MRS Meeting Scene...
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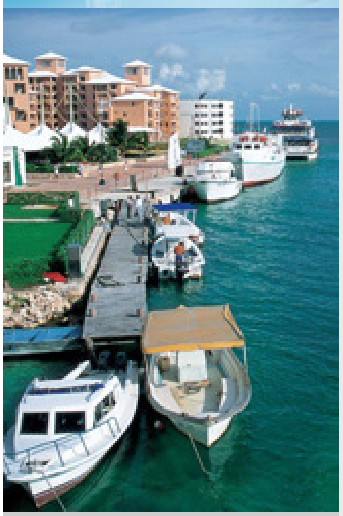
Advancing materials. Improving the quality of life.
IMRC 2011—XX International Materials Research Congress 2011

Cancun, Mexico
August 14 - 19

International Materials Research Congress IMRC XX



Meeting Day 3: Tuesday, August 16

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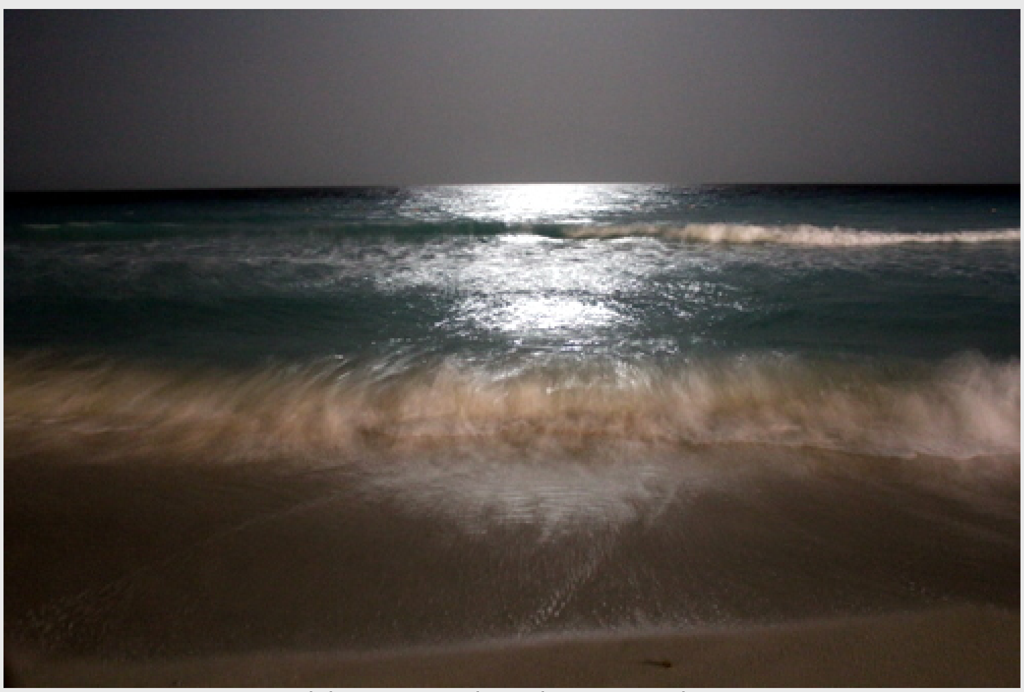
The working days are long at the International Materials Research Congress (IMRC) in Cancun, with talks starting at 9 AM and finshing at 6:30 PM. Of course, we benefit from the traditional two-hour lunches from 2:00 to 4:00 in the afternoon. But today was a working lunch, with Gary Fullerton of the University of Colorado giving the Luncheon Lecture on *in vivo* biomaterials as we enjoyed the delicious food prepared by the banquet chefs. In today's Plenary Lecture, Eduard Arzt of Saarland University taught us all about the wonders of "sticky" gecko feet and how materials scientists are trying to mimic their properties for many applications, including a "gecko tape" that might someday be used to repair punctured ear drums. In a spirited Symposium 19, the speakers were eager to talk about the latest techniques they have developed in the field of electron microscopy, which seems to be enjoying a burst of innovation from both the manufacturers and the scientists who use their equipment. No doubt many of the other symposia had a similar high level of energy, but you can't atttend them all in a single day. In this newletter, we do our best to relate some of the highlights of this day at the IMRC in lovely Cancun, Mexico.



Night waves rush to the Cancun shore

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■ Third Plenary Lecture: Eduard Arzt

Bio-inspired Meso-textured Surfaces for Adhesion—From Basics to Applications

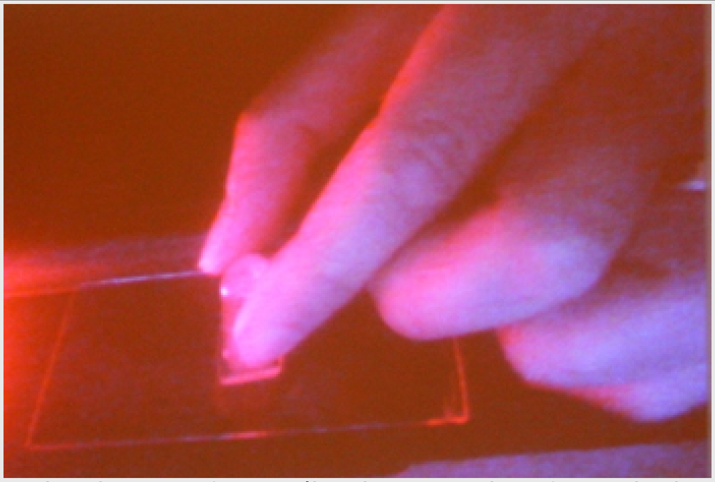
Near the beginning of his plenary lecture, Eduard Arzt of Saarland University, Germany, said that his research has brought him to "the realization that nature also has to deal with materials problems." He gave examples in which nature has evolved patterned structures to impart desired properties to various species: the anti-reflective pattern of a moth's eye, the surface pattern of a shark's skin that minimizes flow resistance, and the lamellae of the gecko's feet that allow it to cling to smooth glass walls and rough, rocky surfaces.

Arzt has been studying these phenomena and fabricating biomimetic structures in his lab for decades now, and has become particularly well known for his attempts to imitate the gecko's feet. The "adhesion organs" of geckos consist of a hierarchical structure of lamellae—basically hairs 100 to 300 nm in diameter—that can adapt to any surface. The "pull-off force" increases with the number of mesocontacts made. He and his group have been constructing adhesion design maps that plot fiber radius versus Young's modulus; these maps have revealed the importance of the "condensation limit," which is the point at which the hairs are too fine and stick together in clumps, entirely eliminating their ability to adhere to a surface.

Lately, he has been studying the effect of contact shape on adhesion. Artificial biomimetic structures nowadays are largely mushroom-shaped, because this changes the stress distribution in the contact area in a favorable way. Viscoelasticity has also turned out to be important: recent tests have shown that the pull-off force scales with the damping factor of the polymer.

Arzt gave an unprecedented "live performance" in which he used a single PDMS polymer column to pick up a glass plate. To release the adhesion, he merely pushed down lightly on the column, effectively creating a pressure switch: the fibers buckled and lost all adhesive properties temporarily.

Possible applications of a scaled up production process for polymeric adhesives based on hierarchical structures include tires, band-aids, construction, and robotics. Arzt is particularly excited about work he and his team are doing in collaboration with surgeons to produce a "gecko tape" that can repair ruptured ear drums. The tape would also have to act as a scaffold for tissue growth, and eventually biodegrade. Many challenges remain in this area, including determining the acoustic effects of the tape.



Eduard Arzt performs a live demonstration of a synthetic polymer pillar adhering to and lifting a glass plate, using biomimetic properties derived from gecko feet

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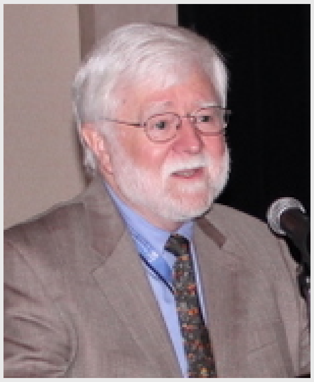
Luncheon Lecture: Gary D. Fullerton

New Horizons in Materials Research: *In Vivo* Biomaterials



The Luncheon Lecture by Gary Fullerton of the University of Colorado combined a historical look at the development of biomedical imaging techniques with a discussion of the latest breakthroughs in positron emission tomography (PET). On the history side, Fullerton started with Roentgen's discovery of x-rays in 1895, followed by the invention of computed tomography (CT) by Allen Cormack and Godfrey Hounsfield in the 1960s and 1970s. Here he made the interesting observation that the first CT scans took one hour, and that, in fact, the first uses of any new biomedical instrument on a patient typically take an hour, because that is about the length of time the patient will put up with it. I.I. Rabi's invention of NMR in the 1930s was discussed, followed by Michel Ter-Pogossians's invention of PET.

"PET opens the potential to convert any molecule of biological interest into a radiopharmaceutical for imaging," Fullerton said. But this requires the location of cyclotrons in hospitals because of the short half-lives of positron emitters. Still, it's worth it, he says, because of the many amazing things the PET scan can do. With PET you can image ^{15}O, ^{11}C, ^{18}F, and ^{13}N *in vivo*. The compound ^{18}F-deoxyglucose is used for tumor detection because tumors love sugar, Fullerton said. Other applications include ^{11}C-methionone for imaging protein synthesis, and ^{15}O-CO for blood volume. He estimates that there are now approximately 100 radiopharmaceuticals for PET under development for different physiological processes in laboratories.

Sergio Mejía, General Chairman of the IMRC and President of SMM

Technical Talks

Audience members listen in rapt attention

Symposium 1: Nanostructured Materials and Nanotechnology

Electrohydrodynamic Synthesis of Nanomaterials
Wolfgang Sigmund of the University of Florida has been interacting with NASA on a problem most of us have never thought about: filtering lunar dust particles. Because they are not subject to erosion or rolling in water streams, lunar soils tend to be angular and abrasive, with a toxicity of 1 to 3% by weight. They can penetrate the lungs of astronauts like asbestos.

Working with a simulated lunar dust called JSC-1, which is composed mainly of silicates, titania, and calcium oxides, Sigmund and his co-workers have been trying to develop a unique filter for use inside a space capsule. They have tried electrospinning of ceramics, using a high electrostatic potential to induce whipping in a charged liquid jet. Electrospinning of TiO_2 nanofibers combined with carbon nanotubes led to many fractured fibers due to surface flaws They had more success with aqueous sol-gels of transition metal oxides and silicates. By electrospinning the sol-gels, they made TiO_2-SiO_2 "fibermats" approximately 2 inches in diameter, which have near 100% efficiency in capturing 300-nm particles of JSC-1. The fibermats are flexible and durable and can be regenerated by heating.

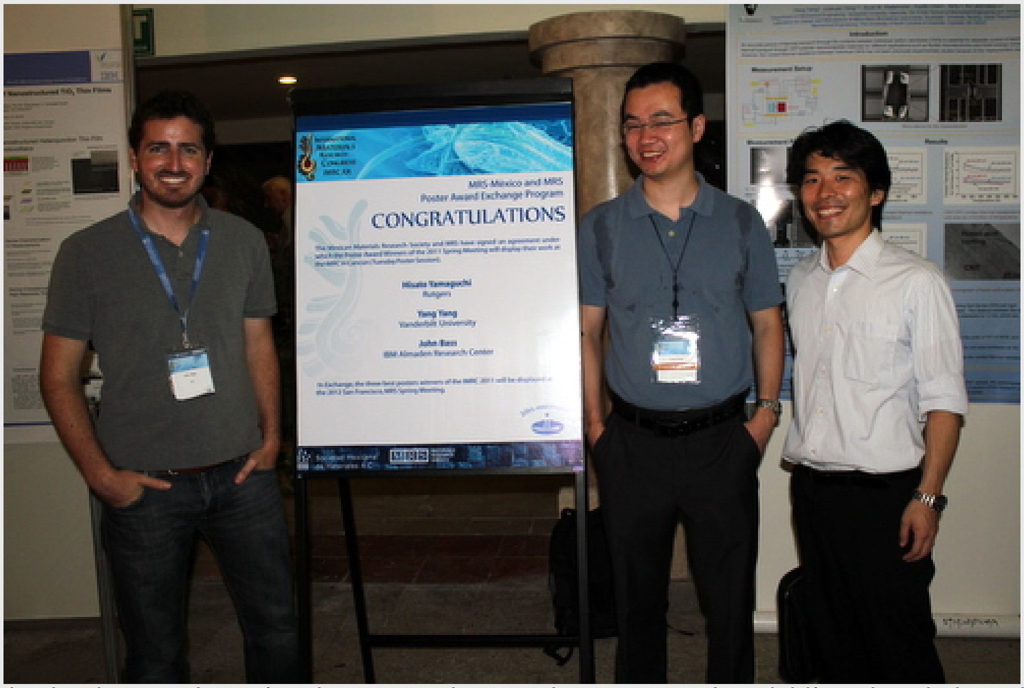
Tengo una pregunta...
(I have a question...)

Interface and Surface Energetics of Nanocrystalline Oxides
The studies of Ricardo Castro of the University of California, Davis, concern the thermodynamics of nanoparticles. Because these systems have an increased surface-to-volume ratio, their total free energy is significantly affected by interface terms. How can one assess the surface energetics of nanoparticles? What about grain boundaries? These were the main questions Castro focused on during his talk. An examination of techniques related to calorimetry was devised to provide answers. In the case of surface energetics, Castro elaborated on a study of alpha- and gamma-Al_2O_3 nanoparticles with and without doping. Based on this study, he showed that the use of dopants provides a route to control the energy of the surface of nanoparticles. Castro evaluated the TiO_2 polymorphs anatase and rutile to understand grain boundaries. Upon investigation of the enthalphy relative to bulk rutile against surface area and grain boundary areas, he concluded that the surface energy of anatase TiO_2 is lower than the surface energy of rutile TiO_2.

Exhibitors from JEOL (left) and Alta Technología en Laboratorios, busy talking to interested scientists

Nanomaterials for Energy Applications
The exponential increase of energy consumption in the world, greenhouse gas emission, and the increasing temperature of the earth's surface describe the main energy problems of the present and future. Can nanomaterials offer a solution for these problems? Y. Bruynseraede of the University of Leuven, Belgium, explained that while there is a growing awareness that nanotechnology can have a profound impact, a shortage of materials will ensue. In order to show how nanomaterials can come to the rescue, he told four success stories about nanodevices fabricated for energy production.

The second point Bruynseraede addressed concerns hydrogen. Here, there are three main problems: its production, storage, and use in fuel cells. The solutions to these problems hinge on finding new nanoscale materials and in developing a basic understanding of the nanoscale phenomena. In shifting his discussion to photovoltaics, Bruynseraede then discussed the necessity of closing the huge gap between the amount of energy received from free solar power and that obtained from photovoltaics. There is enormous potential in using solar energy. A review of current state-of-the-art photovoltaics addressed the necessity to overcome the efficiency limits of these devices. Nanomaterials science, engineering, and technology are still in a formative stage with most of their growth potential ahead. Bruynseraede hence concluded: Be a scientist, save the world!



(L-R) John Bass (IBM Almaden Research Center), Yang Yang (Vandebilt University), and Hisato Yamaguchi (Rutgers University). They are 2011 MRS Spring Meeting poster winners who were invited to display their posters at the IMRC meeting.

Symposium 2: Advances in Computational Materials Science

Controlling Electrons in Graphene using Disorder, Electromagnetic Fields, and Nanoribbon Width

The experimental realization of isolated sheets of graphene has given rise to numerous questions regarding the study of new physics and the possibility of achieving novel devices, said Gerardo Naumis of the Universidad Nacional Autónoma de México. Due to its 2D character and other properties, graphene is the natural candidate to replace silicon in silicon-based technologies. The main problem in considering graphene for this purpose is its non-semiconductor behavior. Intense research has aimed at exploring routes to open a bandgap in this system. Naumis delineated the different routes he and his group examined to achieve that goal. These routes entail the study of the electronic properties of graphene under the influence of disorder and external perturbations.

One of the possible routes to opening a gap is via doping. Naumis demonstrated that it is possible to induce a transition from a metallic to a semiconductor state in this way. He also discussed the application of electromagnetic waves and strain to an isolated sheet of graphene. In the first case, he showed that electromagnetic waves induce non-linear effects in conductivity and optical properties. The second case showed that the application of strain produced a bending of the surface. Here, it was necessary to consider the movement of an electron in a curved space. To understand this, ideas were drawn from relativity. Finally, in a third case, Naumis discussed the electronic properties of graphene nanoribbons, which show metallic or semiconducting behavior depending on the width.

Pedro Hugo Hernández Tejeda, past president of SMM

Symposium 5: Advances in Semiconducting Materials

Electronic Structure of Impurities and Defects in SnO_2

SnO_2 is a transparent conducting oxide widely used in gas sensors and flat panel displays, among other applications. When not intentionally doped, it shows an *n*-type semiconductor character. The origin of this behavior is the main question that L. M. R. Scolfaro of Texas State University attempts to answer. She did so by performing a first-principles study of defects and impurities in SnO_2 that considered the influence of oxygen and Sn vacancies in supercells of SnO_2. Since none of the defects showed a transition energy level in the gap, she concluded that oxygen vacancies in SnO_2 cannot explain the *n*-type behavior. She then proposed that H impurity centers present in experimental samples of SnO_2 could explain the *n*-type character of unintentionally doped SnO_2.

Due to its electronic and optical properties, SnO_2 offers a good opportunity to realize devices suitable for spintronics operating at room temperature. This possibility is explored by building superlattices made of CrO_2 on SnO_2 along the [001] direction. These systems were found to be half-metallic and ferromagnetic in character. This behavior is preserved for increasing thicknesses of SnO_2. These findings are important because although CrO_2 is a half-metal, it is not stable at room temperature.

Informative discussions at the exhibit

Symposium 8: Cultural Heritage and Archaeological Issues in Materials Science

Combined XRF, PIXE and SEM-EDS Study of Pre-Columbian Gold Artifacts

Jose Luis Alcaba and his colleagues at the Universidad Nacional Autónoma de México elaborated a methodology which combines different techniques aimed at investigating materials in a non-destructive manner, particularly those found in archeological objects. During his talk, he presented a unique collection of pre-Colombian objects belonging to "El Dorado," elaborated in gold which comes from Colombia and Costa Rica. Among these objects, those from Colombia belonged to the Quimbaya, an aboriginal group dating to 600 AD.

Alcaba's methodology enhanced understanding of many aspects of these objects, in particular the composition of the materials, the techniques used in their elaboration, and the understanding of the style and ways used for handling gold and other metals. The objective is to unveil how metals and gold where handled and to determine the distribution of the elements which form the inner surface without destroying the object. The combination of these techniques allow for the determination of surface composition starting from the inside and then moving to the outside. A particle accelerator was used in this process. Alcaba highlighted the importance of studies that shed light on the production methods used in archaeological objects, without destroying or damaging those objects in the process.

(L-R) Weijie Lu (Air Force Research Lab),
Patrick Soukiassian (CEA-Saclay and
Université de Paris-Sud/Orsay), and
John Boeckl (Air Force Research Lab)

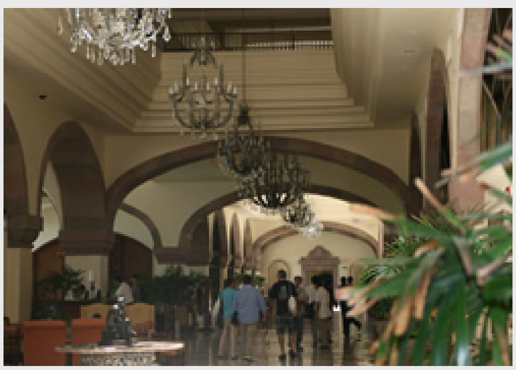
Symposium 19: Advanced Electron Microscopy and Nanospectroscopy

D-STEM combined with Precession Microscopy for Nanoscale Crystal Orientation

As materials continue to get smaller, scientists run into more and more grains and grain boundaries in a given volume than ever before. How are we to map grain orientations, phases, and grain boundaries in these large numbers, asked Paulo Ferreira of the University of Texas at Austin. It might be done by using a novel technique he and his co-workers have invented called "D-STEM," for "diffraction scanning transmission electron microscopy." Ferreira demonstrated how they used this technique to form diffraction spot patterns on a 4-nm Ag particle, and on three locations across the width of a nanowire. In the latter case, the analysis showed that the nanowire was crystalline in the center and amorphous on the walls. By coupling D-STEM with precession, they were able to overcome the problem of identifying the nature of grains that are misoriented with respect to the scanning beam. When the beam hits the sample at an angle, precession of the beam allows it to sample a grain in all orientations during one 360-degree turn. One of his students has used the technique to characterize not only the grain boundaries but also the texture of Cu interconnect lines as they decreased in diameter from 180 nm to 70 nm.

Exhibitors for Zeiss (left) and Ocean Optics, Inc.

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.

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- The Meeting Scene is edited by Tim Palucka, Science News Editor, with contributions from Andrea Salguero and Betsy Fleischer.
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