MEETING DAY 4, Thursday, April 28

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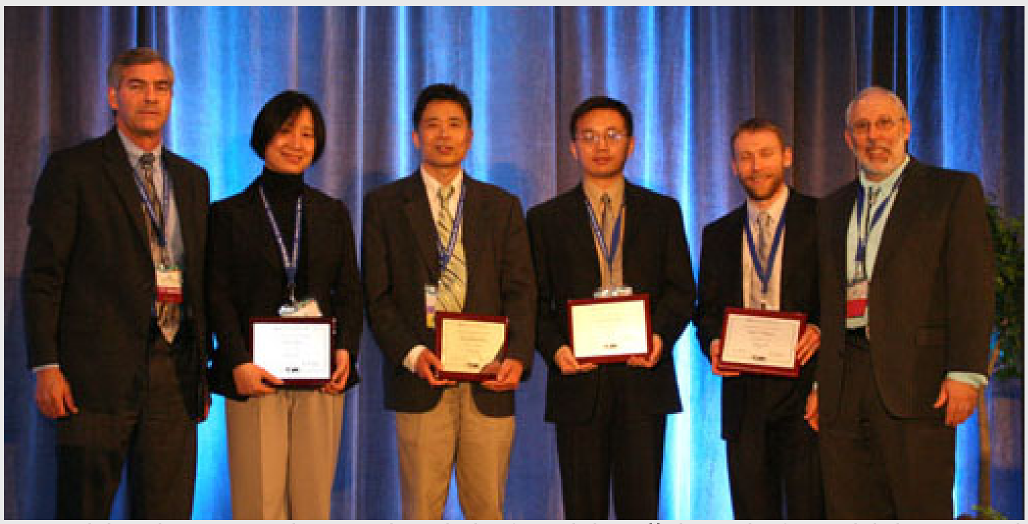
Thursday at the MRS Spring Meeting in San Francisco was another day filled with technical talks, a fascinating symposium X lecture, the Innovation in Materials Characterization Award lecture, Poster Awards, and the announcement of the Science as Art winners, which is always a favorite of the meeting attendees. See the winners below and enjoy the beauty that emerges when science--particularly materials science--meets art.



Recognizing the 2011 Spring Meeting Chairs for a job well done! (Left to Right) MRS President Jim De Yoreo, Chairs Ping Chen, Chang-Beom Eom, Samuel S. Mao, and Ryan O' Hayre, and Immediate Past President Dave Ginley.

Contents

Other Links of Interest

- Itinerary Planner
- Exhibitors
- Proceedings Submission

Women in Science and Engineering Breakfast

Women and Materials Science and Engineering - is the “Leaky Pipeline” the Wrong Metaphor?


Fiona M. Doyle

The Women in MS&E breakfast was held Wednesday morning. Fiona M. Doyle of the University of California gave a talk on the so called “leaky pipeline” model for women in the field. She described her own “accidental career” in MS&E with a PhD in extractive metallurgy and subsequent position in the mineral engineering program at Berkeley. She discussed why there is a need for a forum such as this: there is obviously not a sufficient number of women in the field. Also, women enhance the field by bringing a different view of the world and different insights into technical problems. She presented current statistical data for women in MS&E.

The leaky pipeline metaphor is often invoked particularly in academic fields to account for the small number of women who are able to rise up the hierarchy. However, the numbers appear to suggest that this may not be necessarily true for women in MS&E. The raw numbers are fairly static and appear to show that there is not much leaking. Also, people enter the field at various levels in their careers and sometimes more than once. Doyle also suggested that those who “leaked away” to other professions from MS&E bring their skills to those professions and it may be inappropriate to label this as “leakage.” Why should we care? Because we do not want to constrain 17-18 years olds and box them in to limited career choices, and this metaphor captures the wrong attributes. The old pipeline is “staid, linear, predictable, high risk of failure, and no cross-fertilization of ideas,” Doyle said. She suggested a new metaphor that is “exc iting, allows for individuality and change, is often unpredictable, where success takes different paths, and cross-fertilization occurs from other disciplines."

Symposium X - Frontiers of Materials Research

Non-oxide Materials for Photocatalytic Water-Splitting Under Visible Light
Kazunari Domen University of Tokyo

While many photocatalysts have been developed to split water under UV radiation with quantum efficiencies of greater than 50%, the goal of visible light photocatalysis for this purpose remains elusive. Kazunari Domen of the University of Tokyo and his colleagues are working hard to prove that the "visible solar energy + $H_2O \rightarrow H_2$ + ½ O_2" is not just what he calls a "dream reaction." The challenge is to develop a catalyst that (1) absorbs visible light sufficiently, (2) is capable of splitting water, and (3) is stable over the long term. "It is hard to get all three in one catalyst," Domen said.

Their approach has been to investigate (oxy)nitrides with promoters or "co-catalysts" as candidate materials, specifically d^{10}-type materials with good light absorption properties in the visible range, such as GaN:ZnO, with Rh and Cr promoters. After much experimentation, the group showed that a Rh-Cr oxide/GaN:ZnO material split water with a quantum efficiency of 5.2% at 410 nm wavelength irradiation.

To understand the mechanism of this photocatalyzed reaction, Domen and his colleagues studied GaN:ZnO with Rh by itself and with Rh/Cr_20_3 as surface species. In the first case, they found that while GaN:ZnO was catalyzing the splitting of water to release oxygen, Rh was joining H+ ions into H_2 molecules, which reacted with the released oxygen to form water again. Rh effectively reverses the water splitting reaction. Because these reactions cancel out, the Rh/Gan:ZnO catalyst appears to have no activity. When a layer of Cr_2O_3 covers the Rh island on the surface, this reverse reaction is quenched, and H_2 and O_2 are generated from water splitting in the expected 2:1 ratio. Further examination with model electrodes showed that H^+ ions can penetrate the Cr_20_3 shell to reach the Rh and form H_2, and this H_2 can penetrate back out throug h the shell and be released. But O_2 cannot penetrate the Cr_2O_3 shell, so it is prevented from getting to the Rh island underneath where the reverse reaction would take place. Hence, O_2 is also evolved in this photocatalytic process. Domen and his coworkers are also experimenting with many other catalytic systems, includingthose based on d0-type materials (Ti^{4+}, Zr^{4+}, Nb^{5+}, Ta^{5+}, and W^{6+}). But there is still a long way to go between the 5.2% quantum efficiencies they are getting with visible light photocatalysis and the 50% or more quantum efficiency of UV photocatalyzed systems.

The 2011 Innovation in Materials Characterization Award Talk

The Second Revolution in Atom Probe Tomography by Jules Verne
Thomas F. Kelly and David J. Larson (Cameca Instruments, Inc.), and Tye T. Gribb, (DTE Research & Design LLC)

Larson (left) and Kelly. Gribb could not attend the meeting**.**

Nothing exists but atoms and the void--Democritus

The 2011 IMC Award was presented to Thomas F. Kelly and David J. Larson (Cameca Instruments, Inc.), and Tye T. Gribb, (DTE Research & Design LLC) on Wednesday at the plenary session, "for the highly successful conception, design, fabrication, and commercialization of an ergonomic three-dimensional local-electrode atom probe (LEAP) tomograph that enables the determination of the local composition information, on an atom-by-atom basis, of metallic, semiconducting, ceramic and organic materials, on a subnanometer scale, in direct space, with high mass resolving power and signal-to-noise ratio, permitting the determination of small concentrations of all elements." On Thursday evening, Kelly and Larson gave the award talk with the above whimsical title.

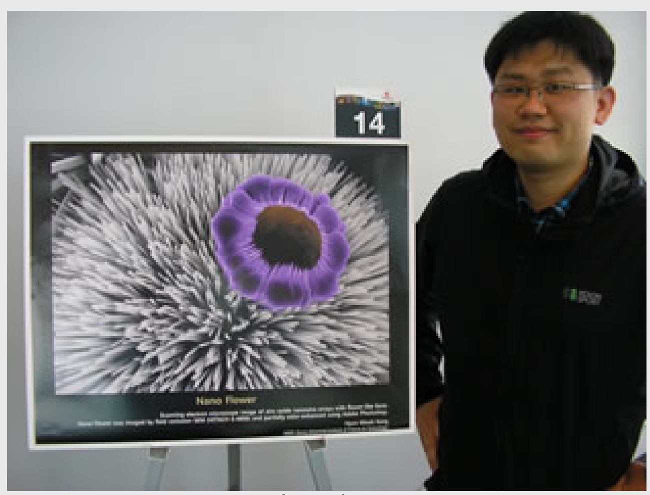
Kelly started with an introduction to the atom probe, and the current abilities of 3-dimensional atom probes and atom probe tomography. He reviewed the critical steps of specimen prep, data collection, data visualization and data analysis. He then gave a fascinating historical account of the atom probe, starting with Erwin Muller, considered the father of high field nanoscience. The atom probe was invented in 1967 and the first revolution occurred in the 1980s. The second revolution occurred in 1993 with the development of the local-electrode atom probe (LEAP). Kelly, who was a professor at the University of Wisconsin, formed IMAGO to develop LEAP instrumentation and new atom probes. IMAGO was acquired last year by CAMECA Instruments, Inc. Kelly indicated that the second revolution was made possible by various developments, along with focused ion beam (FIB) specimen prep, LEAP, and thermal pulsing.

Larson then described the similarities between Tom Kelly and Jules Verne in a humorous vein. Kelly made several predictions in the early 1990s that are close to realization now. Larson's work and contributions were focused on specimen prep, and he described FIB liftoff and dual beam FIB, which are currently used techniques. These allow for specimens to be formed with, for instance, embedded transistors that can be used to view the 3D distribution of elements. Kelly concluded by describing their latest proposal, the ATOM project, to build the ultimate microscope for full atomic scale tomography, including 100% atoms recorded with 0.1 nm spatial resolution in 3D with crystal structure determination. This will enable position identity of every atom in practical 3D using superconducting detectors. Kelly ended the presentation by stating, "In the century of nanotech, every atom has its place."

Science as Art Winners

Congratulations to our winners, and thanks to all who participated in this competition!

First Place
Steve Herron
"Nano Graveyard"

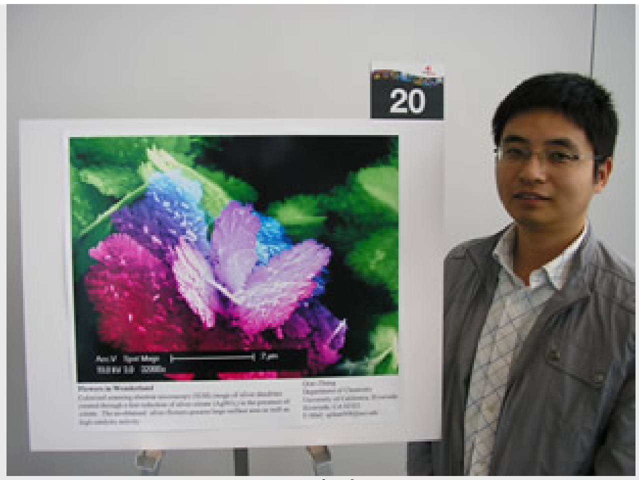


First Place
Kyun Wook Kang
"Nano Flower"

First Place
Elizabeth Kupp
"Salt Crystals"

Second Place
Sukjoon Hong
"Nano Garden"

Second Place
Shirin Usmani
"Good Ole' Fishing"



Second Place
Qiao Zhang
"Flowers in Wonderland"

Second Place
Talia Gershon
"Cubist Microflower"

Government Funding Agency Seminars

Professional Development: Crafting Successful Broader Impacts Plans for NSF Proposals

NSF Broader Impacts from a K-12 Educator's Viewpoint

Every National Science Foundation (NSF) proposal is evaluated based on intellectual merit and broader impacts. For researchers used to focusing on technical merit, that second criterion can be daunting. High school biology teacher Sue Whitsett, an Einstein Distinguished Educator Fellow at NSF, shared some ideas for how researchers can strengthen their broader impacts with outreach to K-12 students and teachers. The best way to improve a proposal's broader impacts statement, she said, is to think rigorously about how to improve the actual impacts.

Whitsett suggested that researchers use the NSF's "intellectual merit" criteria as a lens through which to think about broader impacts: Whose knowledge and understanding will be advanced, and how? What are the principal investigator's qualifications in K-12 education? Is the plan well-organized and conceived? Are the plan's "creative, original or potentially transformative" elements implemented in a way that is feasible, relevant to its audience, and respectful of known best practices?

Successful K-12 outreach has the potential for a huge impact, Whitsett pointed out. Getting elementary students excited about science is crucial, because kids who are not interested in science by fifth grade will almost never go into STEM careers, Whitsett said. Engaging teachers is also powerful, because a single teacher will work with hundreds or thousands of students.

ARPA-E Government Agency Session

The Department of Energy's Advanced Research Projects Agency-Energy (ARPA-E) focuses on high-risk, high-reward research, with an eye towards developing energy technologies with high impact and breakthrough technologies. Program Director David T. Danielson described his agency as being unusually risk-tolerant in its pursuit of game-changing research within its focus areas: reducing energy related emissions, reducing energy imports, and improving energy efficiency.

ARPA-E, which celebrated its second anniversary only yesterday, tends towards granting big awards ($1 million - $5 million) to researchers who can demonstrate the possibility of big rewards. Danielson said that the agency's emphasis on rapid and nimble program development typically allows it to move projects from conception to execution within 6-8 months.

Projects begin with a 6-page application. Danielson said that approximately 5-10% of these applications are then invited to submit a full 30-page project plan -- at which point a project then has a 20-25% chance of moving forward.

To receive ARPA-E funding, a project is expected to be what Danielson called "high-impact" -- meaning a 1% or greater impact on total energy usage, and/or to have large commercial applications. Danielson also described ARPA-E projects as developing "breakthrough technologies," which he described as technologies that either don't currently exist or those that would make existing technologies obsolete.

Finally, ARPA-E projects need to demonstrate "additionality" -- meaning projects that would be difficult or impossible to move forward without ARPA-E funding. Danielson concluded with an announcement of new funding oppportunities in the following areas:

- Rare Earth Alternatives in Critical Technologies
- High Energy Thermal Storage
- Green Electricity Network Integration
- Solar: Agile Delivery of Electric Power Technology

The deadline for the above opportunities is May 19, 2011. For more information about these or other ARPA-E opportunities, Danielson suggests contacting an ARPA-E program director as well as subscribing to their mailing list at arpa-e.energy.gov.

Materials Research Support at the Department of Defense (ONR)

William M. Mullins, Program Manager of the Structural Metals Naval Materials Science and Technology Program, gave a detailed look at research and funding opportunities at the ONR. As an executive branch agency within the DOD, the ONR supports the President’s budget. They provide technical advice to the Chief of Naval Operations and the Secretary of the Navy.

The ONRG (Office of Naval Research Global) sponsors programs and provides seed funding that fosters collaboration between Navy personnel, scientists and technologists around the world. The associate directors promote collaboration with international scientists, and science advisors identify fleet/force needs and implement technology solutions.

The biggest areas they are trying to address in science and technology are power and energy. The naval science and technology funding is 500 million. In 2011, university money is going up slightly. The D.O.D. has a budget of $75,721, 840,000 for Research Development Test and Evaluation for FY2012. Navy S&T represents 0.36% of this defense budget and it remains stable at this time.

To get research funding you have to get to the right people. To check on contracts and grants go to www.onr.navy.mil. All research must address a broad agency announcement.Mullins says that It is written to be broad, so please write if you don’t find your topic and it will be added. Then find the program officer. Be persistent since this can be challenging. The best way to do this is by e-mail, but always be ready to try again. Not receiving a response is not a negative response. Also be prepared to be re-routed. You may not be talking to the right program officer. If you are asked to write a proposal you will need to download mandated forms. The proposal evaluation can take only a few hours. The submission for management approval will take around five days. It may sit in the contract office for several months. I t is very important to keep in contact with the program officer. Once you have approval, spend your money! If you don't it goes away.

Materials Research Support at the Department of Defense (ONR)

The Department of Energy (DOE) is mission driven and strives to sustain basic research and discovery. They are focused on basic research at atomic and molecular levels and are trying to understand phenomena at these scales.

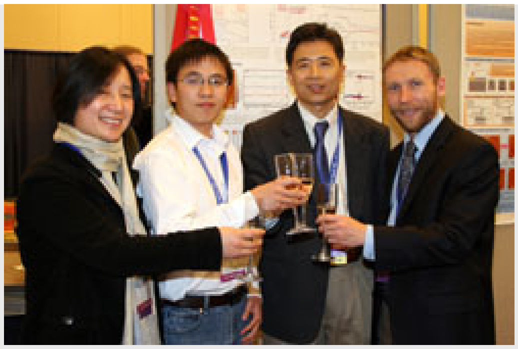
The Materials Sciences subprogram is a premier sponsor of condensed matter and materials physics in the U.S. Half of their budget goes to support BES (Basic Energy Sciences) Scientific User Facilities for Research. They have five Nanoscale Science Research Centers. These centers are visited by more than 10,000 scientists and engineers yearly. There are also 46 Energy Frontier Research Centers across the country, which identify and focus on energy problems.

DOE has $40M in the budget to guide Materials by Design. The 2012 budget includes a request for solar energy research to help improve the electrical grid. They have a new website http://science.energy.gov where you can find information about their Early Career Research Program. This year they also held their first Energy Frontier Research Centers Video Contest and the winners were recently announced. There is now a People's Choice Contest so you can go to the website to vote. The video with the most votes by 5:00 pm on May 24, 2011 will win and be shown during their first summit on energy held in Washington on May 25-27, which is a free event open to the public.

Poster Awards for Thursday

BB9.3 Contact Thermal Resistance Between Individual Multi-walled Carbon Nanotubes
Yang Yang, Vanderbilt University

Q9.1 Oxygen Migration at Pt or Cu/HfO_2 Interface Under Bias Operation: Oxide Based ReRAM Application
Takahiro Nagata, National Institute for Materials Science, Tsukuba, Japan



WW11.50 Ferroelectric Polarization and Domain Structure in Tetragonal Phase BFO Thin Film
Di Yi accepting on behalf of Jinxing Zhang, University of California, Berkeley

Y10.9 Field Emission from Atomically Thin Edges of Reduced Graphene Oxide
Hisato Yamaguchi, Rutgers University

Technical Talks

Symposium T: High-Speed and Large-Area Printing of Micro/Nanostructures and Devices

Large-scale Analysis of Neurite Growth Dynamics Using Micropatterned Protein Substrates
Zachary D. Wissner-Gross of Harvard University and MIT brought some biology into the printing symposium with a talk on symmetry breaking in neurite growth.

As a neural cell grows on a plate, it sends out multiple arms, called neurites. The neurites are initially symmetrical, but one eventually grows longer and becomes the cell's axon while the rest become shorter dendrites. Several mathematical models have been proposed for the symmetry-breaking process, but the difficulty of locating individual neurons on a plate has hampered comparisons of the models. Neurons can be forced to develop in one dimension by creating lines of proteins on a hydrophobic substrate—which is where printing enters the picture.

Protein printing had previously been done with a laser micropatterning technique called LAPAP, but it has a raster rate of 10 microns per second, too slow to generate the volume of data needed to study neurite growth. By using a titanium-sapphire laser, Wissner-Gross and his colleagues discovered that they could achieve raster speeds of 1,000 to 10,000 microns per second, with higher resolution than previous methods. This printing technique allowed the production of hundreds of protein stripes. The resulting data pointed to several simple, biology-based modifications that could improve the existing models for neurite growth.

Fast, High-throughput Micro, Nanoparticle Printing with Sub-10 Micron Resolution via Porous Silicon Membrane
Steve Choi of the University of California, Berkeley, presented a new type of solution printing that can form precise spheres with tunable sizes on the order of ten microns or less. The technique relies on gravity to form picoliter-scale droplets of solution at pores in a print head. The drops are then transferred to a substrate simply by lowering the print head. With a hydrophobic substrate and small droplet volumes, evaporation takes place before particles can be transported within the drops. That means that the particles cluster into spheres at the droplet center, rather than forming coffee ring patterns. The diameter of those spheres can be tuned by adjusting the solution

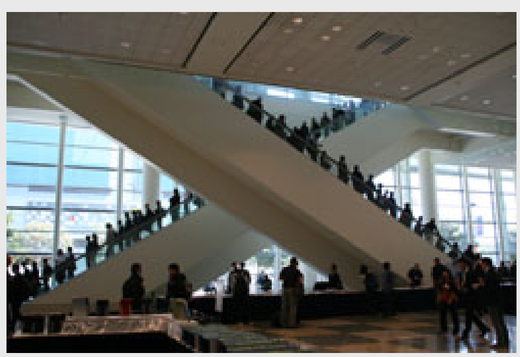
concentration. A series of trials have shown that this printing method has high throughput, low processing time, and good alignment for a variety of materials.

Symposium DD: Quantitative Characterization of Nanostructured Materials

Properties of Multiferroic and Ferroelectric Nanostructures from First Principles
Laurent Bellaiche of the University of Arkansas presented several dramatic ferroelectric phenomena that have been predicted by effective Hamiltonian modeling methods. Vortex patterns are well known in ferromagnetic systems, but their presence has now been confirmed in ferroelectric systems as well. Bellaiche and his colleagues predicted the possibility of field-induced control of vortex chirality in asymmetric rings, which would allow a 10,000-fold increase in memory storage. That result was found to hold for both ferroelectrics and ferromagnetics, and has now been verified experimentally. In $KTaO_3$ nanodots, classical assumptions predicted ferroelectric vortices, but those vortices disappeared when quantum effects were taken into account. From that, a new class of materials, incipient ferrotoroidics, was predicted. Another study, which Bellaiche expects to publish this year, examined a shape-induced phase transition in a mes oscale ferroelectric, where polarization and toroidal moment appear only as the length-to-width ratio moves away from unity.

Symposium II: Ion Beams--New Applications from Mesoscale to Nanoscale

Broad Ion Beam Treatment for Geometry and Surface Energy Controllable Bio-inspired Dry Adhesives
This talk presented an exciting and innovative idea, one so simple it made the audience smile. I guess we needed that to counterbalance all of the serious scientific sessions we've been attending this week. Not to say the development of a dry adhesive 10 times stronger than the gecko feet is not scientific. In fact, gecko feet have a unique hierarchical structure, comprising mesoscale lamella containing microscale setae which in turn are made of scores of nanoscale spatula- like structures. These researchers, while working to understand the forces acting on this gecko-inspired hierarchical structure, developed a technique to fabricate tilted nano-hair arrays with modified surface energy that not only emulate the ultrahigh adhesion strengths of the gecko foot, but makes it 10 times stronger. The nanoscale hair-like polymer structures are first fabricated and then irradiated with a broad argon ion beam to "tilt" or bend them. Depending on the angle at which the argon ions come into contact with the polymers, this process also allows control over the surface energy of these structures. The resulting surfaces adhere so well to other surfaces that they can easily support the weight of what looks like three heavy first-year engineering textbooks. A combination of van der Wall and capillary forces are responsible for the adhesion properties, which can be further enhanced by modifying both the shape of the nano-hair structures and the directions at which they are titled. This technology will find plenty of applications in areas ranging from microelectronics to biomedical devices.



Symposium F: Renewable Fuels and Nanotechnology

Paper and Textile Nanostructures for Renewable Energy Applications
Paper and textile fabrics (polyester, cotton) are extremely low-cost, light weight, highly porous materials that can be used to make the next generation of "green" energy storage applications. L. Hu of Stanford University spoke about how replacing the metallic (copper and aluminum) mesh current collectors used in conventional lithium ion batteries can reduce their weight by 20-30%. But there is another advantage. Paper is made up of cellulose nanofibers that have a hierarchical

structure, which is the reason we can easily write and paint on them. These nanoscale pathways can also manipulate the transport of ions and electrons, resulting in more efficient batteries for energy storage. In order for all this to happen though, paper has to be made electrically conductive using a stable carbon nanotube or graphene-based ink. The same approach can be transferred to textile fabrics to realize wearable textile- based electronics. Textile fabrics are stronger than paper, can be stretched andfolded, and have large surface to volume ratios, resulting in high energy density batteries that can last for up to 3000 cycles. Hu and his colleagues also demonstrated a MnO2-based textile psuedocapacitor that can be made at a substantially lower cost than other supercapacitors. They have also successfully demonstrated this technology in a 3D wearable battery and in a nanostructured textile for microbial fuel cells.

Scanning the Meeting

ABOUT THE MEETING SCENE

The Meeting Scene e-newsletter of the Materials Research Society (MRS) presents news from MRS and other conferences directly from the conference venue.

- The Meeting Scene is edited by Tim Palucka, Science News Editor, with contributions from Laura Lutz, Reeja Jayan, Bob Braughler, Kasia Bruniany, Gopal Rao and Kathy Sutton.
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