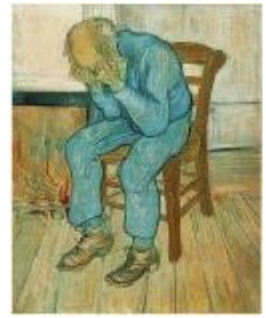
The PTF Newsletter

I want to express my sincere appreciation to those who have provided valuable feedback regarding the content and the format of the newsletter. The upcoming Summer Issue will focus on technical content. One of the objectives of our newsletter is to facilitate sharing of ideas and expertise amongst PTF members, and to educate and inspire the young researchers. All contributions furthering this mission are welcome.

Shrikant Dhodapkar
The Dow Chemical Company
Editor, PTF Newsletter

IN THIS ISSUE...

Letter from the "Chair"



Welcome to another year of exciting PTF activities! Hope you enjoyed the AIChE Annual meeting and much needed Holiday break. I take this opportunity to thank all those who helped with the PTF events, from programming to managing bus tours! My personal thanks to Bruce Hook and Willie Hendrickson for a great PTF dinner, and thanks to all the sponsors of the dinner and bus tour.

This year, PTF is undertaking several new initiatives; the most exciting of those is the student travel awards. This effort is led by Ben Freireich and others of the Executive Committee (EC), who are all working hard to find sponsors and selection procedure. Let Ben and/or I know if your company is interested in sponsoring doctoral students for travel awards to attend the 2018 AIChE Annual meeting. More details to follow, so stay tuned.

This year we also hold elections for new members of the PTF EC. The positions are designated as 2 from industry/ government and 2 from academia, with 4-year terms starting 2019 to end in 2022. Responsibilities include attendance at the Executive Committee meeting on Sunday (typically around 5pm) at the start of the AIChE Annual Meeting, in addition to conference calls and contributing to PTF tasks and activities throughout the year. There are several specific tasks that are available for you to select from for your responsibility as a PTF-EC member. Both self-nominations and nominations of others (with their consent) are encouraged. The nominator and the nominee should both be members of the AIChE-PTF. Please send a short paragraph bio (limited to 150 words) of any nominee to me <dave@njit.edu> by Friday June 15th, 2018 if interested in being on the PTF ballot.

I hope most of you will be attending the World Congress in Orlando next months. Safe travels and I see you there.

Rajesh N. Dave, NJIT
Chair, Particle Technology Forum

PTF Award Lectures

Lifetime Achievement Award - Prof. Al Weimer

H.T. Sears Memorial **Professor Alan (Al) Weimer**, 2017 recipient of the PTF Lifetime Achievement Award, has had a distinguished career spanning both industry and academia. Al received his B.S. in chemical engineering from the University of Cincinnati in 1976 and his Ph.D. in chemical engineering from the University of Colorado in 1980.

Al had no inclination to pursue an academic career and joined the Dow Chemical Company (Midland,. MI) immediately following graduation in 1980, where he pursued research his entire industrial career. He received five promotions with Dow including promotion to Associate Research Scientist in 1995. He developed a fluidized bed process for Fischer-Tropsch Synthesis and later carried out internal fluidized bed agglomeration consulting work with Dow's then pharmaceutical entity, Marion Merrill Dow. He was also involved with troubleshooting Dow's polymeric fluidized bed dryers and a fluidized bed process in Ludington, MI to make spherical Peladow calcium chloride ice-melter. In the mid to late 1980's he invented the rapid carbothermal reduction (RCR) process for the direct synthesis of submicron sized non-oxide ceramic powders, including boron carbide (B_4C) [1], silicon carbide (SiC)[2], and ultimately tungsten carbide (WC) which was commercialized first at Dow and later by Sandvik AG in Coromant, UK. All commercial ceramics powder processing methods at that time used extended reaction times at high temperature to drive highly endothermic carbothermal reduction reactions followed by intensive grinding to reduce particle size (such as the Acheson Process, or electric arc furnace processes. Alternatively, Al discovered that the same precursor powders could be reacted to completion in fractions of a second as dispersed dust clouds using radiation heat transfer from the walls of a containment vessel. If the reaction time were limited, fine submicron B_4C, SiC, and WC particles could be synthesized directly and required no subsequent grinding. He developed this process and designed the first commercial reactor which was a transport tube operating at near 2000^oC. The innovation was met with major skepticism within Dow, but pilot plant data confirmed the discovered innovation and funds were allocated to construct a commercial market development plant. One of Al's most memorable moments was receiving a letter from Dr. Svante Prochazka at GE who is considered by many as one of the founders of the modern day field of technical ceramics. Dr. Prochazka discovered the method for making SiC useful in order to fabricate SiC parts. In his letter, Dr. Prochazka told Al that he believed the RCR process was "the most significant innovation in ceramics in the last 25 years". A photo of the high quality WC powders made by RCR as well as a photo of the first commercial RCR reactor and the commercial process building housing it are shown in Figure 1. For this innovation, Al received the Dow *Spangenberg Ceramics Founder's Award* in 1991, was named a Dow *Inventor of the Year* awardee in 1993, and was recipient of the coveted Dow *Excellence in Science Award* in 1995. A photo of him receiving the *Excellence in Science Award* from the Dow VP for Research, the Dow Director of Research, and Dow's Chief Scientist is shown in Figure 2. He was named a Dow Chemical Associate Research Scientist in 1995, but subsequently left Dow for the University of Colorado (CU) in 1996. The fun went away for him as the global economy hit and Dow, like many other U.S. companies, elected to significantly cut back on their discovery type research as they pursued capital projects around the globe instead.

At CU, Al started research programs in two areas, both of which were take-offs from his Dow career experiences. The first is using concentrated sunlight to drive high temperature chemical reactions, replacing conventional electric resistive heating (like commercial RCR), to achieve temperatures above 1500^oC. His research group has published over 75 peer-reviewed research papers in the solar thermal chemical processing field. It is recognized as a leading global entity for the design of solar thermal chemical reactors, using concentrated sunlight to achieve the required ultra-high temperatures. A major focus of the research is using concentrated sunlight to split water producing renewable hydrogen. Al's research has resulted in papers published in the journal Science[3]where he demonstrated the ability to carry out redox reactions under isothermal conditions using chemical potential to drive the process instead of a wide variation in the reduction and subsequent steam oxidation temperature. This finding changed the way researchers investigated the redox processing, which was done for decades. His research group is a leader in the development of active particulate materials for redox water splitting processing focusing on robust redox materials which function by generating and filling O-vacancies in a stable matrix. Al's research team is the largest academic solar thermal chemistry research group in the Unites States. He received the 2005 U.S. DOE *Hydrogen Program R&D Award* and the 2015 AIChE *Sustainable Engineering Forum Research Award* for his pioneering developments using concentrated sunlight for chemical engineering applications.

His second research thrust is focused on the functionalization of fine particles by atomic layer deposition (ALD). From his Dow research, he understood the importance of controlling surface chemistry on fine particles. So, when he heard an ALD chemistry seminar by one of his now chemistry colleagues in 1997, he immediately considered the impact of such chemistry for the coating of fine particles and initiated a collaboration. He saw the unique ALD chemistry being applied to flat surfaces and recognized the extraordinary potential of the method to coat ultra-fine particles (i.e., Particle ALD). He and his group used in-situ FTIR analysis to demonstrate that self-limiting surface chemistry ALD techniques could be used to place nanofilms on the surfaces of primary particles[4]. This proof-of-concept work was critical to begin exploring more traditional/scalable particle-coating unit operations. Shortly thereafter, Al's group demonstrated that a fluidized bed reactor could be used to deposit Al_2O_3 nanofilms on bulk quantities of micron-sized particles using Particle ALD[5]. His group was then the first to coat polymer particles with ceramic films by ALD[6]. They were also the first researchers to demonstrate that Particle ALD could be used to apply conformal, pinhole-free films onto individual high-surface-area nanoparticles without "gluing" them together[7]; the first to deposit metal films (tungsten) on metal or polymeric particles[8]; and the first to deposit ceramic films on polymers using a fluidized bed reactor[9]. Subsequently, Al and his group were the first to demonstrate molecular layer deposition (MLD) using scale-able fluidized beds[10], that nanothick microporous/mesoporous films (1250 m^2/g) could be placed on particles[11], and that skeletal nanothick walled particles could be fabricated using sacrificial polymer particles as templates[12]. On the engineering side, Al's team has demonstrated that Particle ALD in a scale-able fluidized bed reactor provides for an efficient cost-effective process where the utilization of ALD precursors to coat high-surface-area particles approaches 100%[13]. Web of Science indicates that the number of publications on "particle and atomic layer deposition" has grown from 10 in 2000–2002 (Al's papers) to 823 today, with a total of 18,178 citations since 2000 (3,853 citations in 2017 alone). Sixty-seven of those publications and 2,485 of the citations are to Al, who invented the method.

On the patent side, Al and his research group were awarded broad patents [U.S. Patents 6,613,383; 6,713,177; 6,913,827] for a facile and controllable method for functionalizing ultrafine primary particles (including primary nanoparticles) with ultrathin, nanometer-thick, pore-free, conformal films using atomic layer deposition, ALD. This enabling technology now serves as a platform for preparing improved devices used in lighting/displays (e.g., CFL phosphors, additives [U.S. Patent 8,637,156]), energy storage/generation (e.g., Li-ion batteries, supercapacitors, solar [U.S. Patent 8,397,508]), medical treatment (e.g., drug contact materials, wound care, dental, implantable devices [U.S. Patent 9,279,120]), personal care (e.g., sunscreens, cosmetics [U.S. Patent 8,133,531]), military defense (superthermites, armor precursor materials), and chemical industry/electronics (catalysts, paint/pigment, thermal fillers, printed inks, powdered magnetics, ESD/surge protection, cement [U.S. Patent 7,132,697]). The progression of particle coating over decades is shown in Figure 3 along with a high-resolution micrograph of primary non-agglomerated nanoparticles conformally coated by ALD (i.e. Particle ALD). Primary commercial applications include the use of Particle

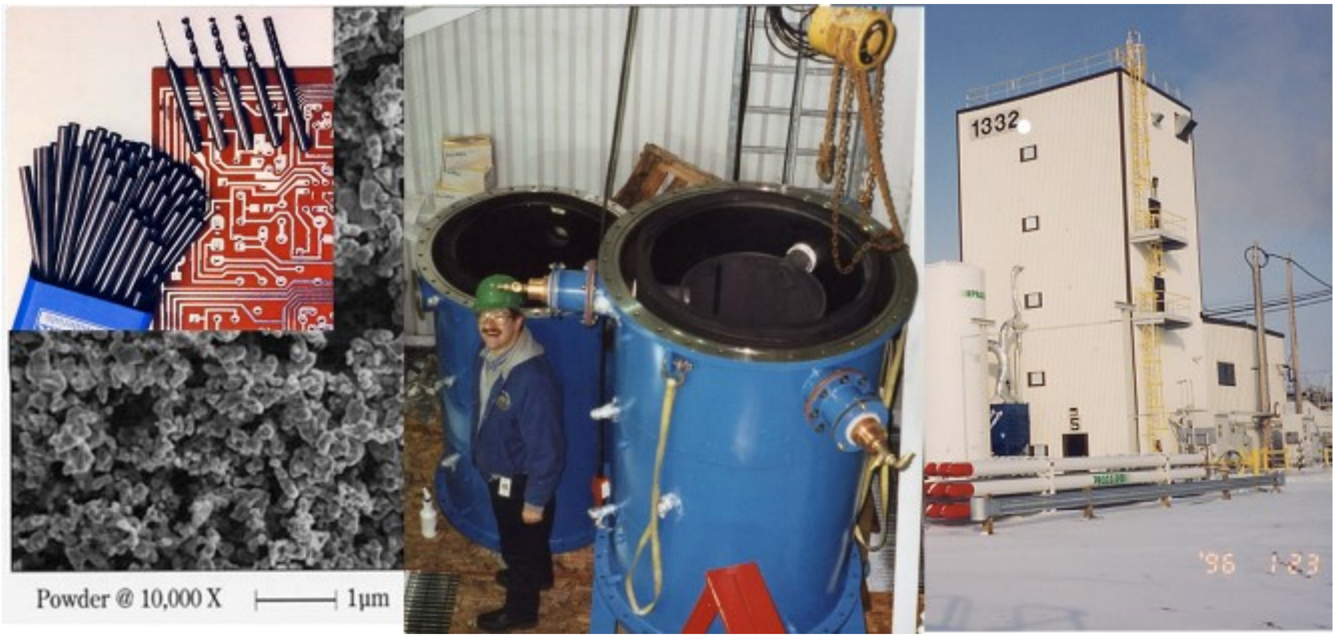
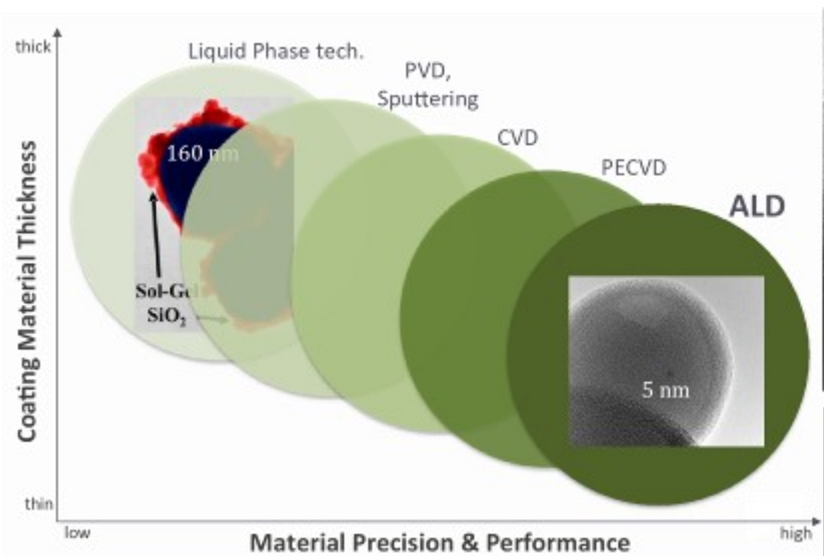
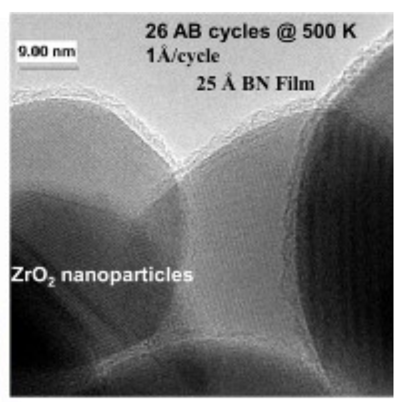


Figure 1. a) Ultrafine WC Micro-powder by RCR (with insert of product microdrills); b) Al Weimer designed 1st commercial RCR reactor; c) First commercial RCR plant for WC Micropowders (Midland, MI)

Figure 2. Al Weimer receives Dow Chemical "Excellence in Science" Award (May, 1995) from Dow Research VPs and Chief Scientist for "Outstanding Scientific Research", Invention, Development and Commercialization of RCR





Each advancement in materials technology has unlocked new $billion markets

Figure 3. Revolution in Particle Material Technology:

Figure 4. Professor Alan Weimer, CU Boulder, with three other co-founders of ALD NanoSolutions in Broomfield, Colorado

ALD as an environmental barrier film for protecting lithium-ion cathode battery materials (safety and improved lifetime) and active phosphors, etc. used in light emitting diodes (LEDs). Some problems that can be solved with atomically deposited films include Smartphone fires, Li-ion battery lifetimes, and "the great LED light bulb rip-off; one in four expensive long life bulbs doesn't last anything like as long as the makers claim".

Al's service to PTF as a member of the Executive Committee, Treasurer, Vice-Chair, and Chair (2000 – 2006) and similar positions for Area 3B (1990 – 1996) prior to the founding of PTF are continuing as he continues to chair PTF sessions and is currently Area Chair (Particle and Nanoparticle Functionalization) for the WCPT 8 (Orlando, April, 2018).

In summary, Al Weimer's pioneering contributions to the synthesis of ultrafine non-oxide ceramic powders, functionalization of inorganic nanomaterials, and nanoscience applications are cross-cutting (industry and academia) and at the interface of materials science and chemical engineering. His work has contributed greatly to both fundamental understanding and industrial innovation in coated nanoparticle production (e.g., he co-founded ALD NanoSolutions, Inc. (www.ALDNanoSolutions.com) in 2001, now 23 employees and operating two ISO 9001 compliant market development facilities). A recent photograph of him with his three co-founders is shown as Figure 4. For his particle processing accomplishments, Al received the 1997 AIChE *Fluidized Process Recognition Award*, the 2009 AIChE *Thomas Baron Award for Fluid-Particle Systems*, the 2010 AIChE *Excellence in Process Development Research Award*, the 2015 AIChE *Nanoscale Science and Engineering Forum Award*, and the recent 2017 AIChE *PTF Lifetime Achievement Award*. Al is named an inventor on 38 issued U.S. Patents and is a co-author on 200 peer-reviewed publications. He has supervised 28 Ph.D. students. Al will deliver an invited keynote address/plenary presentation at the 2019 PARTEC Meeting to be held in Nuremberg, Germany in April, 2019, as a tribute to his pioneering/trailblazing work in particle processing.

Al would like to thank SABIC, Chevron, Phillips 66, ExxonMobil, Shell, ALD NanoSolutions, CorosTek, NSF, DOE, USDA, NASA, NEUP, and the Bill & Melinda Gates Foundation for their significant professional and financial support of his program. He would also like to thank the Dow Chemical Company for providing him the opportunity to invent, develop, and commercialize novel particle processes.

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PTF Award Lectures

Thomas Baron Award - Dr. Jeffery Morris

The 2017 Shell/Thomas Baron Award in Fluid-Particle Systems was made to **Jeff Morris** of CUNY City College of New York for research contributions focusing on suspensions over a wide range of conditions and scales of examination by several methods of inquiry. These studies have impacted on issues including understanding of nonequilibrium microstructure in suspension flows, constitutive modeling and bulk flow analysis, experimental measurement of the particle pressure, and elucidation of the influence of particle-scale inertia on rheology and flow. The basic formulation of several of these issues has been presented in a book co-authored with E. Guazzelli [1].

The Baron Award lecture by Morris focused on recent developments from the Morris research group examining strong shear thickening. The observation that a very concentrated (or "dense") suspension can undergo an essentially discontinuous change in the viscosity as the imposed rate of flow (shear rate) increases has been known for many years [2,3], and is very easily seen at home by stirring a dispersion of about 50% by volume of cornstarch in water; this mixture is popularly called "Oobleck" after the gooey substance in a story by Dr. Seuss [4] and some amusing examples of its behavior can be seen in online videos [5].

However, there has been substantial uncertainty regarding the mechanism of this behavior. In the work presented in the lecture, Morris discussed the use of computational simulations to explore the complex rheology seen in colloidal dispersions. He focused on recent simulations from his group [6,7] with the crucial developmental work by Dr. Ryohei Seto (now at OIST in Okinawa, Japan) and Dr. Romain Mari (now with the CNRS in Grenoble, France). In these studies, discontinuous shear thickening in close agreement with experimentally observed behavior is found. These simulations are based on considering the particles to have a repulsive force between them. For shearing below a critical threshold value, the particle surfaces remain separated and therefore lubricated by the suspending liquid, while above this threshold it is assumed that they can be pushed together to form contacts due to a bit of roughness on the particles surfaces. The repulsive force thus sets the shear rate needed to drive the suspension into the "thickened" state. A crucial feature of the modeling is that the particles are assumed to interact by a friction law once in contact. Data from simulations by the Morris group are shown in Figure 1, illustrating the range of behavior which particles interacting by a given set of forces of the form described can display as the solid loading is increased. These data show the viscosity as a function of a dimensionless shear rate obtained by scaling the actual rate by a shear rate based on this force scale, particle size and liquid viscosity.

The underlying phenomenon leading to the shear thickening is found to be related to the formation of a frictional contact network which makes the mixture much more resistive to motion. This network formation, illustrated in Figure 2, leads to the observed viscosity increase, and at sufficiently large solid loading, is predicted to lead to a flow-induced solidification or shear jamming as shown in work led by Dr. Abhinendra Singh [8]. Under funding from the National Science Foundation, the Morris group is now actively studying by computational means the contact network and the ways in which strong shear thickening may be controlled and thus enhanced or reduced, for example through better understanding of the role of surface chemistry.

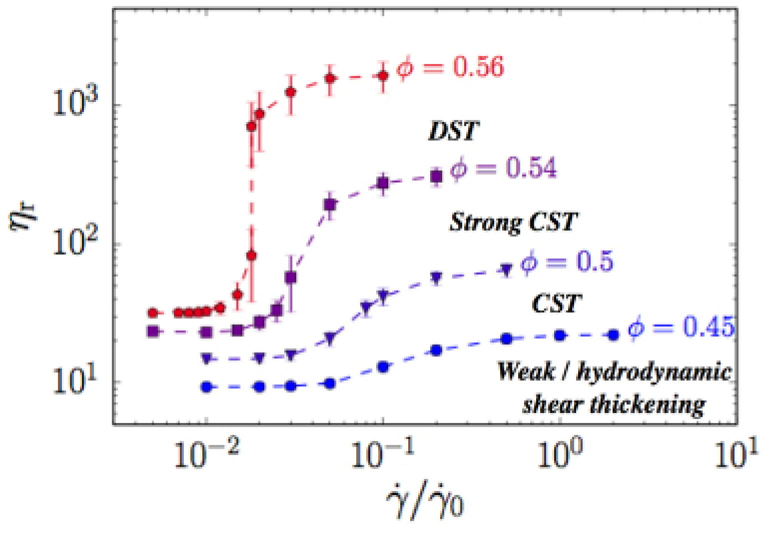

Fig.1 Relative viscosity η_r (measured viscosity divided by fluid viscosity) on the vertical axis, plotted as a function of a scaled shear rate in suspensions of varying solid volume fraction ϕ.The plot demonstrates using simulation data that a suspension may undergo weak thickening when hydrodynamic lubrication between particles dominates at smaller solid fraction, through increasing but still continuous shear thickening (CST) with increasing ϕ until the viscosity jumps discontinuously with increase of shear rate at the highest ϕ considered.

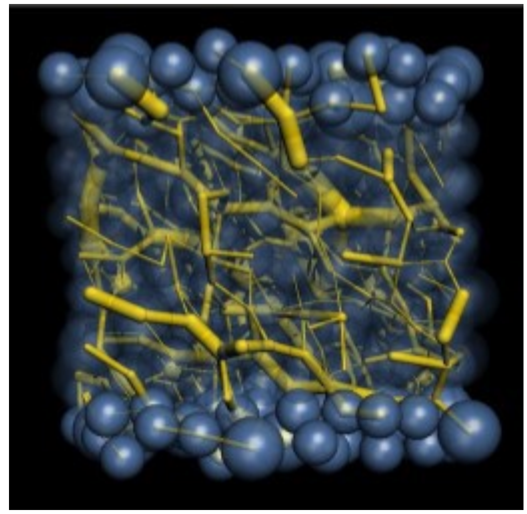

Fig. 2. Transparent images of suspended spherical particles and a representation of the contact network caused by shearing the suspension. The suspension is in the high viscosity or “thickened” state. The lines between particles represent the frictional contact forces acting between the connected pair of spheres, with the magnitude of the force proportional to its thickness.

Key References:

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Special Session Honoring Dr. J.R. Johanson
AIChE Annual Meeting 2017 - Minneapolis

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PTF Membership

To continue receiving the PTF newsletters (3 issues per year) and stay current with particle technology events and news, please make sure to renew/start your membership by either:

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- Become a PTF lifetime member so that you don't have to renew membership every year.

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You can also contact AIChE customer service at 800-242-4363 (US); +203-702-7660 (Outside the US); or email customerservice@aiche.org for membership questions and help.

PTF Membership Committee

PTF Award Nominations - Now Open

Dear PTF Members:

As a result of action by the PTF Executive committee, there again have been changes to the awards criteria and process this year.

Contrary to the last few years, *Nominees no longer are required to be PTF members. On the other hand, those making the nominations must be PTF members.*

Also we are back to a single step nomination process. The nomination form, criteria and package requirements for each award may be found on the AIChE webpage for their respective award. *Full nomination package is due latest by **May 20, 2018** and should consist of a single PDF file that contains all of the following items to be sent to **ptfawards@aicheptf.org**. **This is a one-step process. Any issues with your nomination will be communicated to the nominator.***

The nomination information, award criteria and previous winners for each of these awards is found in the links below:

Elsevier Particle Technology Forum Award for Lifetime Achievements

George Klinzing Best PhD Award

PSRI Lectureship Award in Fluidization

Sabic Young Professional Award

Shell Thomas Baron Award in Fluid-Particle Systems

Dow Particle Processing Recognition Award (only awarded in odd-numbered years, not 2018)

Key information for this year is below.

- ***Nomination process is back to a single step***: The full package is due by **May 20, 2018**, containing items specific to each award
  - If the nominee has previously received any award from PTF, an explicit statement of new accomplishments or work over and above those cited for the earlier award(s) must be included (max. of one double spaced page).
  - Selected bibliography (including books, patents, and major papers published).
- ***It is required that the nominators are current PTF members***
  - For the PTF Lifetime Achievement Award, one of the support letters must be from a former PTF Lifetime Achievement Award winner.
- ***Nominees no longer are required to be PTF members***
  - Except for the PTF Service Award, the Executive Committee has released the nominee PTF membership requirement. PTF membership is still expected for the PTF Service Award.
  - In a given year, the same person cannot win more than one PTF award
  - Those making nominations must be members of AIChE-PTF at the time of the nomination.
  - Wait period for nomination after previous award
  - A former PTF award winner cannot be nominated for another award for at least three years after receiving any previous PTF award

We hope that these changes continue to make the award process smoother and simpler for our membership.

Bruce Hook

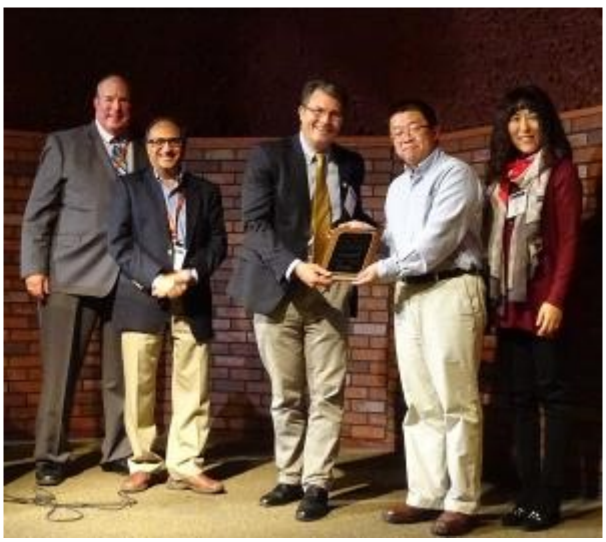
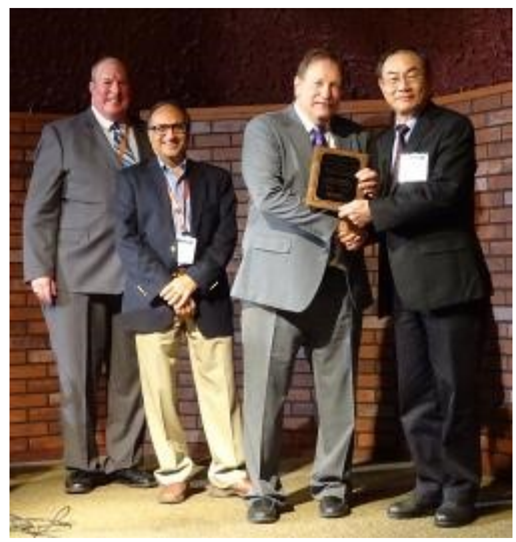
PTF Vice Chair 2016-2018

Particle Technology Forum Awards Dinner

Wabasha Street Caves

Particle Technology Forum Awards Dinner



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Held every 4 years since its inception in 1990, the World Congress on Particle Technology is intended to stimulate discussions on the forefront of research in particle science and technology. The 8th World Congress on Particle Technology (WCPT8) will be held in Orlando in conjunction with the 2018 AIChE Spring Meeting & 14th Global Congress on Process Safety.

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- Coffee Breaks
- Access to the Exhibit
- Also allows you to attend sessions and exhibit of the 2018 AIChE Spring Meeting & 14th Global Congress on Process Safety

FEATURED EVENTS: PLENARIES

Monday, April 23, 2018

10:00 AM - 11:00 AM • Crystal Ballroom G

Contact Charging in Granular Materials

Heinrich M. Jaeger, *University of Chicago*

Contact charging of fine, sub-millimeter particles and the resulting clustering is important in circumstances ranging from the early stages of planet formation to industrial powders to airborne pollutants. Even in systems comprised of grains of identical dielectric material, contact charging can generate large amounts of net positive or negative charge on individual particles, resulting in long-range electrostatic forces. Remarkably, even basic aspects of contact charging, such as the nature of the charge carriers or the charge transfer mechanism are still under debate. This talk focuses on recent work where collision events between individual particles are tracked with high-speed video and the charge on single particles can be extracted. In freely falling granular streams we observe collide-and-capture events between charged particles and particle-by-particle aggregation into clusters. Size-dependent contact charging is found to produce a variety of charge-stabilized "granular molecules", whose configurations can be modeled by taking many-body dielectric polarization effects into account. I will also introduce a new approach, based on ultrasonic levitation, for studying contact charging of single particles. This method allows for measurements under a wide range of environmental conditions as well as applying an electric field, and its exquisite sensitivity makes it possible to determine the charge transferred in a single collision.

11:00 AM - 12:00 PM • Crystal Ballroom G

Mesoscience: Opening a New Paradigm of Particle Technology

Jinghai Li, *Chinese Academy of Sciences*

Mesoscale phenomena exist in between "unit" scales and "system" scales at different levels of the real world, spaning from elemental particle to the universe. Understanding of complex processes at mesoscales, characterized by spatiotemporal dynamic structures, is a common challenge for the whole spectrum of science and technology.

This presentation reviews the three decades of research on mesoscales of particulate systems at IPE-CAS. It was initiated by the energy-minimization multiscale (EMMS) model specific for gas-solid fluidization, which established the stability condition or variational function for particle clustering phenomenon. In extending the model to many different complex systems, such as gas-liquid, turbulence, gas-liquid-solid, emulsion, material preparation, protein, and catalysis systems, the EMMS principle was then proposed generally for different complex systems, featuring compromise in competition between different dominant mechanisms in physics and formulated as multi-objective variational problem in mathematics. With increasing understanding of the generality of this principle, the concept of mesoscience was further advanced, and is believed to be potentially universal for all complex mesoscale phenomena at different levels.

The presentation will also give a perspective on mesoscience. It is believed that more evidence will be needed from various disciplines, particularly, from the field of particle technology where mesoscale phenomena occur everywhere such as in formulating and processing particles. The development of mesoscience will enable our capability in particle design, rational synthesis, smart massive production and system optimization due to its underlying principle to bridge unit scales and system scales. In contributing more evidence to mesoscience in exploring its universality, in return, the knowledge, tools and methods in particle technology will be upgraded to a new paradigm. In such a paradigm, the theory, computation and experiment at mesoscales will be dominant, and the virtual process engineering will be enabling.

Tuesday, April 24, 2018

10:30 AM - 11:30 AM • Crystal Ballroom G

Nature-Inspired Chemical Engineering - a Pathway to Innovation in Particle Technology

Marc-Olivier Coppens, *University College London*

From the way trees grow and what makes our lungs so efficient, to what renders bacterial communities resilient or how regular patterns form in the sand by the action of the wind – nature holds a treasure trove of ideas to inspire solutions to technological problems. These include some of our most challenging problems in manufacturing, energy, sustainability or healthcare. Many of these problems relate to particle technology. Most often, nature's best solutions to a problem extend beyond first appearances and superficial similarities, and, so, observing nature should go beyond mimicking. Gaining inspiration from nature is most effective in solving technical problems when we have sufficient fundamental understanding that can then be appropriately translated within the context of an application. As in any product and process design, the real power of nature-inspired design requires moving beyond biomimicry, and appreciating the technical, industrial or societal context.

In my presentation, I will illustrate the thematic, mechanistic approach underpinning «nature-inspired chemical engineering» (NICE) and then apply it to timely problems in particle technology. I will focus on three key mechanisms that are ubiquitous in nature. First, efficient hierarchical transport networks, which allow for optimal scalability. Second, balancing of various forces, on large scales (mechanics) but also at the nano-scale, leading to confinement effects, where electrostatics play a key role in issues around selectivity and stability, as well as activity for catalysis or permeation for membranes. Third, dynamic self-organization, which is key to resilience and self-healing properties, as well as pattern formation, both in living and non-living systems.

For applications, we will consider problems in gas-solid fluidization, as well as in the design of hierarchically structured particles, which combine nano-confinement effects and optimized transport across length scales. The NICE approach leads to unexpected, out-of-the-box solutions (innovation), but also to new fundamental insights in, for example, fluidization, especially to tackle outstanding questions in particle technology that revolve around mesoscopic physics, which are key for engineers to translate science at the microscopic scale to the macroscopic world of applications.

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Wednesday, April 25, 2018

10:30 AM - 11:30 AM • Crystal Ballroom G

Towards Sustainable Energy and Materials: Carbon Capture and Conversion using Novel Liquid-like Nanoscale Hybrid Particulate Systems

Ah-Hyung (Alissa) Park, *Columbia University*

The atmospheric concentration of CO_2 has naturally fluctuated on the timescales of ice ages. Concerns, however, stem from the recent dramatic increase in CO_2 concentration, which coincides with global industrial development. This rise is mainly due to the high use of fossil fuels during power generation and chemical production. In order to meet the ever-increasing global energy demands while stabilizing the CO_2 level in the atmosphere, the development of carbon capture, utilization and storage technologies is one of the critical needs. In particular, there has been significant efforts to develop CO_2 capture solvents and some have shown very promising results. For example, amine-based aqueous solvents can effectively and selectively capture CO_2 from flue gas of coal-fired power plants. Unfortunately, the energy requirement for the current aqueous solvent systems is still considered to be too high. Thus, efforts have been focused on the development of second and third-generation CO_2 capture solvents which are often water-free. Nanoparticle Organic Hybrid Materials (NOHMs) are a new class of organic-inorganic hybrids that consist of a hard nanoparticle core functionalized with a molecular organic corona that possesses a high degree of chemical and physical tunability. NOHMs are liquid-like, non-volatile and stable over a very wide temperature range, which make them interesting materials for various energy and environmental applications. While their CO_2 capture efficiency and selectivity are great, like other anhydrous CO_2 capture solvents, NOHMs suffer from high viscosity. Thus, an innovative encapsulation system has been developed to create large gas-liquid interfaces for CO_2 capture using these viscous solvents and encapsulated solvents show greatly improved CO_2 capture rates. Furthermore, it has recently been discovered that NOHMs have interesting electrolyte properties which may allow the CO_2 capture to be pulled by the in-situ CO_2 conversion reactions. The development of these unique particulate systems will not only advance CO_2 capture materials design but also introduce unique particle technology research opportunities in various fields.

Thursday, April 26, 2018

10:30 AM - 11:30 AM • Crystal Ballroom G

An Industrial Perspective on the Future Needs in Solids Processing Research and Education

Karl Jacob, *The Dow Chemical Company*

It is easy to get the impression that progress in the field of solids processing has been slow and plodding; however, if we examine the gains in particle technology over the last several decades, we should be proud of the collective accomplishments of the research community. Yet, many problems still persist – old ones still needing a solution (ratholing and dense phase conveying, for example) and new ones that have surfaced as a result of recent technological advances and changes (additive manufacturing, advanced drug delivery, specialty materials and resource conservation to name just a few). This should delight the solids processing research communities in both academia and industry as there are many interesting, challenging and rewarding problems ahead of us. The key research problems across the 15-20 solids processing sub-disciplines will be examined from the viewpoint of their importance to particle technology, engineering science, industry, and more broadly, society as a whole.

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As of March 16, 2018

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Formulaction	213
Freeman Technology	106
FRITSCH	112
Heumann Environmental Company	103
IFPRI	100
LUM	201

Exhibitor	Booth #
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National Energy Technology Laboratory	111
Oxford Lasers	104
Particle Sizing Systems, LLC	205
Particle Technology Labs	203
Particulate Solid Research, Inc. (PSRI)	200
Process Systems Enterprise (PSE)	202
Quantachrome	110
Siemens PLM Software	105
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Tech4Imaging	207

DON'T FORGET TO SIGN UP FOR TICKETED WORKSHOPS & THE BANQUET

Another way to add to your experience and expand your networking opportunities is to attend **Ticketed Events.** To register, simply add the event to your Meeting registration.

If you have already registered and wish to add a ticketed event to your registration, please contact Customer Service at 800.242.4363 or **customerservice@aiche.org**. Space for some events is limited and tickets will be sold on a first-come, first-served basis.

SUNDAY • APRIL 22, 2018

Computational Fluid Dynamics (CFD) Workshop on Particle Technology • 9:00 AM – 5:00 PM • Cost: $150

The application of computational fluid dynamics (CFD) in multiphase flow systems has gained popularity over the years. CFD is now often used in a wide range of industries due to its potential to successfully help the companies make engineering decisions pertaining to the designing, troubleshooting, debottlenecking, retro-fitting, and scale-up aspects of commercial-scale systems.

Participate in this workshop that promises to provide a unique platform and opportunity to interact with six multiphase flow CFD practitioners and experts from academia, industry and national laboratory.

For more information & to register, click here.

TUESDAY • APRIL 24, 2018

EMMS Workshop • 9:00 AM – 5:00 PM • Cost: $150

The effects of heterogeneous, meso-scale structures within a computational cell are critical to computational fluid dynamics for particle-fluid two-phase and multiphase flows. Recently, we have witnessed a blossom of meso-scale modeling, among which, the energy-minimization multi-scale (EMMS) modeling of drag, heat and mass transfer and reactions has found successful applications. This workshop on EMMS modelling will help users begin their coding with EMMS and address the difficulties occasionally encountered for users.

For more information & to register, click here.

WEDNESDAY • APRIL 25, 2018

8th World Congress on Particle Technology Banquet • 7:00 PM – 10:00 PM • Cost: $100

Join your colleagues at the WCPT8 Banquet, network with plenary speakers and the future researchers in particle science and technology from around the globe.

For more information & to register, click here.

APRIL 22-26, 2018 | ORLANDO, FL

WORLD CONGRESS ON PARTICLE TECHNOLOGY

Expanding Boundaries 2018

Computational Fluid Dynamics (CFD) Workshop on Particle Technology

Sunday, April 22, 2018
9 AM to 5 PM

The application of computational fluid dynamics (CFD) in multiphase flow systems, especially multiphase fluidized bed reactors, has gained popularity over the years. CFD is now often used in a wide range of industries, such as oil and gas, energy, pharmaceutical, chemical, food processing, automotive, metallurgy, etc., due to its potential to successfully help the companies to make engineering decisions pertaining to the designing, troubleshooting, debottlenecking, retrofitting, and scale-up aspects of commercial-scale systems. Key examples of the use of commercial as well as open source CFD codes include fluid catalytic cracking (FCC) reactors in the oil industry, gas-phase polyolefin reactors, fluidized bed reactors for polysilicon production, coal and biomass gasification reactors, and many more.

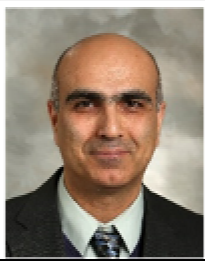
Many CFD codes are available in the market today, and they all require good understanding of the basic principles of multiphase flow and numerical methods. One of the objectives of this workshop is to review basic multiphase flow conservative laws, and to show the participants how to use CFD codes to obtain meaningful information. The workshop will also provide users with the information on several modeling approaches involving physics relevant to certain applications. During this hands-on workshop, attendees will also have a chance to run a sample multiphase model on their laptops (to be brought in by the attendees) using the Illinois Institute of Technology (IIT) multiphase code and evaluate the results.

This workshop is for undergraduate and graduate students, engineers and scientists who want to learn how to use modern computational tools to improve the performance and design of multiphase fluidized bed reactors. The audience is encouraged to participate in this fun-filled and educational workshop that promises to provide a unique platform and opportunity to interact with six multiphase flow CFD practitioners and experts from academia, industry and national laboratory, with a combined experience of over 100 years in this field. The instructors have delivered several successful workshops on multiphase flow CFD in various fora, and the bar is expected to rise even higher at the 8th World Congress on Particle Technology.

In addition to learning key features about CFD codes, such as Barracuda®, ANSYS® Fluent, IIT multiphase code, MFiX, and STAR-CCM+, the workshop will also include a live demonstration of a mini-circulating fluidized bed (CFB) prototype comprising a riser, standpipe, and cyclone, and its comparison with Barracuda®. The cold-flow mini-CFB is capable of fluidizing particles classified as Geldart groups A, B, C and D in various fluidization regimes, such as bubbling, turbulent, transport regimes, etc.

Please select **CFD Workshop on Particle Technology** as an **add-on** at www.wcpt8.org once the registration is open. Lunch and snacks will be provided during the day of the workshop.

For any questions regarding the workshop, please contact Mayank Kashyap (mkashyap@sabic.com) or Reza Mostofi (reza.mostofi@honeywell.com).

Presenters		Topics
	**Mayank Kashyap**, Ph.D., Lead Scientist – Process Technology, SABIC E: mkashyap@sabic.com	Introduction to fluidization; Plexiglas mini-circulating fluidized bed demonstration unit comprising a riser, standpipe and cyclone that has the ability to fluidize particles in the core-annular and other flow regimes; Introduction to Barracuda®
	**Dimitri Gidaspow**, Distinguished Professor, Emeritus, Illinois Institute of Technology, Chicago E: gidaspow@iit.edu	Conservation laws and constitutive equations (D. Gidaspow. "Multiphase Flow and Fluidization". *Academic Press*, 1994); Formation and elimination of bubbles using IIT multiphase CFD code with input viscosities for the Westinghouse 3 meter fluidized bed (D. Gidaspow & V. Jiradilok. "Computational Techniques". *Nova Science Publishers*, 2010)
	**Reza Mostofi**, Ph.D., Lead Engineer, Honeywell E: reza.mostofi@honeywell.com	Overcoming challenges in a gas-solids CFD model; Simulations using ANSYS Fluent
	**Madhava Syamlal**, Ph.D., Senior Fellow – Computational Engineering, National Energy Technology Laboratory (NETL), U.S. Department of Energy (DOE) E: madhava.syamlal@netl.doe.gov	Multiphase flow science at NETL
	**Oleh Baran**, Ph.D., Product Manager - STAR-CCM+ Lagrangian Multiphase and DEM, Siemens PLM E: oleh.baran@cd-adapco.com	Coupling DEM and CFD to optimize particulate flows
	**Huilin Lu**, Professor, Harbin Institute of Technology, China E: huilin@hit.edu.cn	Modified MFiX code to simulate hydrodynamics of gas-solids circulating fluidized beds

Book Review

The History of Multiphase Science and Computational Fluid Dynamics—A Personal Memoir

By Robert W. Lyczkowski

More money and effort has been spent on nuclear safety by the former Atomic Energy Commission for whom I worked for a few months in 1973 and 1974, and later by the Nuclear Regulatory Commission, than on the safety of any man-made process or device, with the possible exception of airplanes. But then why did the Fukushima Daiichi nuclear accident occur?

Bob Lyczkowski's book provides a partial answer, without going into the details of the accident. Its description requires a separate book.

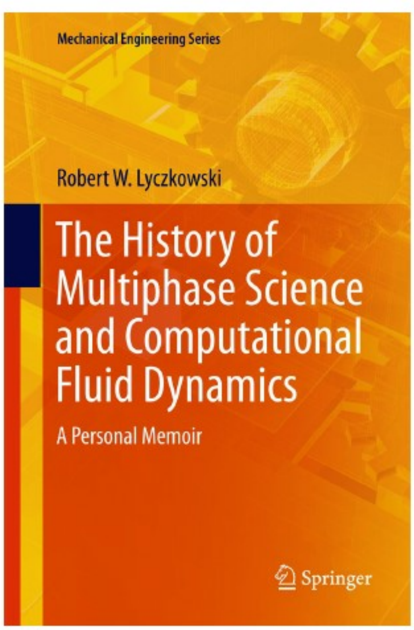
Multiphase flow science would not have become useful without the CFD codes for one-dimensional flow developed in Idaho, as discussed in detail by Bob, and later at Los Alamos for two- and three- dimensional flow based on their long history of code development for designing nuclear weapons.

At IIT, with Bob's help, we modified the K-FIX code developed at Los Alamos. to make it well-posed as an initial-value problem and put in reasonable drag expressions and viscosities. See Chapter 12, IIT Begins Using Los Alamos' K-FIX Code. Over the last four decades, we solved a variety of practical problems. These include CFD design of chemical reactors, pyroclastic flow from volcanoes, and blood flow, to explain why the red blood cells move away from the walls of the blood vessels and the platelets move toward the walls. To understand the physics of transport in blood vessels, later on we added dense phase kinetic features to the IIT codes.

Dimitri Gidaspow

Distinguished Professor, Emeritus

gidaspow@iit.edu



1st ed. 2018, XVII, 334 p. 19 illus., 4 illus. in color.

R.W. **Lyczkowski**

The History of Multiphase Science and Computational Fluid Dynamics

A Personal Memoir

Series: Mechanical Engineering Series

- **Imparts a personal narrative tracing the critical events in the initiation, development, and propagation of multiphase science and computational fluid dynamics in its historical context**
- **Reveals the amazing chain of incidents and coincidences but for which multiphase science and computational fluid dynamics would never have evolved**
- **Presents in narrative form many facets of multiphase science (MPS), including sand grains, bubbles, and water droplets and how MPS differs from single-phase science**
- **Describes the development of what came to be called the seriated loop (SLOOP) code, intended to replace the RELAP4 code, used to perform safety studies for and to license nuclear reactors and the politics of science that led to its demise**

CPFD Student Travel Grant

The Particle Technology Forum (PTF), through generous support from CPFD Software LLC, is offering up to four student-member travel grants to support attendance to the 2018 AIChE Annual Meeting. This support (**$500/student)** will roughly cover the student registration fee and one ticket to the PTF dinner on Wednesday, October 31st 2018. The grant is available to any graduate student who is or whose advisor is a member of the Particle Technology Forum and the student is planning to present a paper at the meeting (regardless of receipt of the award). The student must also be at least 21 years of age upon attending the Annual Meeting.

To apply, the student must write a letter requesting the grant and the student's advisor should add a letter of support, certifying that the advisor and/or the student is a member of the PTF. The student's brief resume or cv should be included. The student letter should indicate the title/abstract and session of the submitted presentation abstract. Only one application per faculty advisor will be accepted. The student letter, advisor letter, and CV should be sent as ONE PDF file to gilchrist@lehigh.edu with the subject **"2018 CPFD Student Travel Grant"**.

Submissions will be accepted starting when abstracts for the Annual Meeting are due (April 18th) and no later than June 1st, 2018. Notice of support is expected to be notified no later than July 1st.

Student recipients are expected to attend the PTF dinner, a social and awards event, at which they will be briefly acknowledged.

The PTF Student Travel Awards Committee:

Dr. Benjamin Freireich, Technical Director, Particulate Solid Research, Inc. (PSRI)

Dr. James Gilchrist, Professor, Lehigh University

Dr. Brenda Remy, Principal Scientist, Bristol-Myers Squibb (BMS)

To learn more about CPFD, visit https://cpfd-software.com/

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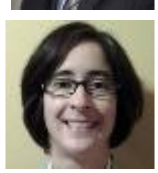

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Vice Chair: Dr. Tim Healy
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