sizes of ringwoodite during PT are getting steady and independent of plastic strain, strain path, pressure, and volume fraction of ringwoodite. Finite element method (FEM) analysis of the sample behavior in the dRDAC reproduces some important experimental observations and implies that the shear-PT bands in the sample are developed, which is required for our deep-focus earthquake theory [Levitas, 2022]. Combined with SPD during olivine subduction, this mechanism can accelerate olivine-ringwoodite PT from millions of years to timescales relevant to earthquakes.

The obtained results call for a change in the main governing parameters (SPD instead of time) in discussions, modeling, and experimental studies of olivine-spinel transformation in relation to the deep-focus earthquake. They also open new directions for coupled experimental/theoretical/computational studies of strain-induced olivine-ringwoodite PT and shear localization in a broad range of strain rates and temperatures to qualitatively advance simulations of the deep-focus earthquakes problems and larger-scale geodynamic processes during olivine slab subduction. The obtained results also lead to reconsidering numerous known PTs in the Earth's interior as strain-induced instead of pressure/temperature-induced, which may change many geological interpretations.

3. Virtual melting and cyclic transformations between amorphous Si, Si I, and Si IV in a shear band at room temperature [3]

Virtual melting (VM) as alternative deformation and stress relaxation mechanisms under extreme load is for the *first time directly validated by molecular dynamics (MD) simulations* of the simple shear of single crystal Si I at a temperature 1,383 K below the melting temperature. The shear band consisting of liquid Si is formed immediately after the shear instability while stresses drop to zero. This process is independent of the applied shear rate. A new thermodynamic approach is developed, and the *thermodynamic criterion for VM, which depends on the ratio of the sample to shear band widths*, is derived analytically for the first time and confirmed by MD simulations. Since stress-free melt is unstable at 300 K, with further shear, the VM immediately transforms to a mixture of low-density amorphous a-Si, stable Si I, and metastable Si IV. Cyclic transformations between a-Si↔Si I, a-Si↔Si IV, and Si I↔Si IV with volume fraction of all phases mostly between 0.2 and 0.4 and non-repeatable nanostructure evolution are reveled. Such cyclic transformations produce additional important carriers for plastic deformation through transformation strain and transformation-induced plasticity due to volume change, which

may occur in shear bands in various material systems but missed in experiments and simulations. The release of shear stresses quenches the microstructure, and shows reasonable qualitative correspondence with existing experiments.

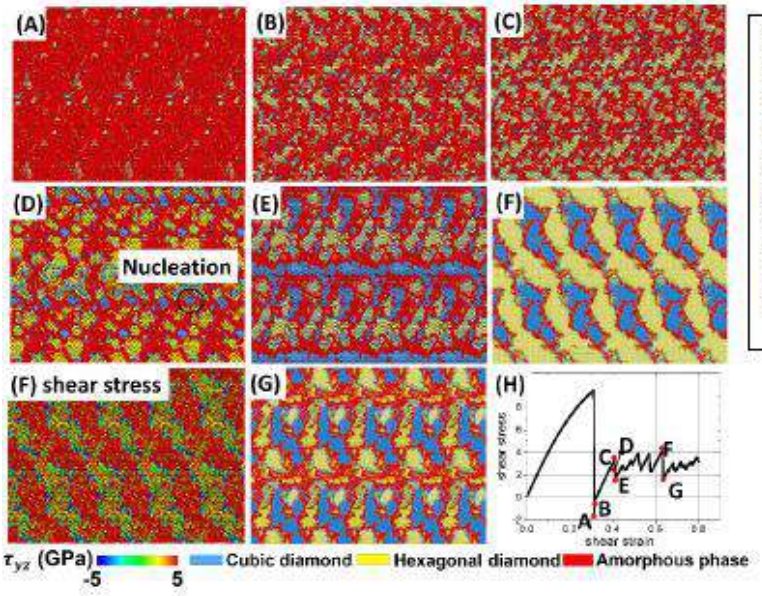

Fig. 4. Cyclic a-Si↔Si I, a-Si↔Si IV, and Si I↔Si IV phase transformations in the shear band during the shear loading. Snapshots of cubic diamond, hexagonal diamond, and amorphous phases are presented in (**A-G**), corresponding to the points in the shear stress-strain curve in (**H**). For point F in (**H**), the shear stress distribution is also presented.

4. Scale-Free Phase-Field and Analytical Studies of α-ω Phase Transformation in Single Crystal Zr under Nonhydrostatic Stresses [4]

Zirconium (Zr) is an important engineering material with numerous practical applications. It undergoes martensitic α-ω phase transformation (PT) at pressures that vary from 0.67 GPa to 17 GPa under different loading conditions. Despite numerous experimental and theoretical studies, the effect of the nonhydrostatic stresses is not well understood. To separate the effect of nonhydrostatic stresses from the plastic deformation, a scale-free phase field approach for multivariant α-ω PT in a single crystal Zr under general nonhydrostatic loadings is presented. Explicit conditions for the direct and reverse PTs between austenite and martensitic variants and between martensitic variants under general stress tensor are derived and analyzed. In particular, the strong effect of the deviatoric stresses on the PT pressures is elucidated. It is shown that their effect cannot explain much larger reduction in the transformation pressure observed during plastic flow, i.e., specific mechanisms of strain-induced phase transformations should be involved. Under assumption of the homogeneous fields in the sample, complete analytical solutions that include stress-strain curves during the PT, PT start and finish stresses (i.e., stress hysteresis), and volume fraction of the variants, are determined for different loadings. Finite element method solutions are found for the phase field simulations of the microstructure evolution for the same loadings, as well as for two grains of the polycrystalline sample. Macroscopic averaged characteristics of the PFA solutions are well described by an analytical Solution, which also simplifies their interpretations. In addition, some controversies of the previous approaches are analyzed.

5. Decoding anomalous grain growth at room temperature during pressure-induced phase transformations [5]

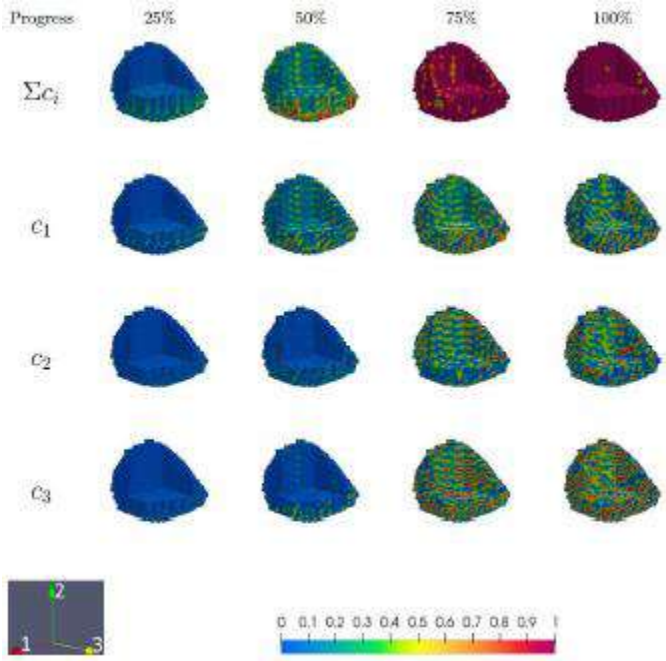

Fig. 5: Evolution of total ω phase and different martensitic variants in single grain selected from a polycrystal Zr sample with periodic boundary conditions in all three directions and compressed in direction 1 showing internal and external views.

Significant grain growth is observed during the high-pressure PTs at room temperature in various materials. The main focus here is grain growth from a few hundred nanometers to 10 microns within an hour during $\alpha \rightarrow \omega$ PT in Zr. No existing theory explains this phenomenon since without PT, Zr nanocrystals do not grow at room temperature even for up to 10 years. Here, a multistep mechanism for the grain growth during $\alpha \rightarrow \omega$ PT in Zr is suggested. Phase interfaces (PI) and grain boundaries (GBs) coincide and move together as a combined PI-GBs under the action of the combined thermodynamic driving force. Such a combined motion *changes the diffusional grain growth mechanism to the transformational one and the martensitic mechanism of PT to a reconstructive one via an intermediate disordered phase.* The primary condition is that the GB energy of the ω phase is smaller than that of the α phase, which promotes the nucleation of ω-Zr and is consistent with the absence of the reverse PT and reduction in the PT pressure with reducing grain size. Several intermediate steps for such motion are suggested and justified kinetically. Nonhydrostatic stresses due to volume reduction in the growing ω grain promote continuous growth of the existing ω grain instead of a new nucleation at other GBs. In situ synchrotron Laue diffraction experiments confirm the main predictions of the theory. The suggested mechanism provides a new insight into synergistic interaction between PTs and microstructure evolution.

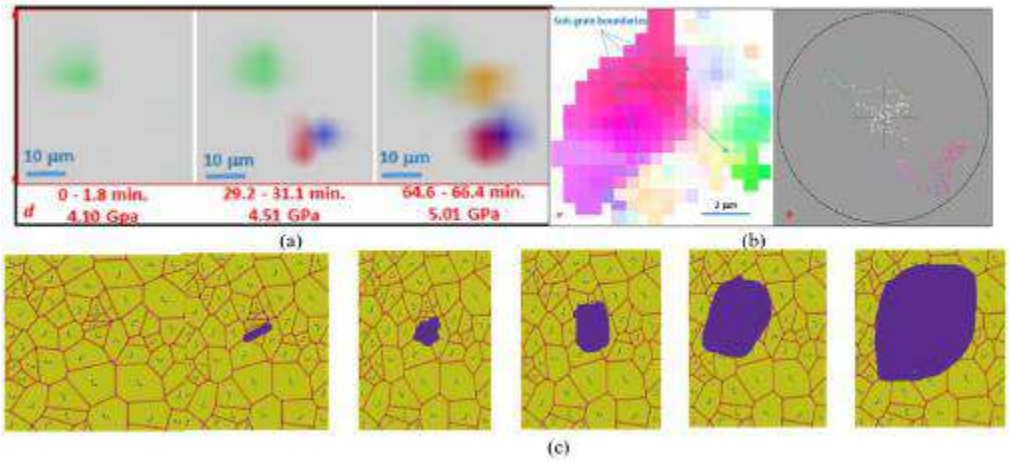

Fig. 6. Laue diffraction experiments and schematic of the ω grains growth within the nanocrystalline α-Zr matrix. **(a)** Images of the appearance and growth of projections of ω-Zr colored grains within α-Zr on the scanning plane determined with x-ray diffraction microscopy technique based on synchrotron Laue diffraction. The overlapping of images of different grains does not mean their contact due to their different out-of-plane coordinates. It is clear that nucleation and growth of different ω grains up to 10 μm occur independently. **(b)** Shape and subgrain structures of a single-variant ω phase grain with misorientation of $< 0.5^0$. Presented via crystal orientation map based on calculated (001) pole figure, in which colors show the misorientation of each volume element. **(c)** Schematics of the single ω-Zr grain nucleation within an α-Zr nanograin, growth within the grain, and forming a combined PI-GB, and further growth in the expense of α nanograins, which do not visibly change their size.

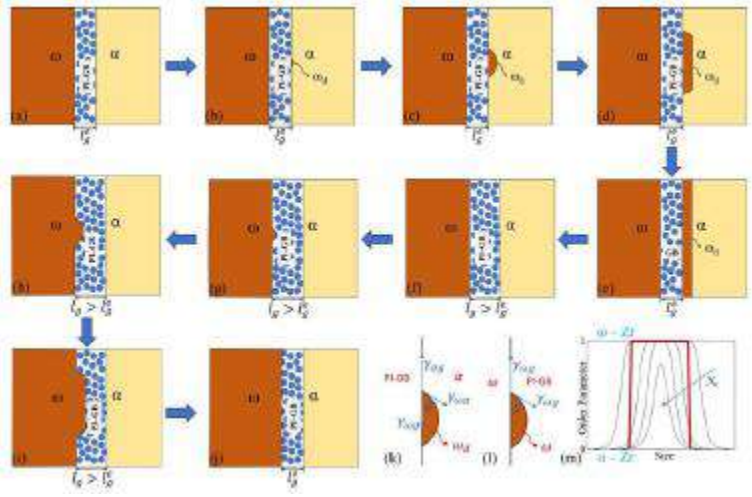

Fig. 7. Schematic of the sequence of the events for the suggested mechanism of the coupled grain boundary and phase interface propagation. **(a)** Initial state of the α and ω phases divided by disordered PI-GB with the thermodynamically equilibrium width l_e. **(b)-(f)** Appearance of the critical nucleus of the disordered ω_d phase at the combined grain and phase boundaries, its lateral growth along the PI-GB, and relaxation to the disordered PI-GB with the width $l_g > l_e$. Appearance of the critical nucleus of the ω phase within disordered PI-GB and its lateral growth along the PI-GB restoring the equilibrium PI-GB width.

Steps **(b)-(j)** results in the incremental shift of the combined PI-GB from ω to α phase. Steps **(b)-(f)** and **(g)-(j)** are independent of each other and may occur in arbitrary sequence, but it is most energetically favorable if they occur simultaneously, i.e., without essential deviation of the PI-GB width from the equilibrium one. **(k)** Appearance of a critical nucleus of disordered ω-Zr at the contact of the PI-GB and α-Zr. Vectors of the surface tension forces are shown. **(l)** Appearance of a critical nucleus of ω-Zr within PI-GB at the contact of the PI-GB and ω-Zr. **(m)** Schematics of the order parameter profiles of the critical nucleus of ω-Zr with increasing along the arrow the driving force for the PT. Critical nuclei represents an intermediate (disordered) state between α and ω phases. Red box is the critical nucleus within a sharp-interface approach.

6. Steady states in severe plastic deformations and microstructure at normal and high pressure – invited review [6]

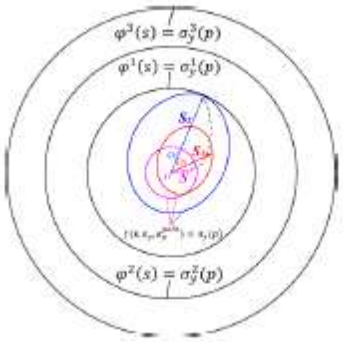

Fig. 8. Sketch of the evolution of the yield surface $f(\boldsymbol{s}, \boldsymbol{\varepsilon}_p, \boldsymbol{\varepsilon}_p^{path}) = \sigma_y(p)$ in 5D space of deviatoric stresses $\boldsymbol{s}$ at fixed p until it reaches the fixed isotropic limit surface of perfect plasticity $\varphi(\boldsymbol{s}) = \sigma_y^1(p)$, after which the material deforms like perfectly plastic, isotropic with the fixed limit surface of perfect plasticity. However, for some classes of plastic strain paths $\boldsymbol{\varepsilon}_p^{path}$, multiple other fixed limit surfaces of perfect plasticity $\varphi^i(\boldsymbol{s}) = \sigma_y^i(p)$ with different yield strengths $\sigma_y^i(p)$ can be accessed

The main fundamental problem in studying plasticity and microstructure evolution is that they depend on five components of the plastic strain tensor $\boldsymbol{\varepsilon}_p$, its entire path $\boldsymbol{\varepsilon}_p^{path}$, and pressure p and its path p^{path}, which leaves little hope of finding some general laws, especially at severe plastic straining and high pressures. Here, we review the validity of the following hypothesis for quasi-static material behavior after some critical level of cold severe plastic strain and some straining paths: initially isotropic polycrystalline materials behave like perfectly plastic, isotropic, and strain-path-independent with the corresponding limit surface of perfect plasticity and reach steady values of the crystallite/grain size and dislocation density, which are strain- and strain-path-independent. However, there are multiple steady microstructural states and corresponding limit surfaces of perfect plasticity. The main challenge is to find for which classes of loading paths $\boldsymbol{\varepsilon}_p^{path}$ and p^{path} material

behaves along the same limit surface of perfect plasticity and steady microstructural state and for which loading paths $\boldsymbol{\varepsilon}_p^{path}$ and p^{path} there is a jump to the different limit surface of perfect plasticity and steady microstructural state. Various experimental, computational, and coupled experimental-computational techniques are analyzed, and some controversies and challenges are summarized.

7. Severe Plastic Deformation of Ceramics by High-Pressure Torsion: Review of Principles and Applications [7]

Ceramics are typically brittle at ambient conditions due to their covalent or ionic bonding and limited dislocation activities. While plasticity, and occasionally superplasticity, can be achieved in ceramics at high temperatures through thermally activated phenomena, creep, and grain boundary sliding, their deformation at ambient temperature and pressure remains challenging. Processingunder high pressure via the high-pressure torsion (HPT) method offers new pathways for SPD of ceramics. This article reviews recent advances in HPT processing of ceramics, focusing primarily on traditional ceramics (e.g., oxides, carbides, nitrides, oxynitrides) and to a lesser extent advanced ceramics (e.g., silicon, carbon, perovskites, clathrates). Key structural and microstructural features of SPD-processed ceramics are discussed, including phase transformations and the generation of nanograins and defects such as vacancies and dislocations. The properties and applications of these deformed ceramics are summarized, including powder consolidation, photoluminescence, bandgap narrowing, photovoltaics, photocatalysis (dye degradation, plastic waste degradation, antibiotic degradation, hydrogen production, CO2 conversion), electrocatalysis, thermoelectric performance, dielectric performance, and ion conductivity for Li-ion batteries. Additionally, the article highlights the role of HPT in synthesizing novel materials, such as high-entropy ceramics (particularly high-entropy oxides), black oxides, and high-pressure polymorphs, which hold promise for energy and environmental applications.

The current author part included review of our (a) in situ experimental studies of strain-induced microstructure evolution and PTs in Si, SiC, BN, fullerene, graphite to diamond, and olivine to spinel in DAC and RDAC; (b) justification of dislocation pileup based mechanism of nucleation for strain-induced PTs, and (c) and revealing transformation-induced plasticity TRIP in shear bands.

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2. Lin F., Levitas V.I., Yesudhas S., and J. Smith. Severe Strain-induced Olivine-Ringwoodite Transformation at Room Temperature: Key to Enigmas of Deep-Focus Earthquake. Geophysical Research Letters, 2025, Vol. 52, e2024GL111281, 10 pages and 13 pages of supplementary materials.

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6. Levitas V.I. Steady states in severe plastic deformations and microstructure at normal and high pressure. Journal of Materials Research and Technology, 2025, Vol. 36, 382-397. In "Advances in Constitutive Modeling of Metals", a Special Issue in Honor of U. Fred Kocks, Editors T. Rollett and M. Meyers, invited paper.
7. K. Edalati, J. Hidalgo-Jiménez, T. T. Nguyen, H. Sena, N. Enikeev, G. Rogl, V. I. Levitas, Z. Horita, M. Zehetbauer, R. Z. Valiev, T. G. Langdon. Severe Plastic Deformation of Ceramics by High-Pressure Torsion: Review of Principles and Applications. Annual Review of Materials Research, 2025, Vol. 55, 36 pages. Invited review.

P.C. Membrane Lipid Replacement and its role in restoring Mitochondrial Membrane Function and Reducing Symptoms in Aging and Age-related Clinical Conditions

by Garth L. Nicolson, Member EUAS

Short Biography

Professor Emeritus Garth L. Nicolson, PhD, MD (H)

Professor Emeritus Garth L. Nicolson is the Founder, President, Chief Scientific Officer and Emeritus Research Professor of Molecular Pathology at the Institute for Molecular Medicine in Huntington Beach, California. He is also a Conjoint Emeritus Professor at the University of Newcastle (Australia). He was previously the David Bruton Jr. Chair in Cancer Research and Professor and Chairman at the University of Texas M.D. Anderson Cancer Center in Houston, and he was Professor of Internal Medicine and Professor of Pathology and Laboratory Medicine at the University of Texas Medical School, Houston. Professor Nicolson has published over 700 medical and scientific papers, including editing 20 books, and he has served on the Editorial Boards of 30 medical and scientific journals and was Senior Editor of four of these. Professor Nicolson has won many awards, such as the Burroughs Wellcome Medal of the Royal Society of Medicine (United Kingdom), Stephen Paget Award of the Metastasis Research Society, U.S. National Cancer Institute Outstanding Investigator Award, the Innovative Medicine Award of Canada and the EU Academy of Sciences. He is also a Colonel (O6, Honorary) of the U. S. Army Special Forces and a U.S. Navy SEAL (Honorary) for his work on Armed Forces and veterans' illnesses.

Professional Experience:

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1981-99, Adjunct Professor, Department of Pathology, School of Veterinary Medicine, Texas A & M University, College Station, TX
1982-99, Professor, Department of Pathology and Laboratory Medicine, The University of Texas Medical School, Houston, TX
1980-96, David Bruton Jr. Chair in Cancer Research, Professor and Chairman, Tumor Biology, The University of Texas M. D. Anderson Cancer Center, Houston, TX
1980-96, Professor, The Graduate School of Biomedical Sciences, The University of Texas Health Science Center, Houston, TX
1980-87, Florence M. Thomas Professor of Cancer Research, The University of Texas M. D. Anderson Cancer Center, Houston, TX
1978-80, Professor, Department of Physiology and Biophysics, College of Medicine, University of California, Irvine, CA
1977-80, Associate Director, Oncology Program, University of California, Irvine, CA
1975-80, Professor, Department of Developmental and Cell Biology, University of California, Irvine
1974-76, Chairman, Department of Cancer Biology, The Salk Institute, La Jolla, CA
1972-74, Head, Cancer Council Laboratory, Director, Electron Microscopy Laboratory, The Salk Institute, La Jolla, CA
1970-71, Senior Research Associate, Cancer Council Laboratory, The Salk Institute, La Jolla, CA
1967-70, USPHS Predoctoral Fellow University of California, San Diego, CA

Honors and Awards:

European Union Academy of Sciences, 2019-
Doctor of Medicine, M.D. (H), University of the Republic of Uruguay, 2015

Yanagimachi Distinguished Lectureship, University of Hawaii School of Medicine, 2012
John Drulle Memorial Lectureship, International Lyme and Associated Diseases Society (ILADS), 2008
Annual Award of the Common Cause Medical Research Foundation (Canada), 2006
Innovative Medicine Award (Canada), 2002
Stephen Paget Award, Metastasis Research Society, 1998
Albert Schweitzer Award (Portugal), 1998
First Norman N. Durham Lectureship, Environmental Institute, OSU, 1996
Indo-American Society for Health & Laboratory Professionals Award, 1996
Distinguished Presentation Award, Third International Cancer Molecular Biology Symposium, 1996
COLONEL (Honorary), U. S. Army Special Forces, 1995
SEAL (Honorary), U.S. Navy Special Forces, 1995
Haskel Visiting Professorship, University of Pennsylvania, 1995
Burroughs Wellcome Medal, Royal Society of Medicine Foundation, London, 1991
Outstanding Faculty Award, The University of Texas Health Science Center at Houston, 1991
U.S. National Cancer Institute U.S.S.R. Scientist Exchange Award for Collaborative Research on Molecular and Genetic Aspects of Tumor Metastasis, 1991
Evan and Marion Helfaer Distinguished Lectureship, The Cancer Center of the Medical College of Wisconsin, 1990
Dean's Teaching Excellence List, The University of Texas Health Science Center at Houston Graduate School of Biomedical Sciences, 1985-1994
Teaching Excellence Award for Best Course, The University of Texas Medical School at Houston, 1990
NCI/NIH Outstanding Investigator Award, 1987
Annual Award of the Japan Histochemical Society, 1976
Eli Nadel Memorial Lecture in Biochemistry, 1983
Rita Ferdinand Memorial Lectureship, 1982
Guy Lipscomb Memorial Lecture in Chemistry, 1980
Upjohn Biology Education Award, 1976
Presidential Award, Electron Microscopy Society of America, 1971

Progress Report 2025

1. Nicolson, G.L., Ferreira de Mattos, G., Settineri, R. and Breeding, P.C. Membrane Lipid Replacement and its role in restoring mitochondrial membrane function and reducing symptoms in aging and age-related clinical conditions. Nature Cell Sci. 2(4): 238-256 (2024).

Abstract: Aging is a multifaceted, dynamic process—at the subcellular level it involves mitochondrial and nuclear structures as well as metabolic, inflammatory, and signaling processes that result in progressive declines in cellular, organ, and tissue function that lead to an increased risk of morbidity and mortality. Here we focus on the importance of free radical oxidant modifications of membranes that result in the loss of mitochondrial (and other membrane) functions that are due, in part, to the reduction of mitochondrial inner membrane transmembrane potential ($\Delta\Psi_m$). Mitochondrial inner membranes (as well as other cellular membranes) can be repaired, and transmembrane potential restored with Membrane Lipid Replacement, the use of dietary supplements containing, protected, undamaged, functional membrane glycerophospholipids that remove and replace damaged membrane

phospholipids that build up during normal aging and in various acute and chronic illnesses. In particular, loss of mitochondrial function and increases in membrane damage can result in a variety of symptoms or multi-morbidities found in essentially all age-related chronic conditions and in diseases where cytotoxic treatments are used, such as cancer cytotoxic therapies. Clinical studies have shown that protected membrane phospholipid supplements can restore mitochondrial and other cellular membranes, resulting in recovery of function and decreases in fatigue, pain, gastrointestinal, and other symptoms in aged individuals and patients with a variety of morbidities. They can also be used to safely and slowly remove hydrophobic chemicals from cells and tissues and to provide an effective substitute or addition to pharmaceuticals for age-related illnesses.

2. Nicolson, G.L. A simple and safe method to slowly remove hydrophobic allophatic hydrocarbons from petrochemically exposed patients using an oral Membrane Lipid Replacement natural oral lipid supplement. Univ. J. Petroleum Sci. 13: 46-54 (2025).

Abstract: Exposures to aliphatic hydrocarbons and polycyclic aromatic hydrocarbons and their heat- generated fragments during the Persian Gulf War in 1991 resulted in long-term symptoms of chemical contamination in deployed armed forces. Some of the veterans display to this day a variety of signs and symptoms related to such exposures. With our success in using oral Membrane Lipid Replacement (MLR) therapy to repair and enhance mitochondrial function and slowly remove oxidized, amphipathic lipids from cellular stores we undertook a study to see if chemically exposed veterans of the Gulf War could benefit from MLR in terms of slowly resolving various chronic signs and symptoms. After 6 months on 6 grams per day oral MLR glycerophospholipids veterans with chemical exposures showed significant reductions in signs and symptoms related to fatigue, pain, chemical sensitivities, neurologic symptoms, gastrointestinal symptoms, breathing, skin lesions and other signs and symptoms. Reductions in the severities of signs and symptoms were gradual and varied among the male subjects in this study. There were also no adverse events during the study. We propose that MLR with protected membrane glycerophospholipids is a simple and safe method to detoxify petrochemical and other hydrophobic toxic chemicals in patients with chronic signs and symptoms.

3. Ferreira, G., Cardozo, R., Chavarria, L., Santander, A., Sobrevia, L., Chang, W. and Nicolson, G.L. The LINC complex in blood vessels: from physiology to pathological implications in arterioles. J. Physiology, (2025).

Abstract: The LINC (linker of nucleoskeleton and cytoskeleton) complex is a critical component of the cellular architecture that bridges the nucleoskeleton and cytoskeleton and mediates mechanotransduction to and from the nucleus. Though it plays important roles in all blood vessels, it is in arterioles that this complex plays a pivotal role in maintaining endothelial cell integrity, regulating vascular tone, forming new microvessels and modulating responses to mechanical and biochemical stimuli. It is also important in vascular smooth muscle cells and fibroblasts, where it possibly plays a role in the contractile to secretory phenotypic transformation during atherosclerosis and vascular ageing, and in fibroblasts migration and inflammatory responses in the adventitia. Physiologically, the LINC complex contributes to the stability of arteriolar structure, adaptations to changes in blood flow and injury repair mechanisms. Pathologically, dysregulation or mutations in LINC complex components can lead to compromised endothelial function, vascular remodelling and exacerbation of cardiovascular diseases such as atherosclerosis (arteriolosclerosis). This review summarizes our current under- standing of the roles of the LINC complex in cells from arterioles, highlighting its most important physiological functions, exploring its implications for vascular pathology and emphasizing some of its functional characteristics in endothelial cells. By elucidating the LINC complex's role in health and disease, we aim to provide insights that could improve future therapeutic strategies targeting LINC complex-related vascular disorders.

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Abstract: Approximately 700,000 United States armed forces personnel, along with armed forces from 30 coalition countries, were deployed to the Persian

Gulf in 1991-1992 for support of military operations (Operation Desert Shield/Operation Desert Storm) that are now known as the 1991 Gulf War. A large fraction of veterans of the 1991 Gulf War slowly developed multi-symptom chronic illnesses that have been termed Gulf War Illnesses (GWI). Many, if not the majority, of these GWI patients were chemically exposed, and they now have few alternatives for the treatment of their symptoms. Membrane Lipid Replacement (MLR) with oral membrane glycerophospholipids has been used as a safe and effective approach for slowly extracting and removing hydrophobic organic molecules from cells and tissues by the process of chemical partitioning into phospholipid structures and exchange by a mass action process. In addition, MLR also enhances mitochondrial function. This combination treatment can decrease the severity of certain signs and symptoms associated with a variety of multi-symptom illnesses, including those environmental illnesses associated with chemical contamination. A preliminary open-label study was conducted on 20 male veterans who were deployed to combat areas in Kuwait and Iraq during the 1991 Gulf War and were exposed to toxic chemicals. These veterans subsequently became ill with GWI and were utilised in this pilot study. This clinical study was designed as an open-label, Institutional Review Board-approved, preliminary or pilot clinical trial to study the effects of an all-natural glycerophospholipid chewable wafer supplement (Patented Energy® with NTFactor® Lipids) on the severity of signs and symptoms of GWI patients over a 6-month period. The subjects took 6 g per day of the all-natural, oral MLR glycerophospholipids, and the severities of over 100 signs and symptoms were self-reported at various times using illness survey forms. Sixteen subjects in the study were fully compliant and completed the study. There were gradual and significant reductions of symptom severities in these patients in categories related to fatigue, pain, musculoskeletal, nasopharyngeal, breathing, vision, sleep, balance, urinary, gastrointestinal symptoms and chemical sensitivities. During the Gulf War, veterans were variously exposed to a number of chemical, biological, and radiological sources, in addition to physical and mental stressors. In addition, GWI patients were exposed to combinations of multiple agents and stressors, and this makes any treatment approach much more complex. During the study, there were no adverse incidents, and the study supplement was extremely well tolerated. It is concluded that MLR with moderate amounts of oral glycerophospholipids appears to be a safe, simple and potentially effective

method for slowly reducing the severity of multiple symptoms in chemically exposed veterans with multi-symptom illnesses (GWI). In addition, MLR also enhances mitochondrial function. This treatment was successfully used to slowly decrease the severity of certain signs and symptoms of chemically exposed veterans of the 1991 Gulf War.

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Abstract: Life is dependent on the separation of body compartments from each other and the environment. The permeability of biological barriers, including the gastrointestinal and blood-brain, depends on the integrity of cell membranes and intercellular tight junctions. Severe mental illness is characterized by premature cellular senescence and subsequent gray matter loss in the central nervous system. Senescence-induced gut barrier disruption enables microbial migration outside the gastrointestinal tract. Systemic immune responses to gut microorganisms or their molecules may lead to neuroinflammation and the subsequent pathology. This review discusses cellular senescence and microbial migration outside of the gastrointestinal tract along with potential strategies for restoring the gut barrier homeostasis. These approaches include membrane lipid replacement, gamma wave entrainment, red light therapy, and pulsed electromagnetic field therapy.

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Abstract: The interrelationship between type 2 diabetes mellitus (T2DM) and cancer reflects a convergence of molecular disturbances involving metabolism, inflammation, and cellular stress, often underpinned by genetic

alterations. This review examines some key shared mechanisms of progression, with a focus on changes in plasma membrane dynamics, ion channel remodeling, Calcium (Ca2+) signaling, mitochondrial dysfunction, unfolded protein response, and oxidative stress. Changes in membrane composition, fluidity, lipid raft organization, and glycosylation affect receptor function and intracellular signaling in both diseases. These structural changes often occur in conjunction with the remodeling of ion channels. Ca2+ influx, K+, and Na+ are particularly affected, contributing to dysregulated excitability, proliferation, and immune modulation. Disturbed ion transport leads to intracellular Ca2+ overload or oscillatory defects, impairing insulin secretion in diabetes and activating prooncogenic pathways in cancer. A sustained Ca2+ imbalance further triggers the maladaptive activation of the UPR, while also affecting mitochondrial function. In T2DM, this response promotes β-cell dysfunction and insulin resistance, whereas in cancer, selective UPR engagement supports cell survival, angiogenesis, and immune evasion. Oxidative stress acts as both a trigger and amplifier in this cascade. Lipid peroxidation and mitochondrial dysfunction reinforce membrane instability and propagate damage, accelerating both metabolic decline and tumor progression. Therapeutically, interventions such as membrane lipid replacement and Ca2+ channel blockers are being explored for their dual potential in addressing some of these molecular dysfunctions. By integrating molecular and epidemiological perspectives, this review highlights the potential of using precision therapies that target some of the overlapping properties of T2DM and cancer, offering a more unified strategy to confront these global health challenges.

Metastable Materials for Sustainable Applications

by Jürgen Eckert, Member EUAS

Short Biography

Jürgen Eckert obtained his Ph.D. in Materials Science and Engineering at the Friedrich-Alexander-University Erlangen-Nuremberg, Germany in 1990. After his Ph.D. he worked for two and a half years as postdoc at the California Institute of Technology. After a short break in industry, he moved to the Leibniz-Institute for Solid State and Materials Research (IFW) Dresden, one of the leading Materials Research Science Centers in Germany. From 1996 until 2003 he was Head of the Department Metastable and Nanostructured Materials at IFW Dresden, before moving to TU Darmstadt as Full Professor for Physical Metallurgy. In 2006 he moved back to Dresden as Director of the Institute for Complex Materials at IFW Dresden and Chair for Synthesis and Analysis of Materials at Dresden University of Technology (TU) Dresden. Her also served as Scientific Director of IFW Dresden (2013/2014). In 2015 he became Chair Professor of Materials Physics at Montanuniversität Leoben, and Director of the Erich Schmid Institute of Materials Science of the Austrian Academy of Sciences. He held an Adjunct Professor Position at Michigan Technological University, Houghton, USA (2002-2005), was a Visiting Professor at University of Vienna, Austria (2009/2010/2012) and was appointed Honorary Professor at Shenzhen University, PR China (2021) and Honorary Researcher at Henan Academy of Sciences, Zhengzhou, PR China (2023).

He is an international expert in the field of metastable materials and has published 1450 papers in archival journals (h-index: 111 (WoSci), more than 59.000 citations), as well as more than 150 conference papers, 19 book chapters, 8 edited books, conference proceedings and journal issues, holds 24 patents, and delivered so far more than 270 plenary, keynote and invited presentations.

Jürgen Eckert was honored as Dr. honoris causa (Dr. h.c.) by the Slovak University of Technology in Bratislava, Slovak Republic (2012), and received the Gottfried Wilhelm Leibniz Award of the German Research Foundation (2009), the highest Science Prize and scientific honor in Germany. Other honors include the THERMEC Distinguished Award (2023), the European Advanced Materials Award of the International Association of Advanced Materials, Sweden (2021), an ERC-Proof of Concept Grant of the European Research Council (2019), the DGM-Prize 2014 of the German Materials Research Society, an ERC Advanced Grant of the European Research Council (2013), the ISMANAM Senior Scientist Award (2012), the Hsun Lee Lecture Award of the Chinese Academy of Sciences (2006), the Georg-Sachs-Prize of the German Materials Research Society and the Austrian Metal Industry (1997), and the FEMS Materials Science and Technology Prize of the Federation of European Materials Science Societies (FEMS) in 1997. He received the Young Scientist Award of the German Materials Research Society (1994), and the ISMANAM Young Scientist Award (1997). He is corresponding Member of the Section Mathematics-Natural Sciences of the Austrian Academy of Sciences (2017), Member of the European Academy of Sciences (2018), MRS Fellow of the Materials Research Society, USA (2018), Honorary Member of The Indian Institute of Metals, corresponding Member of the Section Technical Sciences of the Saxon Academy of Sciences and Humanities in Leipzig, Germany (2020), Foreign Fellow of the Indian National Academy of Engineering (2021), Fellow of the International Association of Advanced Materials (FIAAM), Sweden (2021) and was elected Full Member of Sigma Xi, The Scientific Research Honor Society, USA (2022), Foreign Fellow of the Indian National Academy of Sciences (NASI) (2023) and Foreign Fellow of the Indian National Science Academy (INSA) (2026)

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Jürgen Eckert's research activities focus on phase formation and structure-property correlations of metastable materials processed under highly non-equilibrium conditions; structural and functional materials with particular emphasis on fundamentals of solidification and solid state reactions; additive manufacturing techniques; high strength, biocompatible and magnetic alloys, and materials for sustainable energy applications (e.g. next generation batteries, supercapacitors, materials for hydrogen production and storage) and

thin film systems for flexible electronics; mechanical and electrochemical properties of bulk materials, coatings and surfaces; biologically inspired far-from-equilibrium materials and architected structures; mathematical modelling of advanced materials and processes.

Over the years, Jürgen Eckert and his team have provided seminal contributions in developing metastable advanced high-performance materials. Early work focused on amorphization and quasicrystal formation in metallic systems, and fundamental observations on establishing nanoscale grain sizes in metallic materials. The interest shifted later to the development and property optimization of bulk metallic glasses and composites, high entropy alloys and structurally modulated systems with hierarchically tuned microstructure for creating plastically deformable and tough engineering materials. This work followed a synergistic approach by understanding how atomic scale structures, microstructural features and stresses, along with processing-induced heterogeneities determine the mechanisms of plastic deformation on different length scales to overcome the brittleness of glassy or nanoscale materials, and evolved into a comprehensive approach using disorder and heterogeneity concepts for creating new strategies to tailor the properties of advanced materials. This provided new high-strength lightweight alloys, advanced hard and soft magnetic materials, porous bulk materials and hybrid structures for biomedical applications, materials for energy applications, and touched on surface modification and development of architected gradient structures.

Jürgen Eckert's recent research activities focus on in-depth *in situ* and *in operando* investigations of phase transformations and structure-property correlations using local probes and high-resolution techniques for structure characterization and imaging of local structures, chemical compositions and interaction of nanoscale objects with external fields and stimuli (e.g. mechanical, thermal, electrical, magnetic fields) for creating tailored biologically inspired metastable materials with hierarchical structure and tuned disorder. An example for such materials is the design of glassy or nanostructured metallic alloys containing heterogeneities on different length-scales to overcome their intrinsic brittleness. The heterogeneities can be triggered through local chemical variations, modulation of short- or medium-

range order or via creating locally tuned stress/strain states. The concept of *in-situ* design and testing is applicable to bulk materials, granular or thin film systems and to a variety of materials, and thus opens new research avenues for designing materials with unique properties. Some of the key publications in this area include:

- F.-F. Cai, B. Sarac, A. Akman, J.J. Londoño, S. Gümrükçü, L. Schweiger, M. Hantusch, J. Schroers, A. Blatter, A. Gebert, F. Spieckermann, J. Eckert, "Enhanced Hydrogen Evolution via Nano-Patterned Pt-Based Metallic Glass and Dynamic Copper Oxide Foam Formation", *Mater. Des.* **249**, 113530 (2025).
- Z.L. Cui, D.K. Si, J.L. Zhang, Q.W. Gao, J.H. Gong, X.Q. Wang, K.K. Song, X.L. Han, K. Zhang, Y.K. Mu, Y.D. Jia, D. Şopu, Z.Q. Zhang, P. Ramasamy, J.C. Qiao, W.D. Song, G. Wang, L.C. Zhang, J. Eckert, "Advancing the Mechanical Performance of Chemically Complex Alloys through Strategically Engineered Bamboo-Inspired Multi-Stage Heterostructures", *Compos. Eng. B* **302**, 112547 (2025).
- L. Schweiger, F. Spieckermann, P. Cengeri, M. Burtscher, L. Schretter, M. Eichinger, G.K. Mori, A. Schökel, M. Zehetbauer, E. Schafler, D. Kiener, J. Eckert, "Achieving Complex Nanostructures: The Role of Hydrogen in Controlling Mechanical Alloying and Microstructure Evolution in the TiVZrNbHf-Cu System", *Adv. Sci.* **12**, e07168 (2025).
- X.L. Yu, X.L. Bian, C. Liu, Q. Wang, D. Şopu, D. Kiener, Y.F. Li, G. Wu, Y. Wu, Y. Yang, J. Eckert, G. Wang, "Oxygen Nanoclustering Evades Inverse Hall-Petch Softening", *Nat. Commun.* **16**, 10602 (2025).)
- S. Hadibeik, H. Ghasemi-Tabasi, L. Schretter, E. Gingl, M.B. Costa, A. Burn, C. Gammer, A.L. Greer, F. Spieckermann, J. Eckert, "Atomic Disorder and Thermal Stability in Laser Beam-Shape-Tailored 3D-Printed Zr-Based Bulk Metallic Glass under In-Situ Heating during High-Energy X-ray Diffraction", *Mater. Today Adv.* **28**, 100617 (2025).
- F. Sourani, P. Ramasamy, E. Sharifikolouei, C. Gammer, A. Scalia, T. Brosio, A. Cochis, L. Rimondini, J. Eckert, "Structure-Property-Bioresponse Correlation in Zr-Based Metallic Glasses: From Glass-Forming Ability to Corrosion Resistance and Gene Expression", *Mater. Des.* **260**, 115227 (2025).

The long-term perspective of these approaches is to advance the understanding of structure-property correlations for hierarchically modulated structures and hybrid systems over a variety of different length-scales under highly non-equilibrium conditions. This provides a descriptive and quantitative picture of phase formation, transformation, dynamics, and property design under extreme conditions, such as ultra-fast heating and cooling on extremely short time scales with or without external mechanical, electrical or magnetic stimulus. Whereas some of these approaches are already well established for crystalline materials, research on disordered and interface dominated materials along these lines touches almost unknown grounds, since the structural diversity represented by disorder is a holy grail of materials science, promising to overcome the compositional and structural constraints of crystalline materials. The ability to predict and design disorder and heterogeneity in architected materials with unique functionality via property-directed material design provides vast opportunities for new structural and functional materials including high-strength-lightweight systems, sustainable and responsive/responsible materials, biomedical implants, or micromechanical components with unique performance characteristics. Not only the fundamental mechanisms of structure formation and property development are of interest, but also the transfer of these findings into parts, devices and systems for sensor and actuator applications, flexible microelectronics, as well as into materials for energy applications and energy harvesting and storage. Besides, biocompatible (biodegradable) bulk materials, porous structures, coatings, and surfaces are in the focus of interest, e.g. for personalized orthopedic implants and medical devices.

For this purpose, state-of-the-art techniques from the fields of materials physics, structure analysis, *in situ* structure investigations under different applied fields (e.g. mechanical, electrical, magnetic), and structure-biological mimetic and 4D printing techniques are used to generate architected materials built from disordered heterogeneous structures. Multi-scale modelling techniques based on hierarchies of overlapping scales including quantum mechanics-based structure modelling, atomistic modelling and numerical methods supplement and strengthen the experimental efforts. A variety of simulation and modelling of length and time scales is utilized, and complemented by Bayesian Interference (BI) and machine learning algorithms to better characterize the local property statistics not assessable

with direct measurements. The outcome of this approach allows for both a quantitative parameterization of local properties and protocols by which they are, in general, to be measured. This is vital for property-directed and machine learning driven material design of disordered systems, and opens up new avenues for nanoscale structure formation in architected materials with unique functionality through generating an atomic structural – functional understanding of the properties, performance and correlation of hierarchical thin film structures and membranes, tailored interface structures, nano- and multiscale hybrid systems and tailored lattice materials.

Evolution of Approximation Spaces in Rough Sets: Toward Insightful Reasoning about Granules as Computational Building Blocks for Cognition

by Andrzej Skowron, Member EUAS

Short Biography

Andrzej Skowron, *ECCAI (EurAI), AAIA and IRSS Fellow, Member of Academia Europaea (MAE), Fellow of the CORE Academy of Sciences and Humanities, Member of the Academic Committee of the CORE Academy, Member EU Academy of Sciences, Web Intelligence Academy founding Fellow (WIA), Member of the National Academy of Artificial intelligence (NAAI), Advisory Board member of Web Intelligence Consortium, received the Ph. D. and D. Sci. (habilitation) from the University of Warsaw in Poland. In 1991, he received the scientific title of Professor. He is a full professor in the Systems Research Institute, Polish Academy of Sciences. He is an Emeritus Professor in the Faculty of Mathematics, Computer Science and Mechanics at the University of Warsaw. Andrzej Skowron is the (co)author of more than 400 scientific publications and editor of many books, special issues of journals and volumes of conference proceedings. His areas of expertise include reasoning with incomplete information, approximate reasoning, soft computing methods and applications, rough sets, rough mereology, (interactive) granular computing, intelligent systems, (adaptive) complex systems, perception-based computing, and machine learning. He supervised 23 PhD theses. From 1995 to 2009 he was the Editor-in-Chief of Fundamenta Informaticae journal. He is on the Editorial Boards of many other international journals. Andrzej Skowron was the President of the International Rough Set Society (1996-2000). He has delivered numerous invited talks at international conferences including a plenary talk at the 16th IFIP World Computer Congress (Beijing, 2000), a keynote talk at the 8th Joint Conference on Information Sciences (JCIS 2005) (encompassing 12 individual conferences and workshops) (USA, 2005), an invited talk at the 2006 IEEE/WIC/ACM International Conference on Intelligent Agent Technology (IAT 2006) and on Web Intelligence (WI 2006) (Hong Kong, 2006), and a plenary talk at the 2nd World Congress on Biologically Inspired Computing (Japan, 2010). He was serving as (co-)program chair or PC member of more than 200 international conferences. He was involved in numerous research and commercial projects, including a dialogue-based search engine (Nutech), fraud detection for Bank of America (Nutech), a logistic project for General Motors (Nutech), algorithmic trading (Adgam), control of UAV (Linköping University), and medical decision support (e.g., in Polish-American Pediatric Clinic in*

Cracow). Andrzej Skowron was on the ICI Thomson Reuters/ Clarivate Analytics lists of the most cited researchers in Computer Science (globally) in 2012, 2016, 2017. H-index=68 (Google Scholar).

Abstract

This article provides a brief overview of the evolution of the approximation space concept in the Rough Set (RS) approach, from its initial introduction by Professor Zdzisław Pawlak to dynamic models based on granular networks of complex granules (c-granules) in Interactive Granular Computing (IGrC). These networks form the foundation for approximating classifications relevant to Intelligent Systems that deal with complex phenomena and discovering approximate solutions to problems specified for c-granules (or their societies) in such systems. Granular networks are states of granular computations steered by c-granule control. The control of c-granules aims to construct approximate solutions to specified problems along with generated computations. According to Professor Leslie Valiant's terminology, the relevant sub-granules discovered and stored in granular networks can be interpreted as computational building blocks for cognition. These computational building blocks are used in the construction of adaptive data models. Methods of insightful reasoning should support the control of c-granules in the discovery of such granules over generated computations.

Optimization in the rough approach

The first RS model, proposed by Pawlak (see, e.g., [7-10]), was based on two partitions of a given, finite set of objects. Conditional attributes define the first partition, and a decision attribute defines the second. The first approach was actually related to binary decision partitions defined by sets and their complements. The lower and upper approximations, as well as the boundary region of the binary decision partition, were expressed in terms of the partition defined by conditional attributes. In this approach, the partitions are given a priori.

Each conditional attribute defines a partition of the set of objects. The partition defined by a set of conditional attributes is the intersection of the partitions defined by each conditional attribute. In this approach, the data reduction optimization problem is as follows: Given a set of conditional attributes, find minimal sets of attributes, called reducts, that define the same partition as the original set. Note that a given set of attributes may have an exponential number of reducts and that the problem of finding a minimal reduct is NP-hard. The definition of an attribute value set should be considered in the context of relational systems. In the discussed case, the equality relation on the value set is considered together with the value set. Next, richer relational systems are considered. For example, when the values are reals, one can consider the natural relation on reals together with the value set. The relations in the Cartesian product of a given attribute's value set naturally define the relations in the Cartesian product of the object set. This is how the evolution of the

c-granule language begins. This language is useful for expressing granules.

The outlined approach was extended to numerous applications, such as the discretization of real-value attributes, symbolic value grouping, association rules, the generation of decision rules, and decision support related to preferences. This can be characterized briefly as follows. Rather than considering a single partition of conditional attributes, an algebra of partitions is considered. Such an algebra consists of atomic partitions and operations on those partitions. Operations enable the creation of new partitions from both atomic partitions and previously generated ones. The sets of atomic partitions may be much richer than in the initial model. For example, one can consider relations related to the degrees of inclusion of classes of partitions [14] or relations related to quality measures of defined approximations. The latter are introduced to balance the description length with the quality of the approximation. The sets of partitions in the algebra of partitions can be large or even infinite. This leads to more complex optimization problems. Over the years, Boolean reasoning was used to construct efficient heuristics for solving these problems (see, e.g., [10]). The discussed approach was also extended by considering coverings instead of partitions.

However, this approach proves inadequate for more advanced applications, particularly because it lacks the insightful reasoning methods necessary to effectively understand real-world situations and make the right decisions. Dynamic algebras and languages over such algebras that define new, relevant granules as computational building blocks for cognition need to be discovered. Furthermore, the entire process cannot be confined to an abstract space because continuous interaction with the physical world is necessary to understand situations and make appropriate decisions. This led to the emergence of the IGrC paradigm.

Rough sets in IGrC

The generalization of Granular Computing (GrC) (see e.g., [11-12]) to IGrC (see, e.g., [15] and https://dblp.org/pid/s/AndrzejSkowron.html) was proposed to support the design of Intelligent Systems (IS's) that deal with complex phenomena. IS’s can be treated in IGrC as examples of complex granules (c-granules) with control. Such systems must be able to continuously interact with the physical world to be successful in applications. Control of c-granules properly implements the physical semantics of specified transformations in the physical world. This implementation is based on discovering relevant configurations of physical objects, providing the basis for perceiving relevant data about these objects and their interactions through c-granule control. Furthermore, to ensure the success of the designed ISs, the configurations of the objects adaptively change to enable the perception of relevant data. This makes it possible to construct high-quality models on which the behavior of the ISs is based. Unlike information granules from GrC, the implementation of c-granule transformations cannot be restricted to an abstract space. A key property of the ISs discussed here is that they cannot be separated

from their interactions with the physical world. The proposed IGrC model differs from the classical Turing model in that it synchronizes four components: language, reasoning, perception, and action. In the IGrC model, granular computations form the basis for insightful reasoning methods that support problem solving by c-granules. The control of c-granule uses its informational layer, its language, which evolves during the control behavior, particularly to express transformations that establish interactions with its second physical layer.

Problem solving (or decision support) by c-granules, particularly ISs, requires an understanding of real-world situations consisting of configurations of interacting objects. Thus, steering computations by c-granules requires the ability to perceive situations in the physical world and form associations between physical and abstract objects. These skills are supported by insightful reasoning over granular computations performed by c-granule control. Note that these computations depend on physical laws.

Recently, the RS approach was generalized by introducing approximation spaces defined over dynamic networks of granular spaces in IGrC (see, e.g., [15]). The goal is to develop RS-based methods that can direct c-granule computations and support the discovery of approximate solutions of an appropriate quality for specific problems. These methods facilitate the discovery of complex games within granular networks created using finite sets of models of vague, complex concepts labeled by transformations triggered when the concepts are sufficiently satisfied. Such games are used by the control of c-granules for guiding granular computations when interacting with abstract and physical worlds. These methods should enable the construction of “abstract and/or physical” approximate solutions of the appropriate quality for a given problem specification for the c-granule(s) involved in these computations. New sub-granules that interact with the physical world are discovered during computations generated by c-granules over granular networks. These sub-granules serve as essential computational building blocks for understanding perceived situations in the physical world. Along with the generated computations, c-granule control constructs approximate satisfactory solutions to the presented problems. Hence, control behavior is based on complex games. These complex games are discovered and adapted during granular computations.

Now, let us consider the problem of discovering granular computations that satisfy with certainty the following concept: *Granular computation has a satisfactory quality relative to the task specified for a given c-granule*. Certainly, the relevant quality measure and threshold for expressing "satisfactory quality" must be specified. In RS, the aim is to discover examples of computations that belong to the lower approximation of this concept. The control of c-granule should be able to generate such examples, although examples of these computations are not yet known. Unlike in typical machine learning tasks, the set of training objects is not predetermined. Instead, the c-granule generates training cases, computations in the considered case, to meet its needs. The c-granule's control system aims to satisfy

its needs (goals) by generating high-quality granular computations relative to the specifications of those needs. Quality measures express the quality of the approximate solutions constructed during computations. This problem (Fig.1) is challenging and involves developing insightful reasoning methods to discover computational building blocks that support the construction of approximate solutions over granular computations.

Despite the fact that Aristotle addressed such logic of discovery, demonstrating how the premises of a syllogism must be formulated to yield a given conclusion, one should note that the logic of discovery is still in its infancy.

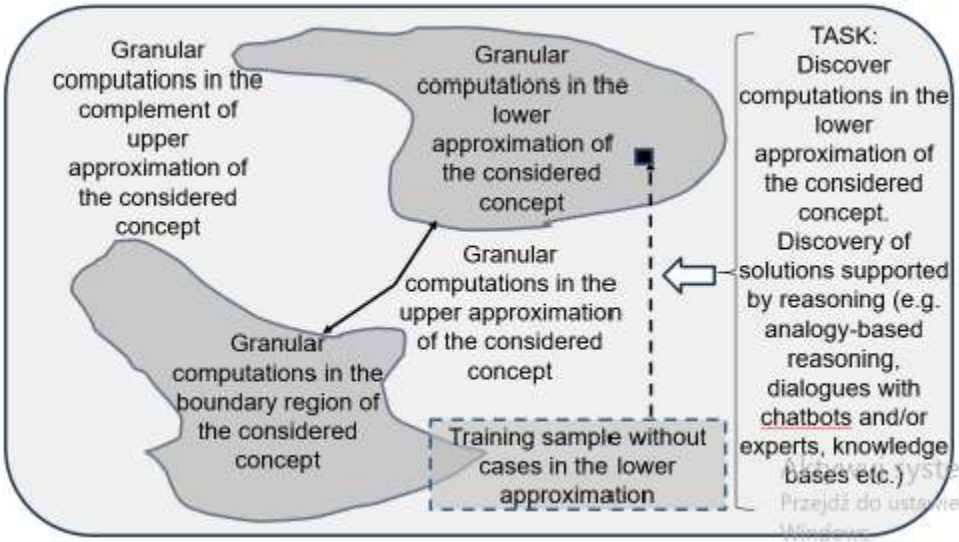

Fig. 1. Approximation areas of the concept: *Granular computations with high-quality solutions of the specified problem* in the domain consisting of computations of c-granule control.

There are numerous related domains to this challenge. A few of these domains include (i) the discovery of learning algorithms and the construction of classifiers [5,13], (ii) the automatic design of robots [6], (iii) drug discovery [1], (iv) algorithmic trading [2], and (v) generative AI [4]. The research roadmap includes developing common foundations based on IGrC and RS for designing and analyzing discovery systems from these domains.

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Recent Trends in Thermal Atomic Layer Deposition

by Markku Leskelä, Member EUAS

Short Biography

Education and degrees completed
D. Techn. 1980, MSc 1974, Helsinki University of Technology
Current position
Professor emeritus of inorganic chemistry, University of Helsinki
Previous work experience
PhD student Helsinki University of Technology (1973-1979); Associate professor University of Oulu (1979-1981; 1982-1986); Professor Helsinki University of Technology (1981-1982); Professor University of Turku (1986-1990); Professor University of Helsinki, 1990 – 2018; Academy professor 2004-2009
Research interests
Research activities include thin films and nanostructured materials made by various chemical methods (Atomic Layer Deposition, electrodeposition and Successive Ionic Layer Adsorption and Reaction) for applications in micro- and optoelectronics. The studies include film growth from precursor synthesis to applications. The other research topic is catalysis where the focus is on activation of small molecules by metal complexes. Co-author of 742 peer reviewed papers, 68 review and 97 proceedings papers and holder of 60 patents and patent applications. Number of citations 36 000; h-index 86 (Web of Science core collection); 61 900 citations, h-index 121 (Google scholar)
Personal research funding
Number of research grants during whole carrier is about 80 and total funding ca. 30 M€. Most important recent fundings: Interfacial engineering of semiconductors for highly selective light-driven chemical transformations (Academy of Finland 2020-2023) 315 000€; European Research Training Network of Functional Hybrid Coatings by Molecular Layer Deposition (EU, 2017-2021) 538 000€; Finnish Centre of Excellence in Atomic Layer Deposition (Academy of Finland, University of Helsinki, 2015-2019) 2 920 000 €; Building-up Centre of Excellence for advanced materials, (EU Teaming project, 2015-16) 130 000 €; Development of ALD processes for microelectronic applications (ASM Microchemistry, 2014-2018) 1 300 000 €
Awards and honors
Member of Finnish Academy of Science and Letters 1991- ; Finnish Academy of Technical Sciences 1996- (President 2019-2022); Finnish Society of Sciences and Letters 2005-; SVR I 2005; Magnus Ehrnrooth Foundation Award 2002; ISI Highly cited scientist 2004-; IUPAC Fellow 2010; A.I Virtanen award 2011; American Vacuum Society ALD innovation award 2012; Award of Finnish Academy of Sciences and Letters 2014; Honorary member (2014-) and honorary chairman

(2019-) of Finnish Chemical Society; Honorary doctor, University of Tartu 2016; Member of EU Academy of Sciences 2018

Other scientific or academic merits

Member of board of governors in University of Helsinki, 2010-2017; supervisor of 73 PhD theses, opponent for 37 PhD theses, pre-examiner for 37 PhD theses, referee for 30 professor positions, evaluator for research proposals in 14 countries, ca. 100 invited talks in international conferences, numerous positions in trust in Finnish and international scientific societies, editorial board member of 6 journals (1989-2022), board member of seven foundations (1992-2022), president of Finnish Academy of Technical Sciences (2019-2022), chairman of the Council of Finnish Academies (2021-2022).

Georgi Popov, Miika Mattinen, Anton Vihervaara, and Markku Leskelä: Recent trends in thermal atomic layer deposition. *Journal of Vacuum Science and Technology A 43*, 030801 (2025)

In this review, we highlight new atomic layer deposition (ALD) precursors and process chemistries based on the ALD database found in atomiclimits.com website. The aim of this paper was to compare the processes and chemistries applied before and after 2010 and see possible changes. We had earlier reviewed all ALD processes published until 2010 (V. Miikkulainen, M. Leskelä, M. Ritala and R.L. Puurunen: Crystallinity of Inorganic Films Grown by Atomic Layer Deposition: Overview and General Trends. *Journal of Applied Physics 113* (2013) 021301) and therefore we focused now on the time after 2010. The motivations for process development and trends in the types of different metal precursors are discussed.

The total number of published thermal ALD processes all time is 1711, of which more than half (942) were published after 2010. The number of materials deposited by thermal ALD is 539, and for 312 of these, the process was published after 2010. The most popular material group are binary oxides. After 2010, the share of nonoxide and ternary materials slowly increased. During the last years, a few material classes have come forth, viz., metals, 2D transition metal dichalogenides, and halides. The development of new ALD processes is clearly application-driven and visible in these material classes, motivated by the most important application areas of ALD: Microelectronics, energy technology, and catalysis.

New elements added to the portfolio after 2010 are alkali metals (Na, K, and Rb), Be, Re, Os, Au, and Sb, the first two as oxides and the latter four as metals. The processes for Re, Os, Au, and Sb were different: Reductive for Re, oxidative for Os and Au, and exchange reaction for Sb. ALD of transition

metals has been of interest because of their potential use in microelectronics. New metal precursors and novel reducing agents play an important role in their process development.

Metal halides, alkoxides, alkyl compounds, β-diketonates, and amides/imides have been traditional metal precursors in ALD. After 2010, amides/imides have been the most applied precursors in new ALD processes, followed by cyclopentadienyl compounds. However, heteroleptic complexes containing two or more ligands are the largest precursor type, and they usually consist of a mixture of the above-mentioned ligands. The use of heteroleptic compounds enables tuning of precursor properties such as volatility, reactivity, and stability.

Recent Activities in Materials Science and Engineering

by Derek O. Northwood, Member EUAS

Short Biography

Professor Derek O. Northwood is a Distinguished University Professor Emeritus and Professor of Engineering Materials in the Department of Mechanical, Automotive and Materials Engineering at the University of Windsor, Windsor, Ontario, Canada. Professor Northwood has an earned doctorate in Chemical Physics (Crystallography) from the University of Surrey (UK) and a BSc (Eng) in Engineering Metallurgy from the Imperial College, University of London (UK). He is a licensed Professional Engineer in Ontario, Canada (PEng) and is a Chartered Professional Engineer (CPEng; NER), APEC Engineer, and International Professional Engineer (IntPE(AUS), in Australia. In the 40+ years as an academic, Professor Northwood has held various administrative positions including Department Head, Dean, Associate Dean of Research, Director of the Office of Research Services, President of the Industrial Research Institute, and, Research Leadership Chair, both at the University of Windsor and Ryerson University, Toronto, Canada. Professor Northwood has taught, researched and facilitated joint research and educational programs at 14 universities worldwide, including the UK, the USA, Australia, Taiwan, China, Singapore and Canada. He has published 720 papers in refereed international journals and conference proceedings, 9 chapters in books and has edited 10 books, on a wide range of topics including materials and their applications, and engineering and technology education. He has been elected Fellow of six international professional societies in Australia, Canada, the UK and the USA; namely, Fellow of the Royal Society of Canada (FRSC); Fellow of the Institution of Engineers Australia (FIEAust); Fellow of the World Institute for Engineering and Technology Education (FWIETE); Fellow of the Institute of Materials, Minerals and Mining (FIMMM); and Fellow of ASM International (FASM); and Fellow of Alpha Sigma Mu (FAΣM), The International Professional Honor Society for Materials Science and Engineering. In 2024, Professor Northwood was recognized again as being among the world's top 100,000 - or top 2% of scientists - according to the database published by Stanford University. Professor Northwood continued in his role as Editorial Board Member (Hydrogen and Fuel Cells) for Renewable Energy.

RESEARCH ACTIVITIES AND PUBLICATIONS 2025

As in 2025, my principal research activities have been conducted in cooperation with Professor Cheng Liu at Yangzhou University, China and Dr. Hao Ma, and associated researchers, at BGRIMM Technology Group, Beijing, China. The cooperative work with Professor Cheng Liu at Yangzhou resulted in two publications in 2025.Both papers concerned the engineering

failure analysis of an industrial component. The first paper looked at the reduced cutting tool life in the machining of a 16MnCrS5 steel piston used in a door closer. The second paper looked at the premature failure of a stamping die used for automotive clutch gear hubs.

Chen, Z., Huang,Y., Northwood, D.O., Liu, C.

Root cause analysis of premature failure in a Cr-Mo-V stamping die used for automobile clutch gear hubs
(2025), *Engineering Failure Analysis*, 185, 110407

This paper describes the failure analysis of a Cr-Mo-V steel gear-shaped stamping die employed in the manufacture of automotive clutch gear hubs. The failure modes of the toothed sections of the malfunctioning die predominantly manifest as cracks, grooves, and material loss. Cracks are readily discernible in the transition zone on either side of the tooth base. The die's microstructure mainly comprises tempered martensite, carbides, and a very small quantity of retained austenite. The TiCN surface coating shows warping, partial cracking, and detachment. The cracks initiate at the interface between the coating and the die material, further propagate along the plastic deformation direction. Hardness testing indicates that while the macroscopic hardness meets the design specifications, the microhardness distribution is nonuniform. Specifically, 12.5 % of the microhardness values are below the design requirement. This phenomenon is associated with the quantity and distribution of large − sized carbides within the die's microstructure.

Hang,Y., Wu,X., Chen,Z., Northwood, D.O., Liu, C.

An investigation of reduced cutting tool life in the machining of a 16MnCrS5 steel piston used in a door closer
(2025) *Engineering Failure Analysis*,170, 109308.

The tools used for the milling and drilling of a door-closer piston repeatedly broke down well before their design life of 500 units. The pistons were fabricated from 16MnCrS5 steel bar stock in the hot-forged and air-cooled condition. A change in tool supplier also led to similar early failure of the cutting tools. Thus, a systematic examination was conducted of pistons manufactured with the failed cutting tools. This examination included chemical analysis, microstructural characterization (optical metallography; SEM) and hardness/microhardness measurements. 14 % granular bainite was formed within the polygonal ferrite-lamellar pearlite microstructure. The hard bainite produced microhardness variations along the piston section. This

produced irregular stress concentrations between the cutting tool and the workpiece, and ultimately premature failure of the cutting tool. Based on considerations of the transformation mechanisms of granular bainite, an isothermal normalization process was designed to be applied to the bar stock before machining. This treatment reduced the granular bainite content to ~ 1 %. Production trials on 1000 units showed that this extended cutting tool life to over 700 units.

The research collaboration with Dr. Hao Ma on the recovery of valuable metals from ores and refractory concentrates has continued with new work on converting ferronickel into high nickel matte. New work was initiated on the integrated irrigation of water and fertilizer with a superior self-correcting fuzzy PID control system and key technologies for online pre-compensation of profile errors in the three-axis computer numerical control (CNC) machine tools based on cross-coupled dynamics. There have been a total of 3 publications in 2025.

Zhou, Q., Liu, Y., Sun, H., Yang, B, Liu, S., Northwood, D.O.,, Waters, K.E., Ma, H.

The process analysis of converting ferronickel into high nickel matte.

(2025) *Minerals Engineering*, 233,109602

Sulfurization smelting is a effective process for the transformation of ferronickel into low nickel matte, with subsequent conversion through oxygen blowing and converting enabling the production of high nickel matte. This study involved the initial mixing and smelting of ferronickel, SiO2, pyrite, and coke, followed by the blending of the resulting low nickel matte with SiO2 during oxygen blowing at elevated temperatures, with an emphasis on optimizing both stages of the process. The research revealed that in the first stage, when 50 g of pyrite, 27 g of SiO2, and 3 g of coke were added, and the smelting was carried out at a temperature of 1425℃ for 2.5 h, over 99 % of the nickel was successfully converted from ferronickel into low nickel matte, with a nickel content exceeding 35 % and sulfur content of around 17 %, while the slag nickel content was as low as 0.4 %. In the second stage, with a conversion time of 8 h, 23 g of SiO2 addition, and a converting temperature of 1300℃, over 96 % of the nickel was transformed into high-grade matte

with a nickel content exceeding 75 % and sulfur content of 18 %. These findings provide valuable insights for the utilization of ferronickel in the production of nickel sulfate to meet the demands of the burgeoning lithium battery industry.

Zhang, W., Tong, J., Zhang, F., Zhang, W., Zhang, J., Zhang, J., Sun, H., Northwood, D.O.., Waters, K.E., Ma, H.

Integrated irrigation of water and fertilizer with superior self-correcting fuzzy PID control system

(2025) *PlosOne*, 20(5 May) e032448.

To address the fixed-parameter limitations of traditional PID control (e.g., excessive overshoot, prolonged settling time, poor adaptability to nonlinearities) and the insufficient real-time adjustment capability of conventional fuzzy PID control, which relies on empirically predefined rule bases, this study proposes a self-correcting fuzzy PID control strategy for agricultural water-fertilizer integrated systems. Traditional PID control, due to its static parameters, suffers from reduced stability and error accumulation under dynamic variations (e.g., irrigation flow fluctuations, environmental disturbances) or nonlinear interactions (e.g., coupling effects of fertilizer concentration and pH). While conventional fuzzy PID control incorporates fuzzy reasoning, its offline-designed rule bases and membership functions lack online adaptive parameter correction, leading to degraded precision in complex operating conditions. To tackle challenges posed by uncertain variables (e.g., time-varying soil permeability) and nonlinear parameters resistant to precise mathematical modeling, this research integrates fuzzy logic with an online self-correcting mechanism, constructs a mathematical model for the integrated control system, designs real-time correction rules, and validates the model through simulations using Matlab/Simulink and a semi-physical PC platform. The results demonstrate that the self-correcting fuzzy PID control significantly optimizes key performance metrics: overshoot (reduced by 21.3%), settling time (shortened by 34.7%), and steady-rate error (decreased by 18.9%), outperforming both traditional PID and fuzzy PID methods in concentration and pH regulation. Its parameter self-adaptation capability effectively balances dynamic response and steady-state performance, resolving issues such as overshoot oscillation and lagging regulation in nonlinear dynamics. In practical applications, the system achieved an average plant height growth rate of 15.86%-21.73% and a

30.41% yield improvement compared to the control group, validating the enhanced synergistic control of water and fertilizer enabled by the variable universe fuzzy PID approach. This study provides a robust control solution with theoretical innovation and practical value for managing complex nonlinear systems in precision agriculture.

Zhang,W., Sun, H., Northwood, D., Waters, K., Ma.

Key technologies for online pre-compensation of profile errors in three-axis computer numerical control (CNC) machine tools based on cross-coupled dynamics
(2025) *MetaResource*, 2(3) 216-242

A design approach for online pre-compensation of three-axis cross-coupled contour errors with mismatched dynamics is proposed. In the context of cross-coupled contour control design, online pre-compensation of contour errors is commonly employed. However, establishing a specific relationship between contour errors is challenging for mismatched computer numerical control (CNC) systems. Therefore, the design of interpolation methods for mismatched systems remains crucial, as most existing systems struggle to be adjusted to match seamlessly. This study introduces an online pre-compensation scheme for cross-coupled contour errors in three-axis motion, which constitutes a compensation system for real-time correction of contour error estimation. The coupling control structure, based on a speed loop, comprises a proportion integration differentiation (PID) control feedback controller, a feedforward controller, and an online pre-compensation cross-coupled contour controller. The experimental results demonstrate that the proposed three-axis cross-coupled contour error pre-compensation scheme significantly enhances the contour accuracy compared to traditional cross-coupled control systems. Moreover, the proposed cross-coupled contour error pre-compensation controller exhibits superior contour performance over conventional cross-coupled controllers when tracking high-order curvature bending paths.

The "Engineering Brain" Framework

by Xiangyu Wang, Member EUAS

Short Biography

Professor Xiangyu Wang is a globally recognised scholar in infrastructure informatics, digital engineering, and intelligent construction systems. He is a Fellow of the European Union Academy of Sciences (EUAS) and was elected to the European Academy of Sciences and Arts (EASA) in 2025. He is also a Fellow of the UK Royal Society of Arts (RSA), Engineers Australia, and the International Association of Advanced Materials (IAAM). He has been named a Clarivate Highly Cited Researcher in both 2022 and 2025, ranking first globally in high-impact publications across civil engineering, transportation engineering, and building and construction. He is also a recipient of a Gold Medal at the International Exhibition of Inventions of Geneva and has been honoured with the Marquis Who's Who Lifetime Achievement Award.

Professor Wang currently serves as Chair Professor and Executive Dean of the Institute for Intelligent Construction and Maintenance of Civil Infrastructure at East China Jiaotong University. Previously, he was Chair Professor at Curtin University (Australia), Co-Director of the Australasian Joint Research Centre for Building Information Modelling (BIM), and Woodside Chair Professor for Oil & Gas Construction and Project Management at Woodside Energy, one of Australia's largest listed energy companies.

He received his Bachelor's degree with First-Class Honours from Tongji University, his Master's degree from the University of Washington, and his PhD from Purdue University. His interdisciplinary training across engineering, computing, and information sciences laid the foundation for his later integration of AI, digital twins, and cyber-physical systems into construction and industrial practice. His industrial collaborations span global corporations such as Shell, Woodside, Rio Tinto, BHP, Huawei, and Samsung Heavy Industries, bridging academic research and industry-scale deployment.

Professor Wang has published more than 400 journal articles and has achieved an H-index of 116 with over 44,170 Google Scholar citations. His work includes 36 ESI Top 1% Highly Cited Papers and 11 ESI Hot Papers. Professor Wang has supervised more than 30 PhD students and 43 postdoctoral fellows, with 40% female participation—exceeding the engineering average. His trainees now occupy

academic and industrial leadership roles across Australia, New Zealand, Europe, Asia, and North America.

Research Vision: The "Engineering Brain" Framework

One of Professor Wang's most influential scientific contributions is the formulation of the "Engineering Brain" theory. The Engineering Brain is proposed as a metaverse-enabled cyber-physical paradigm for the future of engineering, integrating neuroscience-inspired mechanisms, digital twins, artificial intelligence, mixed reality, IoT, and advanced computing architectures into a unified decision-making system.

The theoretical foundation of Engineering Brain draws upon neuroscience, neural engineering, bionics, and cyber-physical systems. Inspired by the divergent–convergent thinking mechanism of the human brain, the Engineering Brain conceptualises engineering projects as intelligent organisms in which heterogeneous, multi-modal, and life-cycle data are continuously sensed, analysed, integrated, and transformed into optimised decisions. The framework positions engineering systems not as isolated digital tools, but as an integrated "cloud reflex arc" capable of sensing, reasoning, predicting, and acting in near real-time.

Structurally, the Engineering Brain consists of four functional "lobes" analogous to the human brain. The parietal lobe corresponds to real-time sensing through IoT systems, wearable devices, and environmental sensors. The occipital lobe processes visual and textual information through computer vision and natural language processing, transforming unstructured site data into structured knowledge. The temporal lobe functions as the memory system, incorporating relational, distributed, and graph databases to store structured and unstructured information. The frontal lobe is responsible for prediction, optimisation, and decision-making, employing multi-objective optimisation, machine learning, and reinforcement learning to balance cost, schedule, safety, and quality objectives.

The Engineering Brain operates as a closed-loop cyber-physical system. Data collected from the physical world are analysed in the cyber domain, decisions are formulated using domain knowledge and AI models, and instructions are transmitted back to physical entities—machines, crews, or robotic systems—for execution. Through this loop, projects evolve continuously with minimised risks and maximised efficiency. The framework effectively positions Engineering Brain as the "Metaverse for future engineering," enabling seamless interaction among physical, cyber, and mixed reality environments.

Translation into Practice and Global Economic Impact

Professor Wang's research is distinguished by its large-scale industrial

translation and measurable economic impact. His digital twin–enabled intelligent scheduling method delivered a 15% reduction in project time and $1.2 million savings during the Woodside Pluto LNG turnaround project, completing the turbine upgrades 2.5 days ahead of global benchmarks and reducing minor first-aid cases by 50%. Similarly, the Woodside Smart Tag System, which introduced real-time tracking of millions of materials, reduced downtime by 65% and improved construction efficiency by 30%, and was later commercialised as Track'em.

Professor Wang's industry impact has been reported more than 40 times in prestigious international media outlets. His collaborative work with industry partners has been featured twice in *The Australian*, as well as in CNN and Business News, reflecting both the technological novelty and economic significance of his contributions.

Through the Curtin Advanced Technology Research and Innovation Alliance (CATRINA), Professor Wang catalysed large-scale collaborations between academia and industry, leading to the creation and commercialisation of ten patented technologies and eleven industry best practices applied across infrastructure, energy, and smart cities. His global collaborations include partnerships with Fortune Global 500 companies such as Shell, China Communications Construction Company (one of the world's largest infrastructure enterprises), Samsung Heavy Industries (the world's largest shipyard), POSCO (the seventh-largest steel manufacturer globally), as well as Woodside Energy Ltd. and over forty international engineering firms, many listed among ENR Top 500 companies. These partnerships demonstrate the global reach and practical influence of his research.

The International Society for Smart Construction and Production (SCP)

Founding, Evolution and Strategic Positioning

The International Society for Smart Construction and Production (SCP) was co-founded by Professor Xiangyu Wang together with Professor Vijay Singh, Fellow of the United States National Academy of Engineering, and Professor Konrad Bergmeister, Fellow of the German National Academy of Sciences Leopoldina and Fellow of the European Academy of Sciences and Arts. The Society represents a deliberate initiative by internationally distinguished scholars to establish a global institutional platform dedicated to advancing intelligent construction and digital production systems.

SCP's origins date back to 2015, when Professor Wang founded the Curtin Advanced Technology Research and Innovation Alliance (CATRINA). CATRINA was created as an industry–academia alliance aimed at pioneering advanced technologies for construction and production industries. Between 2020 and 2024, the initiative evolved through the Asian Institute of Engineering Brain, broadening its theoretical scope and international engagement. In 2024, the organisation was

formally rebranded as the SCP, reflecting its expanded global mandate and strengthened commitment to innovation, collaboration, and knowledge dissemination across academia, industry, and government sectors.

SCP was founded on the recognition that the future of construction and production industries requires coordinated international leadership to integrate artificial intelligence, robotics, digital twins, smart sensing, generative design, and sustainable materials into mainstream practice. The Society therefore functions not merely as an academic association but as a global innovation platform accelerating technological transformation in the built environment.

Mission, Vision and Strategic Focus

The mission of SCP is to advance the integration of cutting-edge technologies in construction and production by bridging the long-standing gap between academic research, industrial implementation, and public policy. It seeks to create a synergistic ecosystem in which emerging technologies are rigorously developed, validated, standardised, and deployed to address real-world engineering challenges.
Its vision is to become the leading global organisation promoting smart construction and intelligent production technologies. SCP aims to foster a collaborative international network of experts and institutions, driving the industry forward through continuous innovation, structured knowledge exchange, and capacity building.

To realise this vision, SCP concentrates on strategic domains including smart sensing systems, construction automation, intelligent production, AI-powered generative solutions, standards and best practices development, and advanced education and training for future-ready professionals. These focus areas align closely with global priorities in sustainability, resilience, digital transformation, and infrastructure modernisation.

Governance and International Leadership

SCP's organisational structure is designed to ensure strategic clarity, scientific excellence, and global reach. The Governance Board provides overall strategic direction and oversight. It comprises distinguished leaders from academia, industry, and government, offering intellectual authority and international credibility.
Members include Ian F. C. Smith (Fellow, Swiss Academy of Engineering Sciences), Mirosław Skibniewski (Elected Member, National Academy of Construction, USA), Mark Billinghurst (Fellow, Royal Society of New Zealand), Surendra P. Shah (Fellow, US National Academy of Engineering), Brahim Benmokrane (Fellow, Royal Society of Canada), Abdel-Hamid I. Mourad (Fellow, Mohammed bin Rashed Academy of Scientists), and Giuseppe Lacidogna (Fellow, European Academy of Sciences). Their participation ensures SCP remains aligned with global scientific and technological frontiers.

Supporting the Governance Board is the Vice President (Dr Jun Wang), who coordinates strategic initiatives across the International Scientific Committee, Youth Professional Committee, Regional Chapters, and Innovation Hubs. This structure enables SCP to combine international research leadership with regional engagement and emerging talent development.

The International Scientific Committee, comprising 26 members from the United States, United Kingdom, Australia, Germany, China, Japan, South Korea, India, and the Netherlands, serves as the intellectual backbone of the Society. It guides research priorities, oversees scientific activities, and ensures high standards for the annual International Conference on Innovative Production and Construction (IPC), SCP's flagship global forum.

The Youth Professional Committee reflects SCP's commitment to generational renewal by providing structured opportunities for young researchers and professionals to participate in innovation initiatives and international collaboration. Regional Chapters and Innovation Hubs extend SCP's operational capacity, facilitating geographically distributed research and engagement.

Recognition and Global Influence

SCP promotes excellence through a structured awards framework recognising lifetime achievement, emerging leadership, collaboration, technological innovation, digital transformation, robotics integration, and community impact. These awards are governed by rigorous eligibility and evaluation criteria to ensure recognition of measurable and impactful contributions to the advancement of smart construction and intelligent production worldwide.

The Lifetime Achievement Award honours individuals with more than 25 years of transformative contributions to the field, while the Young Professional Award recognises exceptional emerging leaders under the age of 38 who demonstrate outstanding promise. Additional award categories celebrate industry–academia collaboration, innovative smart construction projects integrating IoT, AI and digital twins, advancements in smart production and off-site manufacturing, digital transformation initiatives, robotics integration in construction, and projects delivering measurable community impact.

In 2025, SCP successfully held its inaugural award ceremony in Perth, Australia, marking an important milestone in the Society's development. The event brought together international scholars and industry leaders, reinforcing SCP's growing global presence and its commitment to excellence and innovation.

Lessons learned from the Fukushima Daiichi Nuclear Power Plant Accident

by Shigenao Maruyama, Member EUAS

Short Biography

Present Affiliation: President, National Institute of Technology, Hachinohe College, Hachinohe 039-1192, Japan

Academic Qualifications

B.Eng. 1977, Department of Mechanical Engineering II, Tohoku University, Japan
M.Sc. 1979, Department of Aeronautics, Imperial College, London University, UK
M.Eng. 1980, Department of Mechanical Engineering, Tohoku University, Japan
PhD 1983, Department of Mechanical Engineering, Tohoku University, Japan

Professional Carriers

1983 Assistant Professor, Institute of High Speed Mechanics, Tohoku University
1988 Visiting Scholar, School of Mechanical Engineering, Purdue University, USA
1989 Associate Professor, Institute of Fluid Science, Tohoku University
1997 Professor, Institute of Fluid Science, Tohoku University.
2005-2006 Specially Appointed Assistant to the President, Tohoku University
2006-2009 Councilor, Tohoku University
2006-2008 Special Advisor to President, Tohoku University
2006-2013 Special Advisor for Centenary Events and Alumni, Tohoku University
2008-2011, 2015-2017 Distinguished Professor of Tohoku University
2016 Visiting Professor, INSA de Lyon
2017 Professor Emeritus of Tohoku University
2017- 2023 President, National Institute of Technology, Hachinohe College
2023 Professor Emeritus of National Institute of Technology, Hachinohe College

Awards

Japan Society of Mechanical Engineers (JSME), Award for Young Engineers, 1989
Fluid Science Foundation, Award for Fluid Science, 1995
Heat Transfer Society of Japan (HTSJ), Award for Scientific Contribution, 1998, 2016
JSME Medal for Outstanding Paper, 1999, 2013
HTSJ, Award for Scientific Measurement, 1999
JSME Tohoku Division, Award for Technical Contribution, 2001
Japan Society of Applied Electromagnetic and Mechanics, Best Technical Contribution Award, 2001
JSME Thermal Engineering Division, Award for Academic Achievements, 2001
HTSJ, Award for Technical Contribution, 2002
Societe Francaise de Themique, 2002 International SFT Award, 2002
JSME Thermal Engineering Division, Award for Contribution, 2003
JSME Fellow, 2004
Government of Japan, Japanese Medal of Honor (Medal with Purple Ribbon), 2012

JSME Thermal Engineering Division, Award for Achievements (Research), 2012
HTSJ Honorary Member, 2020

Research Activities

Professor Shigenao Maruyama specializes in thermal engineering. He has published more than 10 books and 300 academic research papers, and has acquired 60 patents. He investigated various aspects of fluid flow and energy exchange. Based on the principle that conventional heat transfer and thermal control focuses on the enhancement of heat transfer and temperature control of equipment, he has proposed a novel concept of heat-transfer control, in which the heat transfer is actively enhanced or reduced. The proposed active thermal insulation system and a heat-transfer control device utilizes Peltier effects. His work is interdisciplinary utilizing knowledge from various academic disciplines. He has co-authored and edited Thermodynamics (JSME Text series) [1], one of the bestselling books on thermodynamics for mechanical engineering students in Japan. He has also published a book to educate the public thermal science [2], and a novel describing accidents in Fukushima Daiichi nuclear plants [3].
Some aspects of his research activities are as follows:

Radiative Heat Transfer

Detailed studies on radiative heat transfer, which is energy transfer by infrared or electromagnetic waves, has been carried out. A generalized analysis method to calculate radiative heat transfer was proposed [4], and this method was applied to analyze heat transfer in semi-conductor processes [5] and industrial furnaces. This method was also applied to large-scale environmental energy transfer processes, such as heat transfer in fogs and clouds [6]. Thermal emission from nano-scale structures was also investigated [7]. These results were published in a monograph [8] which is the first textbook on radiative heat transfer in Japan.

Natural Convection

Natural convection induced by temperature differences in fluid and the gravitational force was studied, and a generalized description was presented [9]. These results were applied to the cooling fins of electronic devices [10]. This research has been extended to understanding large-scale natural convection in oceanography. The up-welling velocity of deep seawater in the ocean which was proposed by Stommel to be a perpetual salt fountain, was

successfully measured for the first time in the world [11].

Active Heat-transfer Control by Peltier Elements

Peltier elements, used as cooling equipment, have been applied to a heat-transfer control device. This device has been utilized to the heat-transfer control of equipment in a microgravity environment [12], in an active catheter, and in artificial heart muscles [13]. Furthermore, this heat-transfer control has been applied to the fields of oriental medicine and cryosurgery [14]. The concept of heat-transfer control has been expanded to fusion of thermal engineering and medical engineering [15].

Wikipedia :
https://ja.wikipedia.org/wiki/%E5%9C%93%E5%B1%B1%E9%87%8D%E7%9B%B4

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[3] S, Maruyama: *FUKUSHIMA*, Yokendo Press, (2012).
[4] S. Maruyama and T. Aihara: Radiation Heat Transfer of Arbitrary Three-Dimensional Absorbing, Emitting and Scattering Media and Specular and Diffuse Surfaces, *Journal of Heat Transfer*, Vol. 119, (1997), pp. 129-136.
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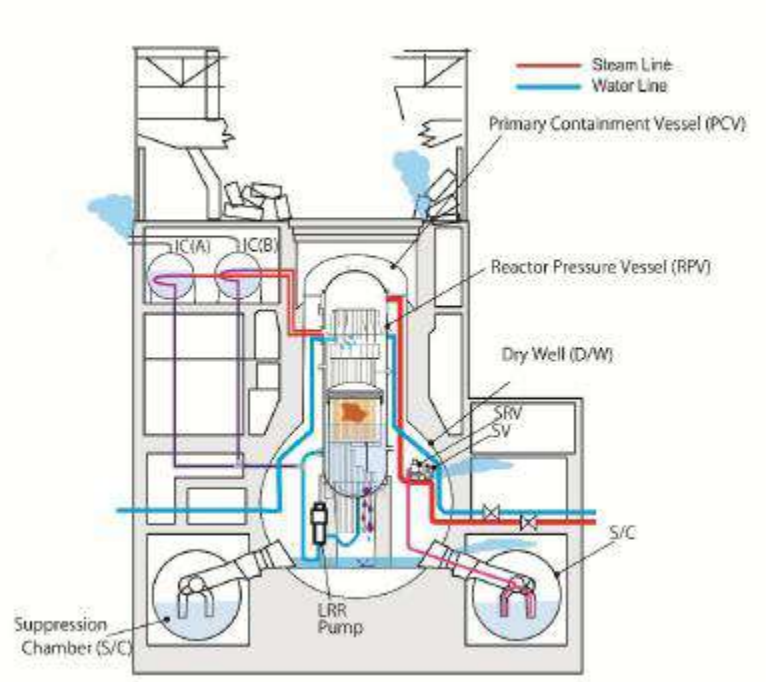
Lessons learned from the Fukushima Daiichi Nuclear Power Plant Accident

Since immediately after the accident at TEPCO's Fukushima Daiichi Nuclear Power Plant in 2011, Maruyama laboratory had been analyzing nuclear reactor accidents and proposing plans for early convergence. We will describe the accident scenario of the Fukushima Daiichi Nuclear Power Plant Unit 1, and discuss why we could not prevent the nuclear accident by comparing with the safety measures of aircrafts and Shinkansen trains.



Improvements in Synthetic Organic and Medicinal Chemistry

by James Cook, Member EUAS

Short Biography

Dr. Cook graduated with a PHD in chemistry from the University of Michigan. He has been a leader in the search for safer drugs to treat patients afflicted with different CNS disorders for over thirty years, including anxiety disorders, neuropathic, pain, resistant forms of epilepsy,schizophrenia,Tourette's syndrome, migraine headaches, depression as well as others. He has published 500 papers in synthetic organic chemistry and neuroscience. One of his compounds was licensed to Bristol Myers Sguibb for anxiety disorders(in humans,Phase I) which led to the development of a back up,KRM-II-81,which is very active in models for treatment of pain,is anxiolytic and is a terrific anticonvulsant. He has patented and licensed this compound to RespireRx for epilepsy, as well as neuropathic pain. He has filed over 70 patents.

He cofounded with Marquette University ,Promentis Pharmaceutical Company, which currently has a compound in Phase II for anxiety and obsessive compulsive disorders. He also developed a lead compound for asthma,which Dr Arnold took, improved upon and formed the basis of the MIDD formed start up company ,Pantherics. Very recently he cofounded a company with Dr.Soma Sengupta and Dr.Daniel Krummel from the University of Cincinnati, called Amlal Pharmaceuticals. His group's compounds are active against Group III cancers, including pediatric brain tumors and melanomas. He is currently working on a license with Alpha Cog with Dr. Etienne Sibilli at CAMH for a compound active against depression that is also precognitive. It is the precognitive and antianxiety effect that makes this compound so novel and we expect it will be active against the negative symptoms and cognitive deficits of schizophrenia. This antidepressant,procognitive agent,GL-II-73, is being targeted toward the treatment of depression, schizophrenia, and Alzheimer's Disease.

In our research group we have been interested in replacing Valium,Xanax,and other sedating, addictive benzodiazepine tranquilizers with ones with no side effects. We have developed potential drugs with an imidazodiazepine structure,which is called a "privileged structure". It is a hybrid of two compounds that have been in humans for over 45 years,with a minor structural change,that inhibits activity at alpha 1 receptors in the brain that cause sedation,ataxia,amnesia,addiction and dependence like Valium. Our lead compound KRM-II--81 has proven very effective in 5 animal models of resistance/refractory epilepsy,which should work in children and adults when other drugs do not ,or other drugs do,but put you to sleep, or the patient develops tolerance. Secondly ,the antinociceptive activity of this compound has been carried out in 7 different models and it was more active against pain than the known gabapentin or tramadol(Lilly). We believe the data indicates it should be active against diabetic neuropathy, back pain,fibromyalgia,complex regional pain syndrome, neuropathic pain and cancer pain.In a recent pain model it showed no signs of tolerance(like morphine does),nor dependence, nor was it sedating or ataxic in rhesus monkeys.

Personal Statement

Dr. Cook and his group recently developed the most subtype selective alpha 6 ligand reported, to date, that is active against trigeminal neuralgia, migraine and opioid use disorder in animal models with no side effects in rodents and primates. It was licensed to a company run by joe beck, thru the UWM research foundation (Brian Walsh). This is one of 4 different compounds licensed for 4 different diseases by his group, one of them he cofounded for cancer (Amlal Pharmaceuticals), he also licensed a compound to damona pharmaceuticals for depression, which has also been cleared for phase i clinical trials and may also be effective to treat Alzheimer's disease. Finally, his group has developed an antiepileptic compound active against pharmacoresistant epilepsy including dravet syndrome with no tolerance, and no sedation, nor dependence. This compound is also active against neuropathic pain, again with no tolerance, sedation, nor dependence. This potential drug has been licensed to respirerx for epilepsy. We published ten papers in this area this year and filed 15 patents, some of which have been issued. Over the years his research group, composed of 70 undergraduate research students and 85 MS and PhD students, has published over 575 papers and book chapters, as well as filing over 120 patents. Many of which have been issued. He has also been assisted by over 20 postdoctoral coworkers.

Early in his career his group developed the asymmetric pictet-spengler reaction, which permitted the enantiospecific total synthesis of over 170 indole alkaloids, some of which were bisindole alkaloids. His group very recently developed the ambidextrous pictent-spengler reaction. This modification permits the entantiospecific total synthesis in both enantiomeric forms of c-19 methyl substituted macroline, sarpagine and ajmaline indole alkaloids beginning with either d or l tryptophan. This permits the synthesis of the unnatural enantiomer of these alkaloids for biological screening. During this phase of his career, he met Dr. Ulrich Weiss, who had discovered the Weiss reaction, which yielded 5 or 6 products, but it was the condensed 5-membered rings that caught Dr. Cook's attention. His group focused on getting only one product from this reaction, which they did. In collaboration with Dr. Steven Bertz another advance was made. From the Weiss reaction Dr. Cook's group was the first to make staurane and staurane tetraene, and in collaboration with Dr. Bertz, the total synthesis of modhephene using novel copper chemistey. Modhephene is a unique propellane like natural product made at the same time by Dr. Paul Wender. Dr. Cook's group then undertook the synthesis of condensed unsaturated five-membered rings, which culminated in a new synthesis of triquinacene, and a number of strained olefinic poluquinenes and substituted triquinacenes, which resulted in the

name the "weiss-cook reaction" still used to this day.

In 1978 he and his group began a program in medicinal chemistry, which was directed towards development of a treatment for alcohol abuse with Dr. Harry June, which continues to this day with Dr. James Rowlett and his team of tenured investigators. This has culminated in a series of papers important in alcohol abuse, cocaine abuse and opioid use disorder. In working toward receptor subtype selective benzodiazepine ligands, his group has developed the best alpha 1 subtype selective (bcct) antagonist, to date. They have developed alp2/3 subtype selective ligands, which are active against epilepsy, neuropathic pain, as well as anxiety disorders with no tolerance, sedation, nor dependence. In this same vein, the alpha 5 subtype selective ligands developed in Milwaukee are active in the treatment of asthma, depression, schizophrenia, anxiety, and tic disorders in animal models. The development of the first alpha 6 subtype ligands was discussed in paragraph one. The early alpha 5 compounds, which relax bronchoconstriction, allowed him and Dr. Charles Emala to file patents on these compounds to treat asthma. These patents and compounds pertimited two colleagues to start a new company termed pantherics. He also cofounded a company initially targeted toward treatment of schizophrenia with dr. David maker at Marquette University termed promentis pharmaceutical company, which later had a compound in phase ii clinical trials for a specific anxiety disorder for his work Dr. Cook has received a number of awards : the Milwaukee section ACS award in chemistry (1989),the wisys(Wisconsin system) innovation scholar award(2006), the UW-Milwaukee innovator award(2007), the hector deluca scientific achievement award from bioforward (2022), the Japanese society for the promotion of science fellowship award, the faculty of the year in chemistry and biochemistry at UW-Milwaukee in 2016-2017 and 2018-2019, and the University of Wisconsin Milwaukee alumni award (2026). Dr. Cook could not have done any of this work without a group of outstanding, undergraduate, graduate and postdoctoral coworkers, for which I will remain eternally grateful.

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Toughened Self-Assembled Monolayers for Durable Perovskite Solar

by Qing Jiang, Member EUAS

Short Biography

Qing Jiang is a Professor of the School of Materials Science and Engineering, Jilin University since 1992. He received his BSc and MSc in Materials Science from Jilin University of Technology (merged into Jilin University in 2000) in 1982 and 1984, respectively, and PhD in Chemistry from University of Stuttgart, Germany in 1990.
Dr. Jiang was elected as a Member of the EU Academy of Sciences in 2018, an Academician of the Asia Pacific Academy of Materials in 2015, and a Fellow of The Institute of Physics (U.K.).
His current research interests include synthesis of nanomaterials as well as their applications in catalysis, energy storage and conversion (fuel cell, batteries, and electrocatalysis), with focus on kinetics aspects of mass transfer and chemical reaction. He has published more than 900 papers in peer-reviewed journals, including Nature, Nat. Energy, Nat. Nanotechnol., Nat. Chem., Nat. Commun., Sci. Adv., etc. His publications have been cited more than 46,000 times with H-index = 105 (Web of Science).

In 2025, he authored and coauthored 60 papers and five representative ones with their abstracts are listed below:

1. Wenlin Jiang,# Geping Qu,# Xiaofeng Huang, Xia Chen, Linyuan Chi, Tonghui Wang, Chun-To Wong, Francis R. Lin, Chunlei Yang, Qing Jiang,* Shengfan Wu,* Jie Zhang,* Alex K.-Y. Jen,* Toughened self-assembled monolayers for durable perovskite solar, Nature 2025, 646, P95-101.

Abstract

Hole-selective self-assembled monolayers (SAMs)1,2 have played a key role in driving the certified power conversion efficiency (PCE) of inverted perovskite solar cells3–5 to 26.7% (ref. 6). However, their instability often compromises the operational performance of devices, strongly hindering their practical applications7,8 . Here we employ a cross-linkable co-SAM to enhance the conformational stability of hole-selective SAMs against external stresses, while suppressing the formation of defects and voids in SAM during self-assembly. The azide-containing SAM can be thermally activated to form a crosslinked and densely assembled co-SAM with a thermally stable conformation and preferred orientation. This effiectively minimizes substrate surface exposure caused by wiggling of loose SAMs under thermal stress, preventing perovskite decomposition. This enables a certified PCE of 26.92% to be achieved for the best-performing cell, which also possesses excellent thermal stability with negligible decay under maximum power-point tracking at 85 °C for 1,000 h. It also retains >98% of initial PCE after 700 repetitive thermal cycles between −40 °C and 85 °C, representing the state of the art of the field. This work offers an in-depth understanding of SAM degradation mechanisms to guide the design of a more robust buried interface for SAM-based devices adopting high-roughness substrates to realize highly efficient and durable perovskite solar cells.

2. Zhiling Luo, Wang Gao,* Qing Jiang,* Determinants of vacancy formation and migration in high-entropy alloys, Sci. Adv. 2025, 11, eadr4697.

Abstract

Vacancies are crucial for the radiation resistance, strength, and ductility of high- entropy alloys (HEAs). However, complex electronic interactions resulting from chemical disorder prohibit the quantification of vacancy formation energy (Ef) and migration barriers (Eb). Herein, we propose an electronic descriptor χSv (electronegativity χ and valence- electron number Sv) to quantify the bonding strength of constituents on the basis of the tight-binding model, which allows us to build analytical models to achieve the site-to- site quantification of Ef and Eb. The descriptor χSv reflects the d-band occupation, indicating the dominant role of the electronic interactions in the vacancy formation and migration of HEAs. As a size effect, local lattice distortion plays a more important role in vacancy migration than in vacancy formation. Our model establishes a universal physical picture of vacancy formation and migration, which helps to understand the radiation resistance and mechanical properties of HEAs, thereby accelerating the design of high-

performance HEAs.

3. Jie Bai, Hui Ping Li, Yu Fei Zheng, Hong Zhang,* Chun Cheng Yang,* Qing Jiang,* Bi: A rising star for low-temperature fast-charging sodium-ion batteries", Mat. Sci. Eng. R 2025, 166, 101056.

Abstract

The rising demand for energy storage, such as electric vehicles in extreme conditions, polar and deep-sea exploration, necessitates batteries with exceptional low-temperature performance. Sodium-ion batteries (SIBs) exhibit wide temperature range adaptability and superior rate capability owing to smaller Stokes radius compared with Li+. Bi-based materials are characterized by low cost, moderate reaction potential and high volumetric capacity. In addition, the integration with ether-based electrolyte endows the Bi electrode with a continuous three-dimensional (3D) porous nanostructure, rendering it a promising candidate for fast-charging anode. Nevertheless, the low-temperature capabilities are constrained by a multitude of factors, including sluggish solid-state diffusion, diminished ionic conductivity, and slow Na+ desolvation kinetics. In this review, the challenges of huge volume expansion and opportunities of high diffusion coefficient intermediate phases for Bi-based materials are highlighted. A series of low-temperature high-performance Bi-based materials are also summarized, along with chemical design strategies tailored to enhance their performance. This review culminates in an overview of the prevailing challenges and prospects for the advancement of Bi-based materials as fast charging anodes in low-temperature environments.

4. Ying Zhang, Hui Li, Xu Liu, Zhen Xin Hui, Zhi Wen Chen,* Jian Li, Zi Wen, Chun Cheng Yang,* Qing Jiang,* Sub-3 nm high-entropy alloy nanoparticles with triple functionalities for efficient electrolytic hydrogen production, Adv. Mater. 2025, 37, 2508975.

Abstract

High-entropy alloys (HEA) exhibit great promise for alkaline hydrogen evolution reaction (HER) due to tunable structures, yet suffer from low atomic utilization, insufficient current density, and unclear catalytic mechanism. Herein, ultrasmall sub-3 nm PtRuFeCoNiCu HEA nanoparticles are synthesized on carbon fiber paper (CFP) via a 0.5 s ultraquick thermal shock strategy (us-HEA/CFP). The as-prepared hybrid demonstrates the best-level

performance among reported catalysts, achieving ultralow overpotentials of 31.4 and 102.5 mV at -100 and -1000 mA cm−2, respectively, in alkaline media. Such exceptional catalytic performance stems from the triple-functional nature of the HEA surface: Ru-dominated regions facilitating rapid H2O dissociation, FeCoNiCu sites enabling optimal H* diffusion kinetics, and Pt-rich zones promoting efficient H* combination. This synergistic dissociation-diffusion-combination mechanism has been unequivocally validated via in situ Raman spectroscopy and density functional theory calculations. Practically, the assembled anion exchange membrane electrolyzer only requires 1.94 V to deliver 1000 mA cm−2 and can operate stably for 500 h, showing strong potential for large-scale H2 production.

5. Hang Shi,# Tian-Yi Dai,# Xin-Ying Sun, Zhi-Lan Zhou, Ying Wang, Shu-Pei Zeng, Tong-Hui Wang, Gao-Feng Han, Zi Wen, Qian-Rong Fang, Xing-You Lang,* Qing Jiang,* High-entropy alloy/intermetallic compound heterostructures for efficient hydrazine oxidation-assisted hydro-gen production, Adv. Mater. 2025, 37, e12081

Abstract

Configuring integrative catalytic heterostructures is an efficient strategy to circumvent the universal linear scaling relationships for accelerating multiple-intermediate redox reactions. Here this study reports nonprecious metal-based high-entropy alloy/intermetallic compound heterostructure with a 3D nanoporous architecture as a high-performance electrocatalyst for hydrazine oxidation reaction. By making use of strain engineering of hexagonal close-packed multicomponent intermetallic compound core, high-entropy NiFeCoCuCrMn alloy surface is comprised of multiple active centers with undulatory adsorption energies, which enable *N2Hx intermediate spillover to adjust rate-determining step and lower kinetic barriers. As a consequence of nanoporous architecture endowing abundant multiple active surfaces, this heterostructure mediates hydrazine electrooxidation of as high as ampere-level current densities at >0.08 V versus reversible hydrogen electrode, showing genuine potential to replace sluggish oxygen evolution reaction for hydrogen production via water electrolysis. Its hydrazine oxidation-assisted water electrolyser delivers 500 mA cm−2 at ultralow cell voltage of 0.87 V, and maintains exceptional stability for 1000 h.