AMERICAN CERAMIC SOCIETY

bulletin

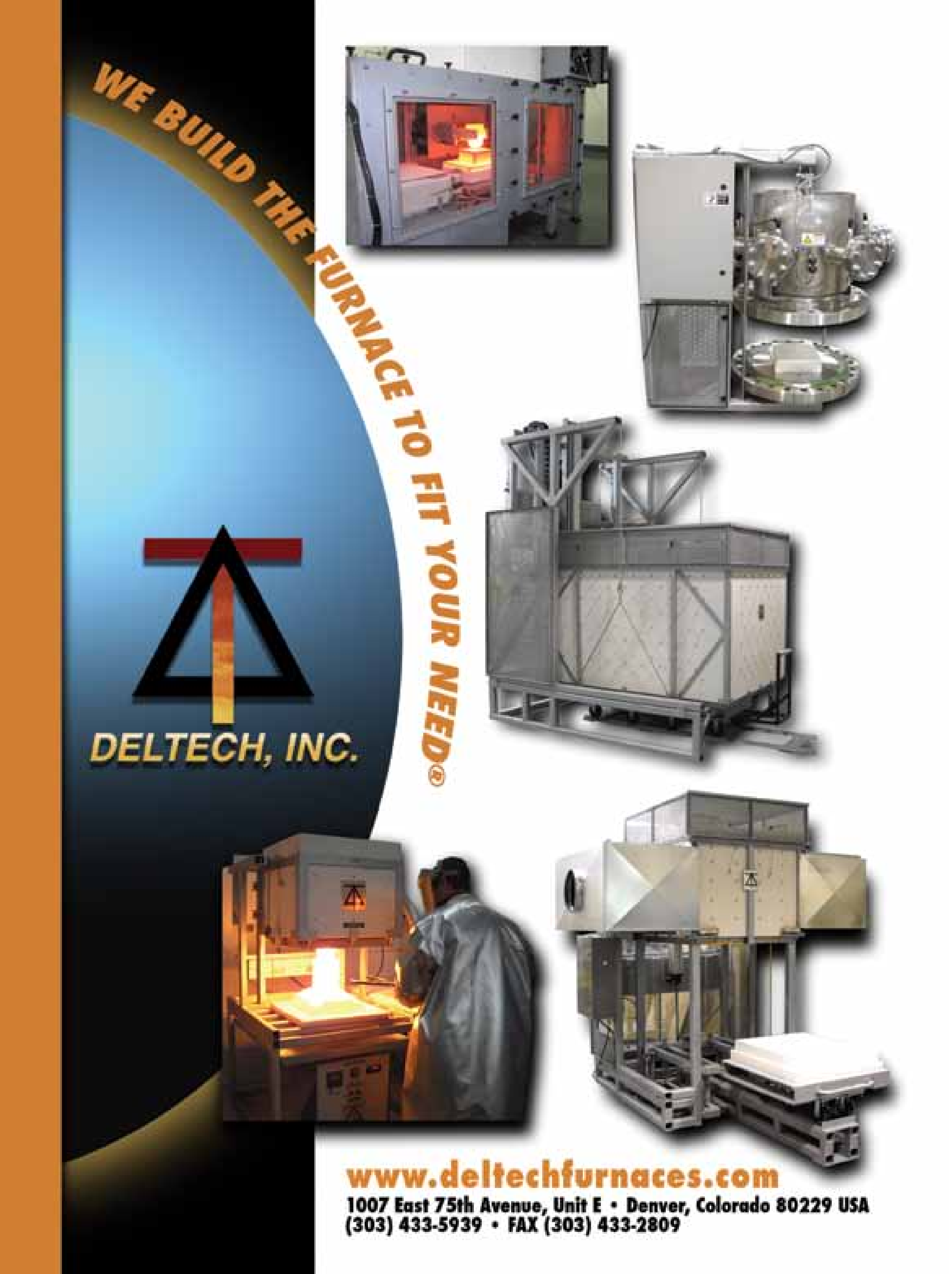
emerging ceramics & glass technology

MAY 2011

Wound healing borate glass nanofibers

Can cotton candy-like pads stimulate tissue mending?

Topological Constraint Theory of Glass •
Indo–U.S. Joint Center on Biomaterials for Healthcare report •
Glass & Optical Materials Division annual meeting program •
Ceramics Leadership Summit speakers and schedule •
Advances in Cement-based Materials: Characterization, Processing, Modeling and Sensing meeting preview •


WE BUILD THE FURNACE TO FIT YOUR NEED®
DELTECH, INC.
www.deltechfurnaces.com
1007 East 75th Avenue, Unit E • Denver, Colorado 80229 USA
(303) 433-5939 • FAX (303) 433-2809

contents

May 2011 • Vol. 90 No. 4

feature articles

'Cotton candy' that heals? Borate glass nanofibers look promising 25
Peter Wray
It may look like the sugary treat, but a new soft, pliable and antibiotic pad made from special glass filaments has been shown in an initial human trial to speed wound healing (with little scarring) in diabetic patients. A wide field of applications — from burns to battlefield injuries — may be in store for this biocompatible material.

Topological constraint theory of glass 31
John C. Mauro
Perhaps the most powerful tool available to predict the relationship between the composition and structure of a glass and its measurable properties, this theory focuses on the key physics that govern the glassy state and bypasses the limitations associated with traditional atomistic modeling.

A report on the Indo-U.S. Joint Center for Biomaterials for Health Care . . . 38
Bikramjit Basu and Thomas Webster
Collaborations between Indian and United States researchers are starting to pay off in breakthroughs for tissue engineering, hard tissue replacement materials and novel manufacturing of complex-shaped implant materials.

2011 Glass & Optical Materials Division annual meeting preview 41
Invitation from the program chair 41
Award winner and sponsors 41
Fundamentals of Glass Science and Technology Short Course 42
GOMD schedule-at-a-glance 42
Symposia schedule 42
Poster session and student poster competition 44

Ceramic Leadership Summit 2011 45
Speakers 45
General sessions 45
Hotel information 46
Schedule of events 47

2nd Advances in Cement-Based Materials: Characterization, Processing, Modeling and Sensing 48
General information 48
Schedule of events 48
Hotel information 48

departments

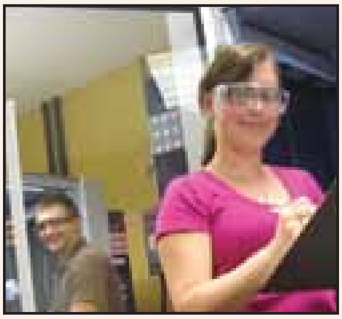
News & Trends 3
- Chinese Academy tilts strategy to applied research, science leadership
- Alfred U. to target leadership development with new E-LEAD scholarships for engineering students

ACerS Spotlight 9
- ICC4 call for papers announced
- CLS 2011 general session speakers announced

Ceramics in the Environment 13
- Novacem's 'carbon negative cement'
- Cabot launches new aerogel additives for coatings
- Leaking water infrastructure is $20B annual market, according to Lux, and growing

cover story
Glass 'cotton candy' wound healing

Borate glass nanofibers look promising – page 25



News & Trends

Alfred U. to target leadership development with new E-LEAD scholarships for engineering students – page 4

Ceramics in the Environment

Cabot launches new aerogel additives for coatings – page 13

AMERICAN CERAMIC SOCIETY
bulletin

contents

May 2011 • Vol. 90 No. 4

departments, continued

Advances in Nanomaterials 15
- Perovskite-based tunable superlens developed
- Bioactive cement plaster: Bioengineering in action
- Spintronics may get boost from enhanced magnetism in BFO films

Ceramics in Energy 17
- Tres Amigas likely to be early high-profile superconductor grid project
- Disordered TiO_2 nanocrystal surface yields durable, more efficient photo-catalyst

Research Briefs 20
- New class of optical fiber developed at Penn State; ZnSe waveguide cores open infrared spectrum
- Analysis of scale of animal trabeculae suggests new materials, structures
- Evidence mounts that 'pseudogap' is distinct phase in superconducting materials

columns

***Journal of the American Ceramic Society* preview** 49
***Int'l Journal of Applied Ceramic Technology* preview** 50
Deciphering the discipline 52
Erica Marden
Biomaterials innovation: Student exposure to 'bio' and health fields needed

resources

Calendar 52
Classified Advertising 53
Display Advertising Index 56

Corrections:
In the article "Developments in electrohydrodynamic forming" (*Bulletin*, March 2011, Vol. 90, No. 2), the correct affiliations of the authors are Michael Laudenslager, University of Florida, Department of Materials Science and Engineering; and Wolfgang Sigmund, University of Florida, Department of Materials Science and Engineering and WCU Department of Energy Engineering, Hanyang University. Also, their work was supported by the World Class University Program through the Korea Science and Engineering Foundation (R31-2008-000-10092). The authors also acknowledge financial support from the Alumni Fellowship Program of University of Florida.

American Ceramic Society Bulletin covers news and activities of the Society and its members, includes items of interest to the ceramics community and provides the most current information concerning all aspects of ceramic technology, including R&D, manufacturing, engineering and marketing.

American Ceramic Society Bulletin (ISSN No. 0002-7812). ©2011. Printed in the United States of America. *ACerS Bulletin* is published monthly, except for February, July and November, as a "dual-media" magazine in print and electronic format (www.ceramicbulletin.org).

Editorial and Subscription Offices: 600 North Cleveland Avenue, Suite 210, Westerville, OH 43082-6920. Subscription included with American Ceramic Society membership. Nonmember print subscription rates, including online access: United States and Canada, 1 year $75; international, 1 year $131.* Rates include shipping charges. International Remail Service is standard outside of the United States and Canada. *International nonmembers also may elect to receive an electronic-only, e-mail delivery subscription for $75.

Single issues, January–November: member $6.00 per issue; nonmember $7.50 per issue. December issue (*ceramicSOURCE*): member $20, nonmember $25. Postage/handling for single issues: United States and Canada, $3 per item; United States and Canada Expedited (UPS 2nd day air), $8 per item; International Standard, $6 per item.

POSTMASTER: Please send address changes to *American Ceramic Society Bulletin*, 600 North Cleveland Avenue, Suite 210, Westerville, OH 43082-6920.

Periodical postage paid at Westerville, Ohio, and additional mailing offices. Allow six weeks for address changes.

ACSBA7, Vol. 90, No. 4, pp 1–56. All feature articles are covered in *Current Contents*.

Chinese Academy tilts strategy to applied research, science leadership

Jane Qiu, writing in *Nature News*, provides a profound story about the Chinese Academy of Sciences' new Innovation 2020 program, which signals a recalibration of the nation's science goals toward more applied research and commercialization. According to Qiu, the CAS will still provide strong support for basic research, but it is signaling a shift in strategic priorities in favor of applications and innovations that ultimately addresses national needs. Multidisciplinary work also will be emphasized.

In particular, Qiu notes that Innovation 2020 charts out several break-through areas and three new research centers: "Innovation 2020 will kick off with new projects this year in seven key areas, including nuclear fusion and nuclear-waste management; stem cells and regenerative medicine; and calculation of the flux of carbon between land, oceans and atmosphere. Other priority areas include materials science, information technology, public health and the environment."

To coordinate resources better and to foster multidisciplinary research, the academy will set up three research centers for space science, clean coal technologies and geoscience-monitoring devices. It also plans to build three science parks – in Beijing, Shanghai and Guangdong province – to accelerate the conversion of basic research to marketable products, especially in renewable energy, information technology and biomedicine.

Innovation 2020 builds on the CAS's 1998 Knowledge Innovation Program. Chinese research spending surged under KIP and produced an explosion of published research. cer

CAS touts that as a result of KIP, "compared to the world's 86 national academic research institutions, CAS scored in the top 10 in 14 subjects. Of those, in eight subjects, including chemistry, materials science, mathematics, engineering, computer science, environment and ecology, earth science and physics, CAS was ranked in the top five."

However, Qiu says CAS leaders are raising the bar. "But the report acknowledges that there is substantial room for improvement. For example, CAS researchers should aim to become leaders of the international scientific community, and shift their focus away from generating as many papers as possible and toward genuine originality and innovation," she reports.

CAS currently has 50,000 employees, 12 branch officers and 103 affiliated institutes, labs and engineering research centers.

In regard to revenues generated by CAS-related companies, president Yongxiang Lu reports that income was more than 170 billion RMB (about $26 billion) in 2010. This represents approximately a 20-fold increase since 2000.

According to the Xinhua news service, "The CAS deputy president, Bai Chunli, said 2011 would serve as a pilot and start-up period for the program, while breakthroughs in strategically important scientific fields, such as energy, health, environment and advanced materials, were expected in the following years."

Qualitatively improving the national research–development–demonstration–deployment conveyor belt is a goal shared by many countries, including the United States. However, making these improvements requires significant and politically difficult strategic decisions about shaking up the status quo in regard to funding, infrastructure, status and accountability. There is no guarantee that China will succeed, for the same reasons.

But China is riding on a lot of momentum from the 1998–2010 period. CAS has laid out its goals clearly, so it will be interesting to watch.

Along these lines, it is worth noting that China will hold its first International Refractory Production and Application Conference May 10–12, 2011, in Guangzhou. The conference is being held in association with China's Iron & Steel Association, Nonferrous Industry Association, Association of Refractories Industry and the Metallurgical Council of the China Council for the Promotion of International Trade. Aside from applications, such as blast furnaces, continuous casters and high-power electric-arc furnaces, organizers of the conference say they intend also to cover refractories for nonferrous metals, cement, glass and ceramic industries, plus green, monolithic, low-carbon and noncarbon refractories.

Visit: Chinese Academy of Sciences http://english.cas.cn. ■

Alfred U. to target leadership development with new E-LEAD scholarships for engineering students

Using $570,000 in NSF seed money, Alfred University's Inamori School of Engineering and the school's Division of Student Affairs are launching an innovative leadership program for engineering students. The program, called Engineering Leadership Education and Development, will begin as a five-year program to identify and work with a group of 16 students at the university, plus help attract high-school-aged females to the field of engineering.

Doreen Edwards, dean of AU's engineering school, explains E-LEAD by noting that leadership and teamwork skills are needed for a successful engineering career. She says, "We hope to teach students that leadership occurs at all levels within an organization and that they can apply their leadership skills during their very first job as new engineers. We are particularly interested in developing leadership around issues related to gender in the science and engineering fields."

The leadership program Edwards and others are crafting at AU will be based on what is known as the Social Change Model. Julia Overton-Healy, director of the Women's Leadership Center, explains that SCM "assumes that there are core values held within ethical leadership, and taken together, create change for the common good. Leadership, then, is not positional: It becomes a shared endeavor of committed persons working toward a common goal."

Overton-Healy says scholars selected for E-LEAD will learn specific leadership skills. Moreover, she notes, the scholars will be helped in three strategic areas: identifying their core strengths, aptitudes and values; understanding how their experiences, privileges and


(Credit: Rick McLay; Alfred Univ.)

Alfred University High-Temp Lab.

disadvantages shape how they lead; and locating opportunities to improve gender inequity in science, technology, engineering and mathematics. Skills training will include public speaking, meeting management, time management, listening and conflict resolution.

Overton-Healy says she expects the mix of theory, self assessments, skill building and real-world application will give E-LEAD scholars higher self confidence and efficacy in assuming leadership roles. She says one component will be "community building" that will include peer mentoring, colocated student housing and networking events. E-LEAD also will be able to leverage programming already offered by AU's Women's Leadership Center.

In regard to career development, E-LEAD will provide on-campus research opportunities for first-year students, résumé and interviewing workshops, optional co-op educational experiences and summer internships.

Edwards and Overton-Healy will serve as coprincipal investigators. They plan on using the first year of the project on program development and recruitment of the first group of E-LEAD scholars. The grant is expected to provide scholarships to 16 male and female students throughout their academic career, plus support outreach activities aimed at increasing the number of female students in engineering.

While the NSF funding provides support for the first five years, Edwards and Overton-Healy view E-LEAD as a long-term effort, and say they will be seeking corporate support to make it a sustainable program for engineering students.

Visit: www.engineering.alfred.edu/ ■

Freedonia: Demand for refractories to increase more than 5 percent annually through 2014

The Freedonia Group, a market research firm, says that the market for refractory products generally will enjoy strong, steady growth over the next three years, especially in the Asia region and particularly in regard to China. A new study available from Freedonia says demand will grow on average 5.3 percent each year through 2014 and eventually will amount to nearly 41 million metric tons per year in sales. As far as products go, the 371-page study says monolithics will outperform brick and shapes.

According to Freedonia, consumption of refractory products by China and India will be above average, but even United States and European mar-

Change in world refractory demand:					
Refractory demand	Thousand metric tons 2004	Thousand metric tons 2009	Thousand metric tons 2014	Percent change 2004–2009	Percent change 2009–2014
Worldwide demand	25,665	31,500	40,700	+ 4.2	+ 5.3
North America	3,305	2,445	3,150	–5.9	+ 5.8
Western Europe	3,550	2,725	3,240	–5.2	+ 3.5
Asia/Pacific	13,350	21,340	21,340	+ 9.8	+ 5.5
Other regions	5,460	4,990	6,460	–1.8	+ 5.3

kets are projected to do significantly better than during the 2004–2009 period when consumption fell at annual rates of approximately 5 percent.

In a news release, the company notes, "Suppliers will benefit from an improvement in the key U.S. market, which will rebound from dismal levels in 2009." But, Freedonia also warns that U.S. and European refractory manufacturers could get squeezed by the raw-material prices, suggesting that, "Raw material supply will continue to be a challenge to refractory producers."

Despite a miniboom in U.S. steel production in the mid- and late-2000s, refractory producers complained because they often had to pay premium prices for bauxite and other key materials, plus they faced tough sales negotiations with metal-making companies.

Demand in all markets will still be driven by steel and iron production, according to the study. "Despite declines in the amount of units needed per ton of steel produced, iron and steel will have the strongest gains of any market through 2014 due to rising steel production," says the company.

Freedonia also expects increased demand for refractory products from aluminum producers as wells as from nonmetallic mineral products markets, such as ceramics, cement and other mineral products, as well as demand from petroleum, chemicals, paper and aerospace applications.

Freedonia's optimism about monolithics is because of the growing use of these products to extend the interval between brick relinings of ovens, ladles and other high-temperature uses.

Freedonia's full report is available for $5,900 from The Freedonia Group, www.freedoniagroup.com, or call 440-684-9600. ■

MS&T'11 symposium to highlight career of Jay Narayan

(Credit: Matt Shipman, NC State News Services.)

Narayan

This fall's MS&T program will have a special symposium dedicated to the research contributions of Jagdish (Jay) Narayan, a professor at North Carolina State University. Narayan, a member of ACerS and many other scientific and technical organizations, has covered a lot of territory in his research, from vacancies and interstitials in ionic solids to laser thin-film deposition, novel LEDs, high-temperature superconductors and diamond-like films.

Besides his research, Narayan also has been a leader in his field, serving in oversight capacities at the Oak Ridge National Lab, the Microelectronics Center of North Carolina and the National Science Foundation. He is currently director of the NSF Center for Advanced Materials and Smart Structures at NCSU.

To mark this materials all-star's contributions, the ACerS, Army Research Lab, ASM International, TMS and the Kopin Corp are sponsoring this special symposium to pay tribute to Narayan.

Formally titled the International Symposium on Advances in Nanostructured Materials and Applications/Acta Materialia Gold Medal Symposia, these sessions will delve into a wide range of topics:

Electronic materials

- Defects, interfaces and thin-film epitaxy across the misfit scale in dissimilar materials;
- Synthesis and non-equilibrium processing of functional electronic materials;
- Self-assembly of nanostructured functional materials;
- Nanoscale and atomic-scale characterization;
- Nanostructure-property correlations and modeling.

Structural materials

- Control of nanostructures and processing of bulk nanostructured materials;
- Stability of nanostructured materials and grain-size effects;
- Role of twinning and properties of nanomaterials;
- Control of ductility and fracture toughness;
- Mechanical properties and related applications.

The MS&T'11 website includes a list of the impressive speakers have who already confirmed their participation. Visit www.matscitech.org ■

Art museums gets technical with advanced ceramic, CoorsTek porcelain exhibits

The science behind ceramic materials has become a point of interest at two museums in the United States. The Denver Art Museum announced that it will have a special exhibit beginning June 11 called "Potters of precision: The Coors Porcelain Company," which will display special porcelain

Beakers, such as this, and other porcelain lab equipment will be be part of an art exhibit opening in early June, which highlights the beauty of functional clay products manufactured by Coors Porcelain Co./ CoorsTek.

labware and tools manufactured by the entity now known as CoorsTek. At the same time, the American Museum of Ceramic Art is installing a permanent exhibit of examples of where ceramic materials are found in many common and advance technical applications.

The Denver museum says in a news release, referring to the variety of crucibles, beakers, evaporating dishes, etc., made by CoorsTek, a Golden, Colo. company, "Beauty and function exist simultaneously in vessels that serve scientists' precisely stated needs."

CoorsTek makes lab equipment, but it also has branched out into a huge range of advanced ceramic technologies, including products for the defense, automotive, aerospace, telecom, semiconductor, medical and general industrial markets.

Farther west, in Pomona, Calif., the America Museum of Ceramic Art also is bringing the arts and science communities together and creating programming and permanent displays about advanced ceramic engineering and science. AMOCA opened in January a new great exhibition on the theme of advanced ceramic and science technology, "Ceramics for the New Millennium."

The museum says the exhibit is an unfamiliar departure from the museum's usual art fare. A brochure tells attendees they will, "See how your every-day life is improved by the multitude of innovations and inventions that use ceramic technology. [. . .] With the current dialogue regarding the necessity for a green environment and global responsibility – have you ever considered that the answer might be clay? Or that clay technology is an energy-efficient practice? Ceramic products are used to create clean energy with lower costs, establishing jobs which build a sustainable economy. Organic clay particles can replace the volatile chemicals used in plastics. Ceramic seeds can be used to deliver localized radiation that kills cancer cells, yet leaves healthy cells alone. You may be familiar with the mundanities of porcelain dental implants, kitchen sinks, light bulb sockets, and ceramic-lined crock pots, but you may not recognize the hundreds of other ceramic engineering applications such as ceramic hip or joint replacements, ceramic space ship tiles and ceramic body armor plates used for defense."

Wendell Keith, CEO of Keith Company, a maker of industrial heat-treat furnace equipment, helped museum staff with the exhibit and to pull together several related events, such as the February 5 ceramic industry mixer, a grand-opening reception and a "Family Science Day" that featured lots of hand-on activities.

On April 9, 2011, AMOCA hosted a special presentation by Vilupanur Ravi, professor and chair of the Chemical & Materials Engineering Department at Cal Poly, Pomona. Ravi lectured on the topic, "How Advanced Ceramics Play an Important Role in Industry Today." Ravi also helped during the special Family Science Day activities held earlier in the year.

AMOCA praises the support they have received from Bryan Vansell of Mission Clay Products; Joel Moskowitz, CEO of Ceradyne Inc.; CoorsTek; Kyocera; and SPT Small Precision Tools.

Visit: www.denverartmuseum.org and www.ceramicmuseum.org ■

Cal Poly Pomona's Vilupanur Ravi demonstrates a superconducting magnet as part of AMOCA's Family Science Day.

Sandia, TEES and Khalifa U. launch GNEII nuclear energy safety institute for Middle East region

The world now is quite a bit more tuned in to the need for multinational cooperation on nuclear energy issues than it was a few months ago. Hopefully, that awareness will translate into some appreciation for the work being done by two United States groups and a university in Abu Dhabi to help "seed" a culture of nuclear energy safety and security around the world.

Sandia National Labs recently announced that representatives of a special group within the lab, along with experts from Texas Engineering Experiment Station and leaders from the Khalifa University of Science, Technology & Research (Abu Dhabi), have signed a memorandum of understanding that establishes the Gulf Nuclear Energy Infrastructure Institute (GNEII, pronounced "genie").

The Texas Engineering Experiment Station is an engineering research agency of the State of Texas and part of the Texas A&M University system. TAMU has a significant Department of Nuclear Engineering and many staff participate in departmental and TEES activities.

The Sandia team, led by Adam Williams, conceived and led the development of the new institute that seeds and cultivates a regional culture of responsible nuclear energy management.

(Credit: Khalifa University.)

GNEII nuclear energy safety, security institute was officially launched with the signing of an agreement among TEES, Sandia National Laboratories and Khalifa University.

Others have used the story of the "genie in the bottle" as a metaphor for nuclear materials, so it is appropriate to note that GNEII is symbolically about keeping the lid on that bottle. Sandia says there is international interest in this topic matter, and it hopes the new program will become a model for others built on a regional basis.

In a Sandia news release, Adams says, "Those of us with knowledge, who understand the safety, safeguards and security that nuclear energy programs require, have a responsibility to help local professionals adequately prepare for what they're building."

The target audience is policymakers, government officials and energy program executives. The three institutions are developing a curriculum around general nuclear energy safety, safeguards and security issues. Specific subjects that will be covered are

- Systems thinking;
- Basic nuclear physics;
- Nuclear fuel cycles;
- Nonproliferation;
- General power plant operations; and
- Radiological materials management.

Participants also will be required to conduct an independent research project. Initially, participation is limited to professionals from three Emirati organizations (not named). There are plans to ultimately include professionals from all six Gulf Cooperation Council members (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates).

"Nuclear energy programs are complex and there are many steps to establishing a responsible nuclear program," Williams continues in the Sandia release. "Among the local ranks in the Middle East, few understood all facets. Our goal is to provide a solid start for a comprehensive, complete and coherent introduction to a responsible nuclear energy program so the idea of a 'Middle Eastern nuclear energy program' won't keep people up at night."

Visit www.sandia.gov ■

Business news

Corning releases a 'Day Made of Glass' video (www.corning.com/news_center/features/A_Day_Made_of_Glass.aspx) … **CM Furnaces** celebrates 65th birthday (www.cmfurnaces.com) … Upgraded universal borescope from **Schoelly Imaging** offers modular advantage (www.schoellyimaging.com) … **Thermal Technology** provides K1 sapphire growers to Silian (www.thermaltechnology.com) … **Harper** awarded contract for complete state-of-the-art carbon-fiber processing line at Oak Ridge National Lab (www.harperintl.com) … Crumm assumes leadership as **Ultra Electronics Adaptive Materials** expands staff 20 percent (www.adaptivematerials.com … **Diamon-Fusion International** announces new officers, directors (www.diamon-fusion.com) … **MV Products** offers vacuum foreline traps for green product manufacturing processes (www.massvac.com) … **CoorsTek** invests $3 million in EmiSense Technologies (www.coorstek.com) … **Michelman** strengthens new global fibers and composites business unit with appointment of business development manager, Asia Pacific (www.michelman.com) … **Paumanok Group** report: Resistors, Discrete Inductors and Capacitors - World Markets, Technologies and Opportunities 2011-2015 (www.paumanokgroup.com) … **Trek** introduces new high-frequency amplifier for MEMS (www.trekinc.com) … **Engis Corp.** plans 54,000-square-foot expansion at world headquarters (www.engis.com) … **Shimadzu** offers new universal testers that streamline analysis (www.shimadzu.com). ■

acers spotlight

Welcome to our newest Corporate Members

ACerS recognizes organizations that joined the Society as Corporate Members in the past few months.

For more information on benefits of becoming a Corporate Member, contact Nick Schafer at nschafer@ceramics.org or visit ACerS special Corporate Member web page, www.ceramics.org/corporate.

Dunhua Zhengxing Abrasive Co. Ltd.
www.boroncarbide.cn

McDanel Advanced Ceramic Technologies LLC
www.mcdanelceramics.com

Resodyn Acoustic Mixers Inc.
www.resodynmixers.com

ICC4 call for papers announced

It's time to submit abstracts for the 4th International Congress on Ceramics to be held July 15–19, 2012, in Chicago. ICC4 is a global event designed to foster discussion and planning concerning issues facing the global ceramic and glass communities and a must-attend event for science, technology and business leaders in this field.

Organizers say ICC4 attendees can shape the future of the ceramics and glass industry and technology by joining more than 600 business, research and government leaders from around the world to

- Listen and learn from leaders in the ceramic and glass materials community;
- Exchange ideas with invited speakers;
- Share ideas in interactive sessions;
- Present your work and vision in the Interactive Technology Forum; and
- Exhibit the latest commercially available materials, equipment, products and services.

ICC4 will incorporate the Ceramic Leadership Summit 2012, an annual meeting where business and technical leaders discuss business opportunities, emerging technologies and critical areas for scientific advancement and process innovations that challenge the ceramic and glass materials community.

Visit: www.ceramics.org/icc4 ■

CLS 2011 general session speakers announced

The 2011 Ceramic Leadership Summit, hosted Aug. 1–3 in Baltimore, will feature impressive general session speakers who represent a top-rung cross section of the materials business and technology field.

Wolfgang Rossner, a leading R&D manager, will lead off the first general session by speaking on "Advanced Ceramics for Sustainability – View from **Siemens Corporate Technology**." Rossner will be followed by respected technology leader **Krishan L. Luthra**, who will be speaking on "Emerging Applications and Challenges in Using Ceramic Materials at **General Electric**."

In the next general session, **A123 Systems** cofounder and CTO **Bart Riley**, **Mo-Sci Corp.'s** president **Ted Day** and **CeraNova Corp.'s** president **Marina Pascucci** will jointly present case studies on building businesses based on materials technology.

The third general session will feature **Thomas A. Cole**, vice president of business development at **Ceradyne Inc.** Cole will explore "Business Opportunities and Strategies in Emerging Markets."

Alexander Michaelis' presentation on "Connecting Research, Technology and Manufacturing" will be the focus of the final general session. Michaelis is the director of the **Fraunhofer Institute for Ceramic Technologies and Systems**.

Registration for CLS 2011 is open now. There is a "super-early-bird" discounted registration of $225 now available, but that savings opportunity ends May 16.

Visit: www.ceramics.org/cls2011 ■

ICACC'12 (Daytona Beach) call for papers issued

ACerS announces a call for papers for the 36th International Conference and Expo on Advanced Ceramics and Composites. The meeting will be hosted at the Hilton Daytona Beach Resort and Ocean Center Jan. 22–27, 2012.

This conference showcases cutting-edge research and product developments in advanced ceramics, armor ceramics, solid oxide fuel cells, ceramic coatings, bioceramics and more.

The meeting will feature symposia on

- Mechanical behavior and performance of ceramics and nanocomposites;
- Advanced ceramic coatings for structural, environmental and functional applications;
- Solid oxide fuel cells: materials, science and technology;
- Armor ceramics;
- Next-generation bioceramics;
- Electric energy generations, storage and distribution;
- Nanostructured materials and nanocomposites;
- Advanced processing and manufacturing technologies for structural and multifunctional materials and systems;
- Porous ceramics: novel developments and applications;
- Thermal management materials and technologies;
- Nanomaterials for sensing applications: from fundamentals to device generation;
- Materials for extreme environments: ultra-high-temperature ceramics and nanolaminated ternary carbides and nitrides (MAX phases);
- Advanced ceramics and composites for nuclear applications; and
- Advanced materials and technologies for rechargeable batteries.

The meeting also has three focus sessions: Geopolymers, inorganic polymers, hybrid organic–inorganic polymer materials; Computational design, modeling and simulation of ceramics and composites; and Next-generation technologies for innovative surface coatings.

For more information on the conference and submitting abstracts, visit: www.ceramics.org/daytona2012 ■

Suresh to be MS&T'11 plenary session speaker

As the date for this year's MS&T meeting approaches, organizers are confirming more of the details of the conference program. Most recently, they had the pleasure of announcing that Subra Suresh, director of the National Science Foundation, will be the featured speaker at the plenary session on Monday, Oct. 17. The session is set to start at 8:30 a.m. and run until noon.

Suresh's lecture will lead off the session, and his presentation – on the importance of the United State's science and technology workforce – will be followed by several prominent speakers on related topics. Look for more information coming soon or visit www.matscitech.org ■

GOMD announces award winners and lecturers

ACerS' Glass & Optical Materials Division has announced the winners of its 2011 awards. The awards will be presented the Division's upcoming annual meeting, scheduled for May 15–19, 2011, in Savannah, Ga.

This year, GOMD has tapped Delbert Day to give its "Stookey Lecture of Discovery" award lecture. Day is Curators' Professor of Ceramic Engineering and Senior Research Investigator at the Graduate Center for Materials Research, Missouri University of Science and Technology. The award was created in honor of materials pioneer S. Donald Stookey to recognize an individual's lifetime of innovative research. Day has titled his lecture "Repairing the Body with Glass," which will be given the morning of May 16.

The Division's "George W. Morey Award" is going to Neville Greaves, Distinguished Research Professor in the Department of Materials Science and Metallurgy at the University of Cambridge (U.K.). As part of the award, Greaves will present a lecture, "Glass Structure, Ion Transport and the Pareto Principle," on the morning of May 17. The award, sponsored by PPG Industries, honors the memory of George W. Morey, who was a pioneer in the study of glass properties. The award recognizes new and original work in the field of glass science and technology.

The 2011 "Norbert J. Kreidl Award" for young scholars is going to Randilynn Christensen, an MSE studying at Iowa State University, based on her extended abstract "The Mixed Glassformer Effect in Sodium Borophosphate Glass." Christensen will be given her award at a lunch ceremony at noon on May 17.

For more information, visit: www.ceramics.org/gomd2011 ■

Call for papers announced for 'Energy 2012'

Abstracts can now be submitted for the Materials Challenges in Alternative and Renewable Energy 2012 meeting. The deadline for abstracts is Sept. 19, 2011. "Energy 2012" will feature symposia on

- Batteries and energy storage;
- Biomass;
- Electric grid;
- Geothermal;
- Hydrogen;
- Hydropower;
- Nuclear;
- Solar power; and
- Wind energy.

Scheduled for Feb. 26–29, 2012, Energy 2012 will facilitate information sharing on the latest developments involving materials for alternative and renewable energy systems. Make your reservations for sunny Clearwater Beach, Fla., today! Visit www.ceramics.org/energy2012 ■

In Memoriam

John Randall Wheeler, 1934–2011

Some detailed obituaries also can be found on the ACerS website, www.ceramics.org/in-memoriam

ADDITIVES, AWARDS HIGHLIGHT REFRACTORIES MEETING

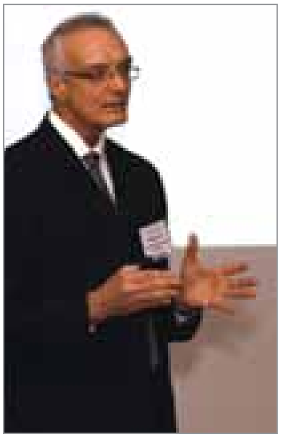
Over 150 attendees at the 47th Symposium on Refractories (March 23-24, 2011) traveled from as far away as Brazil, France, Germany, Norway, Peru, Turkey and the United Kingdom, and as close as from Rolla, Pevely and, of course, St. Louis. Mo. The symposium, sponsored by the St. Louis Section and the Refractory Ceramics Division of The American Ceramic Society, had a theme this year of "Additives for Monolithics."

The meeting was honored to have at least 14 T.J. Plange Award winners present, including, from left, Lou Trostel Jr., Jim Hill, Howard Johnson, Dilip Jain, Kent Weisenstein, Charles Semler, Rob Crolius, Roy Bottjer, Len Krietz, Mark Stett, Orville Hunter and George Taylor.

The organizers, who include people such as Mary Reidmeyer (Missouri S&T), James Hemrick (Oak Ridge National Lab), Dave Tucker (CE Minerals) and Ben Markel (Resco Products), put together a stellar schedule that included presentations from Dale Zacherl from Almatis, Rajan Srinivasacharya from Momentive Specialty Chemicals and Xiaoyong Xiong from Damrec–Imerys.

At the symposium luncheon, the St. Louis Section honored The Refractories Institute's Rob Crolius with the T.J. Planje Award, named in recognition of the contribution to the former dean of what years ago was called Missouri School of Mines and Metallurgy, the precursor to Missouri S&T. ■

Missouri University of Science & Technology's Patty Smith was recognized during the meeting for her organizing efforts on behalf of the Annual Symposium.



Victor Carlos Pandolfelli gave an invited lecture on Refractory Microstructure Engineering. Pandolfelli, who is from Brazil's Universidad Federal de Sao Carlos, also called for efforts to enhance public awareness about refractory technologies and careers.

Rob Crolius, of The Refractories Institute, receives the St. Louis Section's 2011 T.J. Planje from Orville Hunter.

RCD chair James Hemrick, left, presented the 2010 Alfred W. Allen Award to Devdutt Shukla and Jeffrey D. Smith for their paper, "Effect of Celsian on Corrosion of Aluminosilicate Castable Refractories," (*Refractories Applications Transactions,* Vol. 4, No. 3, November/December 2009). The biennial award is presented in recognition of the refractories-oriented paper that the award committee believes reflected the highest level of technical quality.

Novacem's 'carbon negative cement'

A "green" material that has received press attention in recent months is a product from Novacem that the company is billing as a "carbon negative cement."

The most recent stimulus for these stories is that in February, a New York-based consultancy group, Material ConneXion announced that it had given Novacem's cement an award as Material of the Year for 2010.

Novacem also has received recognition from *Technology Review* and the *Wall Street Journal*.

According to Novacem (London, U.K.), its MgO-based cement not only doesn't emit carbon dioxide, but absorbs it. The company's website provides the following explanation: "Novacem has developed a new class of cement which will offer performance and cost parity with ordinary Portland cement, but with a carbon negative footprint. It is uniquely positioned to meet the challenge of reducing cement industry carbon emissions."

The website continues, "Our cement is based on magnesium oxide and hydrated magnesium carbonates. Our production process uses accelerated carbonation of magnesium silicates under elevated levels of temperature and pressure (i.e., 180°C/150 bar). The carbonates produced are heated at low temperatures (700°C) to produce MgO, with the CO_2 generated being recycled back in the process.

The use of magnesium silicates eliminates the CO_2 emissions from raw materials processing. In addition, the low temperatures required allow use of fuels with low energy content or carbon intensity (i.e., biomass), thus further reducing carbon emissions. Additionally, production of the carbonates absorbs CO_2; they are produced by carbonating part of the manufactured MgO using atmospheric/industrial CO_2. Overall, the production process to make one ton of Novacem cement absorbs up to 100 kg more CO_2 than it emits, making it a carbon negative product."


(Credit: Novacem.)

Blocks made with Novacem cement.

To avoid confusion, it is worth noting that although it has some similarities, Novacem's product is not to be mixed up with geopolymers, which is another family of cement alternatives.

Members of the ACerS Cement Division explained to the *Bulletin* that magnesium-based cements are far from new and have been around since at least 1867. They are sometimes known as "Sorel cements."

Although magnesium-based cements have a chemistry different from the magnesium silicate cements proposed by Novacem, some members of the Division believe that they would likely be much more expensive than Portland-based cements.

One perplexing thing about this product is that there appears to be no independent research on the properties of the Novacem cement. It would be important to examine, for example, the durability and water resistance of Novacem's product compared with Portland-based cement. Therefore, some caution must be exercised in regard to accepting their claims.

Certainly, there is an interest in "green" alternatives to Portland-type cements, the production of which requires major CO_2 emissions and is very energy intensive. The mainstream cement industry, itself, has been taking steps to address some of these problems, but change has been slow.

One reason why engineers and contractors haven't embraced alternatives, such as geopolymers and Novacem, is that most building and construction codes are formula based rather than performance based. In other words, the codes tend to spell out in detail what mix of concrete can be used where, instead of establishing a set of characteristics (e.g., compressive strength). Unless these codes are modified – and there doesn't appear to be any motion in that direction – general demand will be curtailed, and the small scale of specialty-type demand (e.g., emergency repairs of military airfields) will keep production costs high.

Nevertheless, Novacem appears to be optimistic about its cement. According to IBTimes website, "the cement will be released commercially starting 2014, but not by Novacem. Instead, they will sell the patent rights to producing companies, who will (hopefully) commercialize it at competitive prices."

Visit: www.novacem.com

Cabot launches new aerogel additives for coatings

The holy grail for thermal insulation is a practical (i.e, inexpensive and easy to use) product that incorporates silica-based aerogel, and, at first glance, Cabot's new Enova line of aerogel particles appears to be a step in the right direction.

Bulk silica aerogel is a hydrophobic superinsulator, but it is extremely brittle and, therefore, not so easy to manufacture in quantity, transport, use in large sizes, etc. Some niche applications have been found where the size of the products are small and buyers are willing to pay a premium for the extra performance.

Other companies, such as Cabot, ThermoBlok and Aspen, also have been trying to find a useful middle ground, where some thickness and performance characteristics are being traded off for ease-of-use considerations. And, so far, even these are being aimed at high-payoff types of applications, such as pipelines and storage tanks, where added temperature control can yield major energy savings and to create thermal barriers in isolated construction elements, such as steel stud facings.

Cabot's innovation in aerogel seems to be developing a product aimed specifically at the coatings market. Although the reliance on particles rather than sheets of aerogel decreases the potential for insulation, this disadvantage could be offset by the advantage of being easily sprayed on using standard manufacturing and constructon equipment.

An announcement from the company, timed to coincide with the opening of the European Coatings Show, says that, "applying a [1-millimeter] coating containing Enova aerogel to a 200°C metal surface meets U.S. and European testing protocols for safe touch temperature, preventing the first-degree burns one would normally expect within five seconds of skin contact. A thicker application, such as a [2-millimeter] coating results in a reduction in energy use of 30 percent for uninsulated metal vessels maintained at 70°C. This can easily translate to potential applications as wide ranging as home and commercial appliances, process piping, building and tank storage."


(Credit: Cabot.)

Cabot's Enova 3110 aerogel particles.

Cabot says the thermal conductivity of the particles is 12 milliwatts per meterper degree kelvin. Although this is theoretically better than polyurethane foam (30 mW/m·K), the company admits that the thermal conductivity of Enova can exceed polyurathane (30 mW/m·K to 50 mW/m·K) when the particles are used as an additive in a waterborne formulation. Cabot points out that this is still seven to 10 times more insulative than standard paint – and I suspect that the company will be looking to develop some partnerships with paint manufacturers and construction material suppliers.

The Enova brand actually encompasses three types of aerogel products, which are mainly differentiated by particle size: 0.1–0.7 millimeter, 0.1–1.2 millimeter and 2–40 micrometer.

James Pidhurney, Cabot's manager for the Enova products, predicts in the company's announcement that big changes may be in store. He says the, "Enova aerogel [additive] creates a paradigm shift in how the industry thinks about insulation and coatings, two products which were once mutually exclusive. In the past, if you wanted flexibility in a coating, you had to compromise on insulation performance. Enova additives enable a new class of coatings that deliver[s] the performance of traditional insulation and the flexibility of a coating in a single product."

Visit: www.cabot-corp.com/aerogel/coatings ■

Leaking water infrastructure is $20B annual market, according to Lux, and growing

Lux Research has just published a new research report, "Patching Water Infrastructure Where it Leaks Money."

Lux divides the opportunities into two categories: pipe repair solutions and monitoring solutions.

Pipe repair, at first glance, seems straight forward, but Lux senior researcher Brent Giles is unexcited about this sector, saying there is little technical innovation. He argues that the big money in this market is in monitoring solutions for water and waste systems. The analogy he draws is to Smart Grid technology that is enabling utilities to monitor their systems in real time, and to target resources and repairs.

According to Giles, water/waste managers likewise need to benefit from advances in information technologies. They need real-time and detailed monitoring of the water infrastructure, which also can alert them to a range of problems, including storm surges and contaminant dumping.

Giles, who authored the report, says software and sensor technologies can provide a dynamic picture of a water utility's entire infrastructure. "Without this holistic view, utilities cannot prioritize the most critical repairs – and may end up throwing money down the drain to address the leaks that are visible today rather than the ones that could prove catastrophic tomorrow," he says.

Giles says, however, to think beyond "Smart Water Meters." There are new opportunities in leak and chemical detectors, underground mapping systems (such as LIDAR), algorithmic event predictors and systems for processing and responding to Smart Meter data.

He says some managers need to own three-dimensional maps that show exactly where the pipe is. The next step will be to start placing detectors and dynamic meters and simultaneously begin to create event models.

Visit www.luxresearchinc.com ■

Perovskite-based tunable superlens developed

The DOE's Lawrence Berkeley National Lab says its staffers have developed a novel mode of fabricating a superlens for the infrared spectrum using, for the first time, perovskite-based oxides. The lab says a group led by Ramamoorthy Ramesh has reported on its "Near-field examination of perovskite-based superlenses and superlens-enhanced probe-object coupling" in *Nature Communications* (doi:10.1038/ncomms1249).

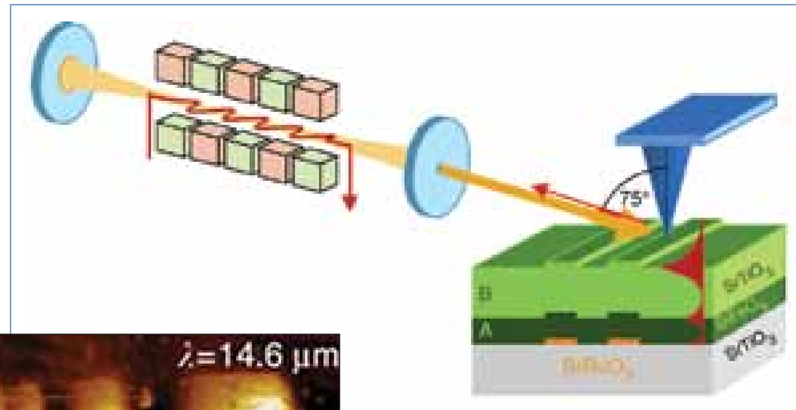
The innovation is an alternative to super resolution imaging approaches that are based on metamaterials. In brief, metamaterials are difficult to make and absorb a lot of precious light energy.

According to the lab's release, "The perovskite-based oxides on the other hand are simpler and easier to fabricate and are ideal for capturing light in the mid-infrared range. This opens the door to highly sensitive biomedical detection and imaging. It is also possible that the superlensing effect can be selectively turned on/off, which would open the door to highly dense data writing and storage."

The group says it is able to achieve an imaging resolution of λ/14 at the superlensing wavelength.

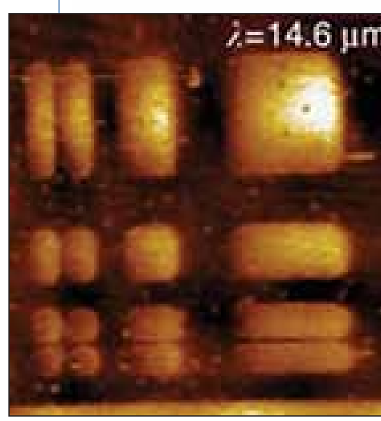
One of the biggest challenges for the researchers according to the report was finding the right combination of perovskites that would make an effective superlens. What they landed on was a layer of bismuth ferrite and a layer of strontium titanate with thicknesses of 200 and 400 nanometers, respectively. These thin films were grown by pulsed-laser deposition.

In the lab's release, Susanne Kehr, now with the University of St. Andrews (Scotland) and Yongmin Liu, a metamaterials expert at Berkeley's NSF Nanoscale Science and Engineering Center, provide additional information about the advantages of perovskites. "The bismuth ferrite and strontium titanate material feature a low rate of photon absorption and can be grown as epitaxial multilayers whose highly crystalline quality reduces interface roughness so there are few photons lost to scattering," they say. "This combination of low absorption and scattering losses significantly improves the imaging resolution of the superlens."



(Credit: Kehr, et. al.)

▲ Experimental setup shows an IR free-electron laser light source and perovskite superlens consisting of $BiFeO_3$ and $SrTiO_3$ layers. Imaged objects are $SrRuO_3$ patterns (orange) on a $SrTiO_3$ substrate. The near-field probe is shown in blue and the evanescent waves in red.



(Credit: Kehr, et. al.)

▲ AFM image of subwavelength strontium ruthenate rectangles imaged with perovskite-based superlens using incident IR light of 14.6 micrometer wavelengths.

This research was conducted by an international collaboration of scientists, including ACerS member Lane Martin at the University of Illinois, Champaign-Urbana.

Because of thickness and related wavelength issues, these investigators sought and found a way to gain detailed control over the superlens, selective tuning sections or toggling the effect via an external electric field.

"The ability to switch superlensing on and off for a certain wavelength with an external electric field would make it possible to activate and deactivate certain local areas of the lens," Kehr says. "This is the concept of data-storage, with writing by electric fields and optical read-outs."

Liu says that the mid-infrared spectral region at which their superlens functions is prized for biomedical applications. "Compared with optical wavelengths, there are significant limitations in the basic components available today for biophotonic delivery in the mid-infrared. Our superlens has the potentials to eliminate these limitations."

Liu suggests the world is full of opportunities for these materials, saying, "Perovskites display a wide range of fascinating properties, such as ferroelectricity and piezoelectricity, superconductivity and enormous magnetoresistance, that might inspire new functionalities of perovskite-based superlenses, such as nonvolatile memory, microsensors and microactuators, as well as applications in nanoelectronics."

Visit: www.lbl.gov ■

Bioactive cement plaster: Bioengineering in action

For some time, it has been common to use enzymes as biocatalysts. When the enzymes required are difficult or expensive to extract, the utilization of microorganisms such as bacteria, yeast, or fungi is an alternative.

For many applications, the living cells are immobilized within a stable matrix system. This prevents the embedded cells against culture wash-out and protects them from external impact, such as shear forces, pH or solvents. Besides commonly used natural polymers, some porous inorganic matrices have become increasingly important for immobilizing living cells.

Results of former studies have shown that bacteria can be successfully embedded within a very hard concrete matrix and can remain viable for a period of four months. This encouraged the R&D organization GMBU and the company InnoTERE (both Dresden, Germany) to investigate the immobilization of microorganisms in cements. The researchers examined the viability and biocatalytic applicability of the bacteria Rhodococcus ruber and the yeast Saccharomyces cerevisiae, in particular their dependence on preparation conditions.

For their investigations, they used magnesium phosphate cement, which can be prepared easily by mixing hard-burned tribasic magnesium phosphate powder and ammonium phosphate solution. Because of the stiffness of the cement matrix, bioactive MPC could be very interesting for applications in bioremediation, in biotechnology as bulk material in large columns or reactive walls, or as bioactive cement plaster within sewers.

The results of the study, "Cements with embedded living microorganisms: A new class of biocatalytic composite materials for application in bioremediation, biotechnology" (doi:10.1002/adem.201080040) revealed that the bioactive composite material exhibits good mechanical and chemical stability. The embedded cells survived the embedding within the cement matrix even though the cements showed much slower glucose and phenol consumption in comparison with nonimmobilized cells.

Combining a cement matrix with living microorganisms is a promising method to fabricate biocomposite materials for application in biotechnology.

Visit: InnoTere, www.innotere.de; and GMBU, www.gmbu.de

Spintronics may get boost from enhanced magnetism in BFO films

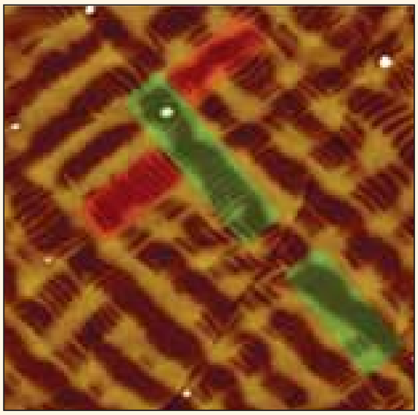
Also from Berkeley Lab (see previous story), we received word about work there regarding spontaneous magnetization in bismuth ferrite, another multiferroic material.

What seems to have researchers really excited is that they can turn this magnetization on and off via an external electric field at room temperature, making the BFO a possible material for spintronic applications.

In a news release from the lab, Ramamoorthy Ramesh, the materials scientist with the lab's Materials Sciences Division who led this research, explains the novel approach taken. He says, "[W]e've created a new magnetic state in bismuth ferrite along with the ability to electrically control this magnetism at room temperature. An enhanced magnetization arises in the rhombohedral phases of our bismuth ferrite self-assembled nanostructures. This magnetization is strain-confined between the tetragonal phases of the material and can be erased by the application of an electric field. The magnetization is restored when the polarity of the electric field is reversed."

In 2009, Ramesh and his research group looked at thin films of the BFO and found that although bismuth ferrite is an insulator, two of three domain wall orientations in the material conduct electricity. They subsequently found that application of a large epitaxial strain changes the BFO crystal structure from a predominant rhombohedral phase to a tetragonal phase.

Conversely, a partial strain reduction produces a nanoscale mixed phase



(Credit: Ramesh Group; Berkeley Lab.)

AFM image of a mixed-phase bismuth ferrite sample. The red and green areas indicate phase regions oriented at 90 degrees to each other.

composed of the rhombohedral and tetragonal phases. Ramesh says the mixture can be stable, with the rhombohedral phases mechanically confined by regions of the tetragonal phases.

As a result of the interaction, a different magnetic moment (30 to 40 electromagnetic units per cubic centimeter) spontaneously arises within the distorted rhombohedral phase, one that is qualitatively stronger than the magnetic moment of fully rhombohedral BFO (6 to 8 electromagnetic units per cubic centimeter).

Ramesh says these differences are large enough to be put to use, and can be manipulated using an external electrical field rather than applying the magnetic field used in conventional memory devices.

The results of the group's work is published *Nature Communications* (doi:10.1038/ncomms1221).

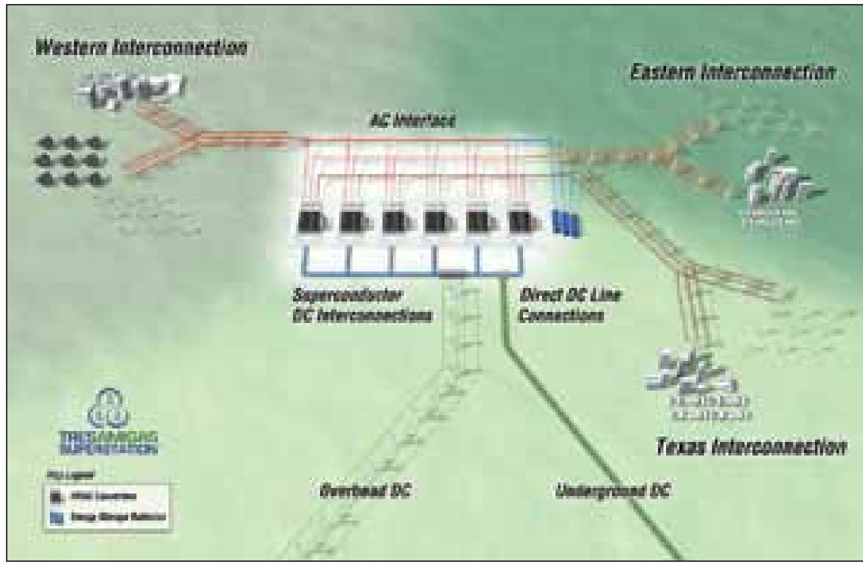
Visit: www.lbl.gov

Tres Amigas likely to be early high-profile superconductor grid project

Although it is sometimes mistakenly thought of as a monolith, the United State's current "electric grid" is more or less an aggregate of two large and several smaller but distinct and, heretofore, separate grids. That may change soon with the planned billion-dollar Tres Amigas LLC project that aims to physically connect at least the two big networks and one of the smaller ones using a system of special alternating current to direct current voltage converters and superconducting connectors.

The U.S. grid's diffused structure is a remnant of how the nation's electrical infrastructure was cobbled together during most of the late 19th and the 20th Centuries. Physical and technical constraints shaped most of the existing structure of the national grid and, for the past few decades, it has impeded energy producers and consumers from assisting or buying from a truly national marketplace. These limitations have been exacerbated as it has dawned on our political and science leaders that many renewable energy generation opportunities (e.g., wind and solar) are going to be centered (or at least optimized) in specific geographical regions that are remote in comparison with where demand is the greatest.

Thus, forging one national grid from the current parts is a priority. That's where the Tres Amigas company and its "SuperStation" comes in. The company describes itself as "a merchant transmission entity composed of electric utility industry operational, technology and thought leaders." The goal is to build a SuperStation hub near Clovis, N.M., one of the closest interfaces among the Eastern, Western and Texas "interconnects." This will be one of the largest projects in the U.S. that includes high-temperature superconducting cables. The architects of the project say the Superstation will be able to transfer thousands of megawatts of power (scalable to 30 gigawatts) among the three asynchronous U.S. grids.



(Credit: Tres Amigas LLC)

The Tres Amigas SuperStation is planned to interface the large Eastern and Western Interconnection, with the smaller Texas Interconnection. The SuperStation is to be located in Clovis, N.M.

The plans of Tres Amigas aren't totally altruistic. The investors realize that without connecting the three parts, it will be extremely difficult to create a market hub for renewable power.

Tres Amigas intends to leverage three special technologies. The first is voltage source converters that process the ac power flowing grid feed to DC power that can be routed through the SuperStation. Likewise, the VSCs transition the dc power back to ac power to flow out elsewhere in the grid.

The second key technology is Xtreme Power's Dynamic Power Resources energy storage systems. Xtreme Power describes the building blocks of the DPRs as "a dry-cell battery technology with a very innovative design. Metal-alloy-coated, ballistic-grade fibers are woven together to offer structural integrity and multiple pathways for ultra-low-impedance current to flow in and out of the battery. Proprietary formulas of fundamental alloys, such as copper, lead and tellurium, are used to form bipolar plates that provide a massive surface area at the nanoscale for the chemical reaction to take place, resulting in an extremely low internal resistance."

The third enabling technology is the superconducting wire and cable system that compose much of the hub. The cables are at least partially manufactured by American Superconductor. AMSC announced in November 2010 that it had selected Korea's LS Cable Ltd. and France's Nexans as subcontractors for the Tres Amigas SuperStation. LS Cable and Nexans will manufacture superconductor power cables utilizing AMSC's Amperium second-generation superconducting high-temperature wire.

The cables and many other Tres Amigas components will be located underground. Tres Amigas says it procured 22 square miles for the SuperStation, and the general design is to have three voltage conversion facilities located about 2 kilometers apart from each other.

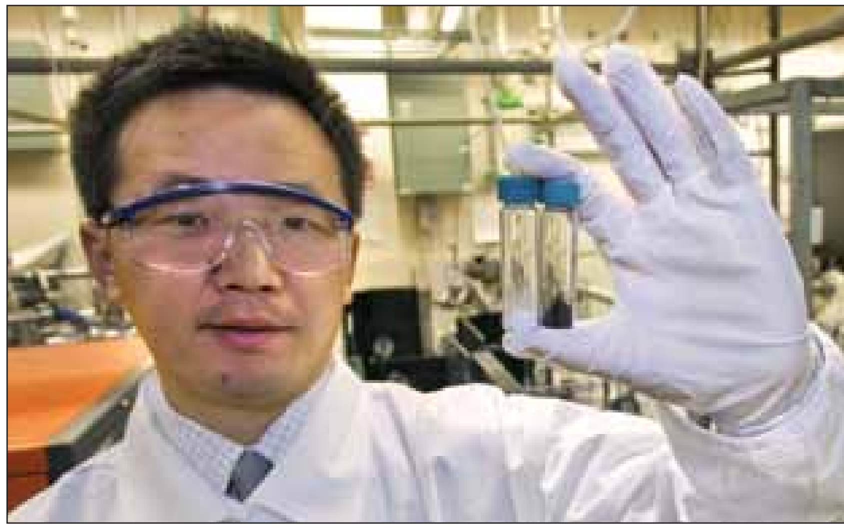
The timeline for the Tres Amigas project seems a little unclear at this point. Company officials are not providing a completion date, but there seems to be general agreement that the construction will take about five years.

Visit: www.tresamigasllc.com/ ■

Disordered TiO_2 nanocrystal surface yields durable, more efficient photocatalyst

By tinkering with the outer layer of titanium oxide nanocrystals, researchers at Lawrence Berkeley National Lab have figured out a way to turn the material into a tough and more effective photocatalyst for environmental and energy applications. They claim this is the first time durability and efficiency have been combined in a photocatalyst.

Samuel Mao, an investigator with the Advanced Energy Technologies Department of the Lab's Environmental Energy Technologies Division, says they were trying to improve hydrogen production from organic materials in water when they had the idea to introduce disorder in nanophase TiO_2 and hopefully expand its light-absorption ability.

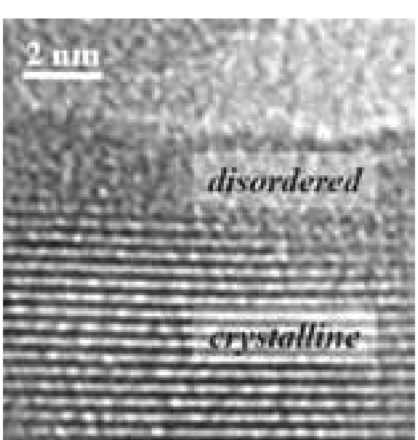


(Credit S. Mao, et al; Science Express.)

Mao shows how the disorder-engineered titanium dioxide nanocrystals turned the material from white to black.

The group's work, "Increasing solar absorption for photocatalysis with black, hydrogenated titanium dioxide nanocrystals," is published in *Science Express* (doi:10.1126/science.1200448), and may offer a path for generating hydrogen from organic compounds found in natural and polluted water sources.

Mao leads a research team that is searching for sustainable ways to generate hydrogen for use in clean-energy technologies. In a first-of-its-kind development, the team jumbled the surface layer of TiO_2 nanocrystals, a feat that turned the material from white to black.



(Credit S. Mao, et al; Science Express.)

TEM image of a $Ti0_2$ nanocrystal after hydrogenation reveals engineered disorder on the crystal's surface, a change that enables the photocatalyst to absorb infrared light.

Mao's group used hydrogenation to engineer disorder in the TiO_2. The researchers had a hint the nanocrystals might be effective over a wider spectrum of light when they saw that the material had turned from white to black after hydrogenation.

After 22 days of lab test using a full-spectrum solar light simulator with methanol serving as a sacrificial reagent, they report that, "We found that one hour of solar irradiation generated 0.2 Formula 0.02 mmol of H_2 using 0.02 g of disorder-engineered black TiO_2 nanocrystals (10 mmol·hour $^{-1}$·g^{-1} of photocatalysts). This H_2 production rate is about two orders of magnitude greater than the yields of most semiconductor photocatalysts. The energy conversion efficiency for solar hydrogen production, defined as the ratio between the energy of solar-produced hydrogen and the energy of the incident sunlight, reached 24% for disorder-engineered black TiO_2 nanocrystals," which they attribute to the nanocrystals new ability to absorb light from the infrared part of the spectrum.

The group also demonstrated similar effects when they substituted phenol and methylene blue for the methanol.

According to an LBL news release, the group says this is the first time a TiO_2-based photocatalyst is able to convert infrared, visible and ultraviolet light. "The more energy from the sun that can be absorbed by a photocatalyst, the more electrons can be supplied to a chemical reaction, which makes black titanium dioxide a very attractive material," says Mao in the release.

Theoretical physicist Peter Yu explains in the release that, "by introducing a specific kind of disorder, mid-gap electronic states are created accompanied by a reduced band gap." Yu, who also is a professor in the University of California at Berkeley's Physics Department, furher states, "This makes it possible for the infrared part of the solar spectrum to be absorbed and contribute to the photocatalysis."

Mao and his group say they are now tackling how to reach similar energy conversion levels in water containing more commonplace organic compounds.

Visit: http://eetd.lbl.gov/aet ■

Two new MgH_2-based approaches for hydrogen storage proposed

Two separate groups have announced what sounds like somewhat similar magnesium hydride-based nanotechnology approaches to hydrogen storage.

One group, at the Lawrence Berkeley National Lab, has designed a new composite material for hydrogen storage consisting of nanoparticles of magnesium metal sprinkled through a matrix of poly(methyl methacrylate) (think Plexiglas). The group says the nanocomposite has several features, including selective gas permeability, blocking oxygen and water.

(Credit: Jeff Urban; DOE.)

Berkeley lab's schematic of how high-capacity magnesium nanocrystals encapsulated in a gas-barrier polymer matrix provide a new and revolutionary hydrogen storage composite material.

Researchers in the group say that with this design, the composite can quickly absorb hydrogen (up to 6 weight percent of magnesium, 4 weight percent for the composite, in less than 30 minutes at 200°C) to form magnesium hydride. The group says it also can quickly reverse the process and release hydrogen, and the polymer barrier prevents oxidation of the metal. In addition, these investigators say the material is pliable.

The group, whose work is being conducted as part of the DOE's Hydrogen Storage Program, hopes that with this combination of properties, the storage material could be a major breakthrough in materials design for hydrogen storage, batteries and fuel cells.

Details of this work can be found in the paper (doi:10.1038/nmat2978), published in *Nature Materials*.

The other group is composed of chemists at the University of Glasgow working with the European Aeronautic Defense and Space Innovation Works group. The group is using nanotechnology to develop plans to improve the design and material composition of a special storage tank with the aim of making it so efficient that it will be feasible to use solid-state hydrogen in airplanes and cars.

Not many details are available, and it appears that this approach is still more conceptual than the Berkeley Lab group, but the Glasgow researchers say they plan on using a magnesium hydride, which has been modified at the nanoscale, to allow it to receive and release the hydrogen at fast rate.

Group leader Duncan Gregory, professor of inorganic materials at the School of Chemistry at the University of Glasgow, has been working on finding a new material for a special storage tank for fuel cell applications under development by Hydrogen Horizons, a company about which there is little public information, but is described in these announcements as a start-up company. Reportedly, prototypes of the HH tank have used a lanthanum/nickel ($LaNi_5$) alloy for storage.

Gregory says in a news release, "Using new active nanomaterials in combination with novel storage tank design principles presents a hugely exciting opportunity to address the considerable challenges of introducing hydrogen as a fuel for aviation. This collaboration between engineers and chemists and between industry and academia provides the pathway to achieve this."

Previously, Gregory has done research on nitridic hydrogen storage materials. Currently, however, he seems to be focusing on a magnesium hydride material that he says will extend its longevity and release the hydrogen at a rate that could feed a fuel cell at energy densities that could power an airplane. Unfortunately, he doesn't offer any hints about how his group is planning to combat the oxidation of the metal.

So, although the details are slim, the plans are bold: With a new tank structure, EADS hopes to fly an unmanned hydrogen-powered test plane in 2014 with a longer term view of introducing commercial airplanes powered by hydrogen.

Duncan and EADS IW have some funding from the Materials Knowledge Transfer Network – part of the U.K. Technology Strategy Board – and the Engineering and Physical Sciences Research Council. This will allow a student to conduct a four-year Ph.D. project.

The University of Glascow's website reports, "Once the technology has been proven in a small-scale demonstration, Prof. Gregory, Hydrogen Horizons and the EADS IW team intend to build a larger collaborative team with academic and industrial partners to seek large-scale funding from the U.K. and the European Union."

EADS is comprised of Airbus, Astrium, Eurocopter and Cassidian.

Visit the DOE Hydrogen Program, www.hydrogen.energy.gov; and EADS, www.eads.com ■

New class of optical fiber developed at Penn State; ZnSe waveguide cores open infrared spectrum

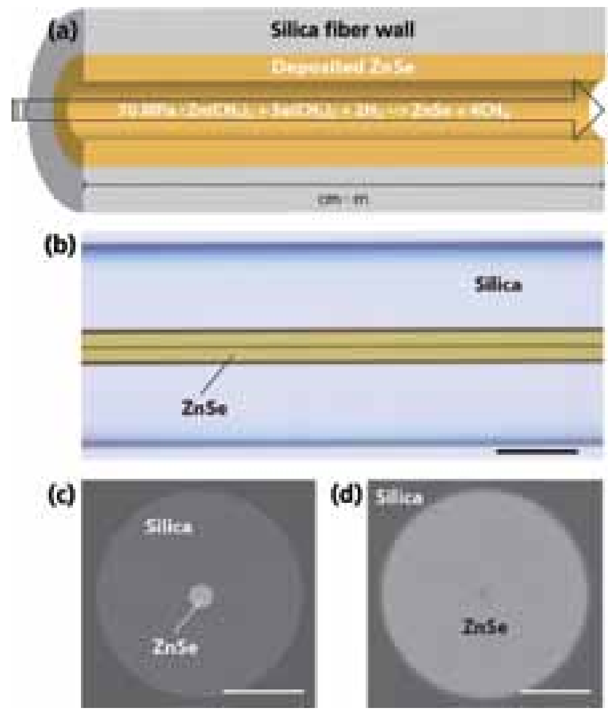
Scientists at Pennsylvania State University report that they developed the first optical fiber made with a core of zinc selenide. The team is led by John Badding, professor of chemistry at PSU, with help from fellow researchers at the school's Materials Research Institute and Department of Materials Science and Engineering, as well as from scientists at the Optoelectronics Research Centre at the University of Southampton (U.K.).

Badding says in a PSU news release, "It has become almost a cliche to say that optical fibers are the cornerstone of the modern information age. These long, thin fibers, which are three times as thick as a human hair, can transmit over a terabyte – the equivalent of 250 DVDs of information per second. Still, there always are ways to improve on existing technology. Glass has a haphazard arrangement of atoms. In contrast, a crystalline substance like zinc selenide is highly ordered. That order allows light to be transported over longer wavelengths, specifically those in the mid-infrared."

The group's methods include a specially developed high-pressure chemical vapor deposition technique. "The high-pressure deposition is unique in allowing formation of such long, thin, zinc selenide fiber cores in a very confined space," Badding says in the release.

According to the PSU release, "this new class of optical fiber allows for a more effective and liberal manipulation of light and promises to open the door to more versatile laser-radar technology." Other applications include the development of improved surgical and medical lasers, better countermeasure lasers used by the military, and superior environment-sensing lasers for measuring pollutants and to detect the dissemination of bioterrorist chemical agents. New lighting uses also may be possible.

ACerS member Venkatraman Gopalan, professor at Penn State's Department of Materials Science and Engineering and the associate director for the Center for Optical Technologies, is a member of the research team. An email from Gopalan to the *Bulletin* provides some important context of their optical fiber discovery. He notes, "Infrared wavelength range is extremely important, and yet even the basic infrared technologies, such as optics, coatings, waveguides, lasers, and detectors, are in their infancy, as compared with technologies in the visible or telecon wavelengths. This development breathes new life into glass fibers that are usually infrared opaque beyond approximately 2.5 microns wavelength."



(Credit: J. Badding, PSU; Advanced Materials.)

(a) Schematic of the HPCVD process, where a high-pressure precursor mixture is configured to flow into a capillary (left). When the capillary is heated, well-developed annular films are deposited. Unreacted precursors, carrier gas, and reaction byproducts are carried out of the fiber (right). (b) Diascopically illuminated optical micrograph from the side showing the transparent, uniform ZnSe fiber core. The deposited structures can have a uniform cross section for as long as 4 centimeter when made in a 10 centimeter long furnace. Note that cylindrical lensing effects magnify the interior tube diameter considerably in this view, making its 400-nanometer diameter appear much larger than it is. (c) Cross-sectional SEM image showing an overview of the silica cladding and ZnSe core. (d) A higher magnification SEM image of the nearly completely filled core. Scale bars: (b) 50 micrometer, c) 50 micrometer, d) 5 micrometer.

Gopalan also predicts that these fibers could revolutionize many important areas of optics research, such as fiber-based guiding, imaging, spectroscopy and tunable lasers. "The deposition technique is versatile enough to imagine a whole family of important compound semiconductors making their way into fiber cores in the near future. Optical fibers may soon come with many flavors and functions well beyond what glass can do," writes Gopalan.

Researcher team member Anna Peacock remarks on her website that, "ultrafast all-fibrer optical switches will reduce costs and improve efficiency of communications systems, whilst laser sources, which operate in the mid-infrared, can be used for environmental sensing and medical applications. The incorporation of the active semiconductor component into the fiber geometry provides an important step toward seamlessly linking semiconductor photonics with existing

Gopalan

fiber infrastructures."

The team's research was published in *Advanced Materials* (doi:10.1002/adma.201003214).

This recent work seems to follow a logical progression of research efforts by many of the team members. Baddin, P.J.A. Sazio and Gopalan demonstrated that they could build semiconductor devices (germanium) in optical fibers in 2006 and predicted then that this would lead to fibers with flexible waveguides. That year, they also demonstrated similar techniques using optical fibers with special microstructure features.

In 2007, the group also published a paper on filling microstructured optical fibers with amorphous silicon and built on this in 2008 by showing how they could use a high-pressure microfluidic process to adapt traditional chemical vapor deposition techniques to deposit silicon carbide in MOFs. Their thinking then was that "the introduction of SiC into the capillaries presents tremendous potential for the development of in-fiber optoelectronic devices with potential applications, including light generation, modulation and amplification."

By 2010, they were able to produce silica nanofibers with circular cross sections that can simultaneously waveguide transverse electric and transverse magnetic polarizations without cutoffs.

Visit Penn State Materials Research Institute, www.mri.psu.edu; and USH Optoelectronics Research Centre, www.orc.soton.ac.uk ■

Analysis of scale of animal trabeculae suggests new materials, structures

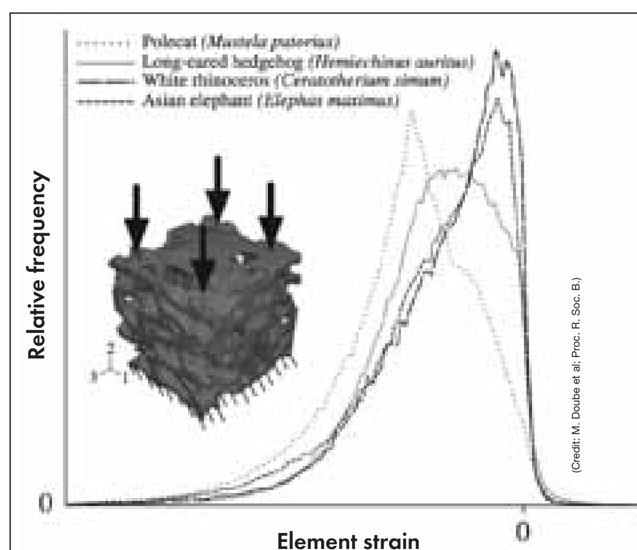
A new paper in the *Proceedings of the Royal Society B* from a group of researchers at Imperial College London and the Royal Veterinary College in Hertfordshire (U.K.) reports on an investigation of trabeculae structures in femurs in a wide range of animals that is yielding some new insights for materials development.

Trabeculae are the beams, struts and plates of bone found in spongy bone tissue that create the irregular cavities that hold red bone marrow. To the uninformed, trabeculae can look like an irregular but tough network, but the osteocytes that form the trabeculae build them along the lines of stress to provide maximum strength for a particular type of animal (and can be reorganized if the direction of stress changes). The corollary in the mechanical world is the system of struts and braces that might be used to strengthen a building or the wing of an aircraft.

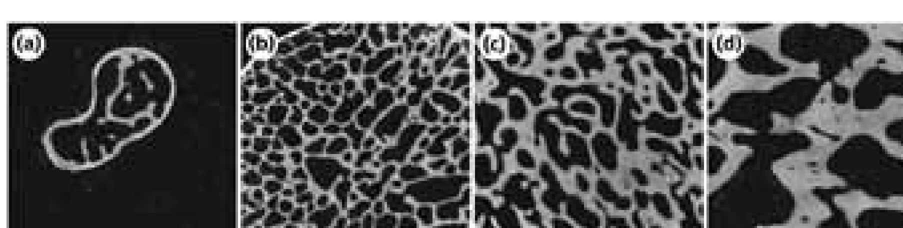
The researchers, led by Sandra Shefelbine, a professor in bioengineering at IC, looked at the femurs of 90 mammals and birds. One purpose was to look at how trabeculae varied from tiny animals, such as a shrew, to the largest of terrestrial mammals, such as an elephant. In terms of mass, the specimens ranged from 3 grams to 3400 kilograms. According to Shefelbine's website, she has been interested in how bone structure can change – fairly quickly – when exposed to a variety of loads. (The classic example is how the bones of astronauts can quickly change in the absence of gravitational loading.)

Shefelbine is seeking answers to some fundamental questions about bone biomechanics. "Bone modeling [e.g., response to changing mechanical environment] and remodeling [e.g., repairing microdamage] can alter bone shape, density and structure," she notes. "Despite the critical role of such mechanical adaptation, the underlying mechanisms remain undefined and many questions remain. For instance: What mechanical stimuli are bones responding to? Why are some bones more sensitive to loading than others? Can we use the adaptive response to prevent deformities from occurring and to strengthen weak bones?"

Her group used a combination of



Trabeculae in larger animals have higher elastic moduli than those in small animals.



(Credit: M. Doube et al; Proc. R. Soc. B.)

X-ray microtomograms of trabecular bone geometry across six orders of magnitude of animals' body mass: (a) lesser dwarf shrew; (b) Arctic fox; (c) Przewlaski's horse; and (d) Asian elephant.

X-ray microtomography and finite element analysis to examine in each of the 90 specimens how trabecular scaling changes in relation to size, and how bone mechanics change in relation to the scaling. For materials scientists, here are the key findings (some of which may be a little counterintuitive):

- From animal to animal, the bone volume fraction does not substantially scale with creature size;
- Although the bone volume fraction does not increase greatly, the trabeculae in the femur of larger animals are thicker, farther apart;
- Also in larger animals, the trabeculae are less densely connected (the number per unit volume is considerably fewer than in small animals; and
- Finite element modeling explains that scaling does not alter the bulk stiffness of trabecular bone, but probably mitigates strain on the scale of the osteocytes.

The authors suggest that the differences in how trabeculae grow in various animals might be "an interspecific manifestation of bone tissue's drive to maintain mechanical homeostasis. It appears that changes in geometry are preferred over increased bone mass."

They and other researchers note that this preference "may be an adaption that limits the physiological cost of producing, maintaining and moving more tissue."

So, what are broader implications? If one is thinking about how to develop a "smart material" that could adapt to a changing environment, there is a lesson in bones: The modeling and remodeling of trabeculae and surrounding internal structures seem to be a mass-efficient strategy for dealing with strain. Elephants do not require thick, dense bones to support their loads. They just use their internal capacity to alter their bone structure.

"We can learn a lot from nature, such as how nature develops these strong, lightweight structures," advises Shefelbine in a story in *The Engineer*. "We could adopt this in design. It could inform how people develop structural foams." In particular, the researchers say, "This may represent a new approach to designing cellular solids for engineered structures of different scales."

The IC research team also has created an open-source computer program ("BoneJ") for examining the number, thickness and spacing of trabeculae as well as analyses of whole bones.

Visit Imperial College, www3.imperial.ac.uk; and BoneJ, www.bonej.org/ ■

Evidence mounts that 'pseudogap' is distinct phase in superconducting materials

Investigators in the field of high-temperature superconductors have been stumped for some time about what is occurring between when the temperature of a material drops to the point (T^*) where electrons begin to form Cooper pairs (T_c) and the critical temperature for full superconductivity. Heretofore, this odd transitional region has been dubbed a "pseudogap," but now a collaborative research project has revealed that three different tests suggest the pseudogap is actually a distinct phase.

The collaboration included scientists from the Lawrence Berkeley National Laboratory, the University of California at Berkeley, Stanford University and the SLAC National Accelerator Lab. Their results were recently published in *Science* (doi:10.1126/science.1198415).

Led by Zhi-Xun Shen, director of the Stanford Institute for Materials and Energy Science at SLAC and a professor of physics at Stanford University, the group focused only on Pb-Bi2201 (a lead bismuth strontium lanthanum copper oxide) because of the materials relatively wide range between T^* and T_c.

Previous research supported two separate theories about the odd pseudogap: One theory is that it is just a range of gradual transition to superconductivity, and the other is that it is a state of material distinct from superconductivity and normal "metallicity" with a quantum critical point.

"Promising as the 'quantum critical' paradigm is for explaining a wide range of exotic materials, high-T_c superconductivity in cuprates has stubbornly refused to fit the mold. For 20 years, the cuprates managed to conceal any evidence of a phase-transition line where the quantum critical point is supposed to be found," says Joseph Orenstein in a news release from the Berkeley Lab. Orenstein works in the lab's Materials Sciences Division and is a professor of physics at UC Berkeley, whose group conducted one of the research team's three experiments.

According to the release, the hope is that once researchers can wrap their thinking around the concept of a quantum critical point (X_c), new routes to superconductivity can be found. "This is a paradigm shift in the way we understand high-temperature superconductivity," says Ruihua He, lead author with Makoto Hashimoto. "The involvement of an additional phase, once fully understood, might open up new possibilities for achieving superconductivity at even higher temperatures in these materials." These two worked with Shen at SIMES and also worked at Stanford's Department of Applied Physics and at Berkeley Lab's Advanced Light Source.

One of the tests they conducted involved angle-resolved photoemission spectroscopy to track the kinetic energy and momentum of the emitted electrons over a temperature range. In another test, investigators measured changes in rotations of the plane of polarization light reflected from the same Pb-Bi2201 sample under a zero magnetic field (magneto optical Kerr effects). The rotations are proportional to the net magnetization of the sample at various temperatures. Orenstein's group performed the third test, a study of time-resolved reflectivity of the Pb-Bi2201 sample.

None of these tests were particularly novel – except that this time they were conducted on the same material and all yielded results consistent with what they expected if there indeed is a phase transition at the pseudogap phase boundary at T^*.

Looking ahead, members of the group hope to exploit their discovery that the electronic states dominating the pseudogap phase do not include electron Cooper pairs found in a superconducting phase, yet seem to influence the motion of Cooper pairs in a way previously overlooked.

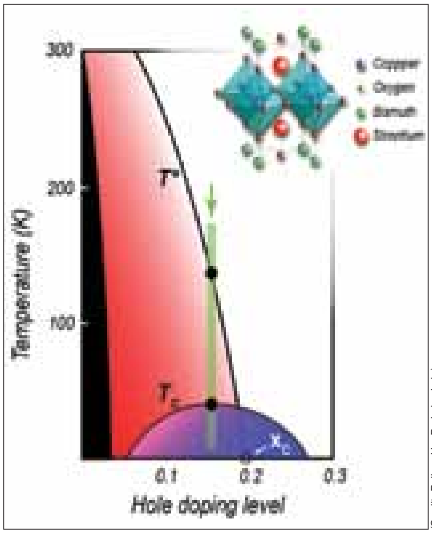
"Instead of pairing up, the electrons in the pseudogap phase organize themselves in some very different way," says He.

"We currently don't know what exactly it is, and we don't know whether it helps superconductivity or hurts it. But we know the direction to take to move forward."

On the SLAC website, He outlines a plan, saying, "First to-do: uncover the nature of the pseudogap order. Second to-do: determine whether the pseudogap order is friend or foe to superconductivity. Third to-do: find a way to promote the pseudogap order if it's a friend and suppress it if it's a foe."

In the SLAC story, Shen also confidently notes, "Our findings point to management and control of this other phase as the correct path toward optimizing these novel superconductors for energy applications, as well as searching for new superconductors."

Visit: Stanford Institute for Materials and Energy Science, http://simes.slac.stanford.edu ■



(Credit: Ruihua He; Berkeley Lab.)

New evidence from studies of Bi2201 (crystal structure inset) along the temperature range shown in green strongly supports the idea that the pseudogap is in fact a distinct phase of matter that persists into the superconducting phase. If so, the *T phase transition must terminate in a quantum critical point (X_c) at zero temperature.**

‘Cotton candy’ that heals?

Borate glass nanofibers look promising.

(Credit: The American Ceramic Society)

by Peter Wray

In late summer of 2010, registered nurse Peggy Taylor suddenly saw some longed-for signs of healing in a nasty shin wound in one of her patients with diabetes. Just a few days before, Taylor had done to the patient something that she and no one else in the world had ever done in wound care before: She had filled the wound with a material that could have been mistaken for cotton, but was in fact specially processed borate glass fibers.

Taylor, a wound-care specialist for more than four years, had been used to dealing with wounds that healed at slow and nearly imperceptible rates. But when she and the patient – who also happened to be a nurse – noticed the edges of the large, deep, stubborn wound had finally started to slope inwards, they were the happiest they had been in a long time.

“That was the first sign of healing,” she said in an interview in late March. “It began as a 50 millimeter by 30 millimeter wound that was 3 millimeters deep. That was the day she really began going down the road to healing. Now, after using the glass fiber treatments for week after week on the wound, it is essentially gone.”

And when Taylor says “gone,” she means something close to “vanished.” Not normal scarring, certainly. “It’s amazing. There is so little scar tissue there, if I didn’t know the wound was there, I’d have no idea,” she claims.

This doesn’t appear to be a fluke. Taylor, a certified Wound, Ostomy and Continence Nurse on the staff of the Phelps County Regional Medical Center (Rolla, Mo.), says that seven other patients participating in trials being conducted by PCRMC have had similar results with the glass fiber treatment. She says, in total, 12 patients are in the trials and the four who still have wounds are making progress, too.

Venous stasis creates hard-to-heal wounds

The history of Taylor's patient's wound is typical for a diabetic. "It started out as a bruise on her shin," she says. "It was the kind of thing where the patient said, 'Ow. It really hurt a lot, but I am glad I didn't break my leg.' It took awhile before she or anyone else realized there was a more extensive and deep-tissue injury there. In fact, it was a deep hematoma that eventually opened. It looked like a big number '6' and if it weren't for the debris in the wound, I would have seen bone."

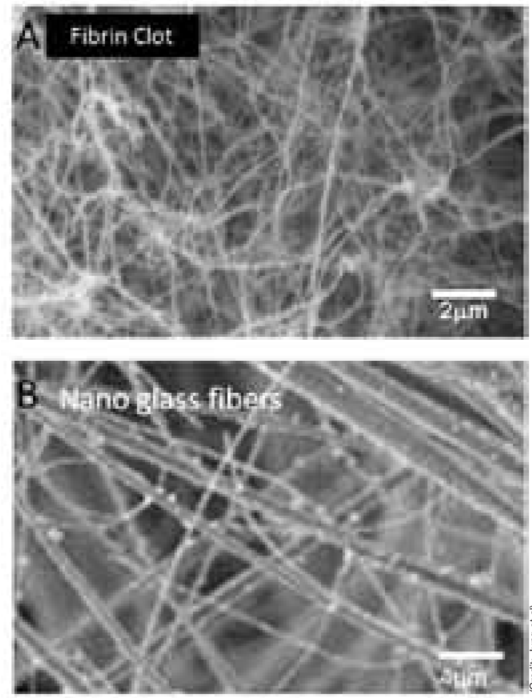
Taylor explains that diabetics and often the elderly develop troublesome and dangerous extremity wounds, called venous stasis ulcers. Aging diseases and diabetes wreak havoc on lower leg blood vessels. Blood and other fluids pool, and the vessels and their valves get damaged to the point where they don't function effectively.

And, unfortunately, that's only the beginning. If the fluid stays in the vessels, big differences in the pressure gradient between inside and outside the vessels form, and they start leaking fluid into other tissues. The fluid looks for a way outside the body and stretches skin tissue to form thin spots that can spontaneously crack and start weeping. A bump, even a small one, can accelerate the weeping process. A big bruise, such as the one her patient suffered, can trigger a large amount of weeping.

In these situations, the worst is yet to come, because the weeping fluids initiate the wound-forming stage. "This wound fluid is something of a cleaner," says Taylor. "It contains lots of enzymes. But, the fluid's enzymatic cleaning action eats away at the tissue at the surface of the wound. If the patient has a bandage or something over it, or even clothing, the fluid is held next to the skin and it starts to erode away the tissue. With the fluids from venous stasis, you get a wound that goes on and on because it won't quit weeping long enough for it to heal."

The wounds are annoying and painful, but a big danger arises because a hole in the skin is an invitation to bacteria and infection. When the elderly and diabetics don't have good circulation the chances of getting an infection in their lower extremities are enhanced. "You have bone that is close to the surface of the skin. The marrow in the bone produces your red blood cells, so suddenly you have a situation where an infection could become systemic" and potentially fatal, says Taylor.

Thus, nonhealing wounds and the infections that often accompany them are a big concern. And, to counter stagnant wounds and infections, limb amputation is often the only recourse. So, it's no wonder that patients with hard-to-heal wounds often seek out specialized wound-care treatments.



The initial stage of wound healing requires the formation of a fibrin clot. The top SEM image shows a fibrin clot composed of nanosized cross-linked fibrin fibers that initiate the healing process. The fibers shown below are made of the bioactive borate glass. The fiber diameter and overall microstructure is similar to the fibrin clot, and provides the wound with an artificial starting point.

Borate-based bioactive glasses

In 2010, Steve Jung, along with the father and son team of Delbert and Ted Day already knew a lot about bioactive glasses.

Del Day founded Mo-Sci Corp., a company that already made glass products for biological uses. Ted recently has taken over as CEO and president of the enterprise.

Jung, who looks to be in his late 20s, got to know the older Day, a renowned professor, at the Missouri University of Science and Technology. Jung earned his bachelor's and master's degrees in ceramic engineering at Missouri S&T and eventually a Ph.D. in materials science from the school.

Jung began working for Del Day in 2001, and in his Ph.D. work and collaborations with Day he became interested in bioactive glasses, especially borate glasses. "For decades, bioactive glasses have been known to bond well with hard and soft tissues," says Jung. "Much of this knowledge has been directed toward the regeneration of bone. But a lot of us also have been thinking about soft-tissue regeneration."

Jung acknowledges that most of the gains in bioactive glasses have been founded on silicate-based materials, but he says he was intrigued by some things he learned about borate glasses.

"An in-vitro study of lithium borate glasses showed it to have beneficial antibacterial effects against harmful bacteria, such as e.coli, salmonella and staph," says Jung. "Apparently the bacteria are killed as the lithium alkali is released into the immediate surrounding area of the glass, which creates a local spike in the pH."

Jung says he, Del Day and other collaborators compared the rates of how silicate-based and borate-based bioactive glasses reacted to body fluids. "In certain in-vitro experiments," he reports, "we determined that bioactive glasses containing boron as the glass former react to simulated body fluids up to five times faster than silicate glasses do."

Jung also says they were curious about a particular bioactive borate glass – 13-93B3 glass (53B_2O_3, 20CaO, 12K_2O, 6Na_2O, 5MgO, 4P_2O_5(in weight percent)) – because of its calcium content. He notes, "Investigators have reported that calcium is an important factor in the wound healing of skin and suspect that it is required for the migration of epidermal cells. It also may play an important role in the late stages of healing. Moreover, it appears that the presence of calcium in the immediate vicinity of an open wound helps the body to regulate wound-healing processes more effectively, particularly in open wounds."

Jung and Day thought about the general process of wound healing and how a beneficial scaffold might help. Medical studies have shown that the most effective treatment has been to cover the wound and allow the body to naturally support the delivery of growth factors or other required nutrients.

"Connective tissue has several progressive steps that must occur in order to properly heal a wound," explains Jung. "In the best-case scenario, initially, the wound will bleed, and in order to stop the bleeding, platelets in the blood are triggered to the wound site and stick to one another. Once the platelets have stopped the blood flow and a fibrin blood clot has formed, the blood clot releases growth factors and biological signals to recruit macrophages needed for inflammation. Typically, inflammation is confused with infection and inflamed tissue is considered to be bad. However, some inflammation is good, and even required to release growth factors that stimulate cell proliferation. These cells can then differentiate into tissues and eventually over the course of weeks to months will be remodeled and appear as if there was never a wound."

Jung and Day had an idea for a possible borate glass scaffold that might mimic the microstructure of a fibrin clot. They already knew how to create tiny glass fibers and they devised a way to make nanofibers (300 nanometers to 5 micrometers) from the 13-93B3 glass that produced a product that looked and felt like cotton.

(Credit: The American Ceramic Society; inset Jung and Taylor)

Peggy Taylor, an RN who specializes in wound care, examines photographs of healing wounds that she has treated with pads made of special borate-based glass nanofibers.

DermaFuse: The first in-vivo tests

Jung says the cottony nanofiber glass, recently given the name DermaFuse, seemed promising from the start. He rattles off, "It's dynamic and 'gives' or bounces back if compressed. It's flexible and could be easily placed on a wound. Its structure maximizes surface area and can control moisture levels. It's antibacterial and antifungal. It's biocompatible. And with DermaFuse's high level of calcium and its clot-promoting structure … it might speed healing."

"It was worth a try," he says.

For comparative in-vivo testing, Jung and Day took the obvious next step and tried the material out on rats. They placed pads of the DermaFuse material, with fibers up to 5 micrometers in diameter, onto 15-millimeter-diameter full-thickness skin wounds next to identical untreated wounds created on the rats. They measured the wounds periodically until the wounds were healed (three to four weeks) and found no significant difference in the wound-closure rate between the treated and untreated wounds.

Jung says they weren't deterred by the lack of difference in closure rates. In fact, he says they expected those results because "wound closure in rats is mostly caused by wound contraction and not epithelialazation. The important thing was that the wounds showed highly differentiated dermal, epidermal and subcutaneous tissues. … The differentiated tissue was a good indicator that the bioactive glass fibers were providing a positive environment for tissue regeneration. In fact, we found soft tissue and blood vessels present adjacent to many of the reacted fibers."

Armed with these results, they wondered how the glass fibers might work on human wounds.

Ted Day knew something about the situation diabetics faced with stagnant, nonhealing wounds. The younger Day had previously worked as a director of Pharmacy and Ancilliary Services divisions of PCRMC.

Day obtained a license from Missouri S&T, which retains patent rights (based on his father's and Jung's work at the university), for Mo-Sci to use the material, and then he began to discuss DermaFuse with some of the doctors in Rolla and the center's staff, including Peggy Taylor.

"Ted Day called me and said they might have a new material for wound care available and asked if I'd be interested in it," Taylor recalls. "He said they used the material in hard tissues, and were interested in how it would work with soft tissue regeneration. Well, I am a nurse and I do nothing

Steve Jung, left, and Mo-Sci CEO and president Ted Day. Jung's research contributed to the development of the DermaFuse material, and he now works for Mo-Sci.

without being directed, so I asked him to talk to some of the doctors and talk to the hospital board and see if they were interested. I suggested to him that if one of the doctors was interested, they should ask for me to assist them with it. Then I could be involved."

Ted Day did formally contact PCRMC officials and the institution's Internal Review Board. He showed them samples of the DermaFuse and presented the data on the biocompatibility and excellent quality of regenerated tissue in the rat model. Day says the IRB ultimately approved a small-scale human trial to treat nonhealing venous stasis ulcers in diabetic patients.

"The IRB agreed to selected possible participants based on protocol they established," Day says. "Their criteria essentially narrowed in on patients whose wound status made them likely candidates for amputation down the road. Each participant had to have at least one nonhealing venous stasis ulcer, and that wound had to have been treated with conventional dressings with no improvement for a minimum of two weeks prior to enrolling. The treatments – applying a pad of the DermaFuse one or two times per week – were to be done only by PCRMC staff supervised by doctors until the wounds resolved.

Dr. William Stoecker, a dermatologist who practices at PCRMC, agreed to do most of the supervisory work for the IRB. And, Ted Day suggested to Stoecker that Taylor might be interested in helping.

"So, Dr. Stoecker did ask for my assistance," says Taylor. "Both of us had our doubts, but we have a pretty open-minded culture and we use a lot of cutting-edge technology for a hospital of our size. But we also got really curious about how the bioactive glass material might work."

The IRB granted approval for the treatments in July 2010, and Stoecker and Taylor got their first patient – the one mentioned at the top of this story – a month later.

"We started with one patient," recounts Taylor. She was our only patient for several weeks. Number two was a patient who soon dropped out of the study. Then came number three, four, five and six."

Taylor confesses that her first patient helped a lot with recruiting other volunteers for the trial. The small-town atmosphere in Rolla also helped. "With her nursing background, our first patient had been exposed to medical research before. She and her husband were very eager to see things like this new study happen. Her husband is a golfer and country-clubber and she is a bridge-club lady, and they talked it up among their friends and at their church. Because of them, pretty soon we had a lot of hubbub about this in the community and more people inquiring about the study. It also helped that a lot of people know the Days in this area," says Taylor.

The nitty gritty of using 'DermaFuse'

Wound care is not for the squeamish. Taylor eventually began treating 12 patients as part of the study, and the wounds she saw ranged from around 1 centimeter by 1 centimeter with a depth of 0.1 centimeter (about the size of a small fingernail) to much larger ones. "We have three or four in our study where I could see bone, tendon, vessels and nerve strands covered by a thin layer of debris. That's because these wounds have gone on and on for so long," she says.

The DermaFuse glass material arrives for use sterilized and in a flat foil packet. Taylor starts by physically removing unwanted debris (debriding) and flushing the area. She needs to begin with a clean, moist wound bed. Often an antimicrobial solution is applied.

Then its time for the glass. Taylor describes her method saying, "Because it comes to me in a flat pack, it gets kind of squished, but it looks just like cotton candy. You can form it, you can pick it, you can make any kind of shape you need out of it. Sometimes I apply the material with tweezers. Sometimes I put it on my gloved hand."

If the wound has a cavity or tunneling, it gets a little trickier. "I will use tweezers to pack the material up into all of the recesses before filling the rest of the wound. I don't pack it hard, but just a little to get it into all of the crevices," she says.

Once the wound is covered in the material, she applies a secondary covering to hold the DermaFuse in place. This is often followed by some type of compression wrap. The patients then can go for two or three days before they need to be seen by Taylor again.

Daily dressing changes can be more detrimental than helpful. She says, "You risk disturbing that fragile tissue in the wound bed too often and not giving a chance to mature into healing tissue. I like to use products that can stretch the changes out to every two or three days, or even five to seven days. I have found that with this glass material changing the dressing daily would be way too often."

After the first treatments with DermaFuse, Taylor says it appears the glass "reignites" a beneficial inflammatory process and she sees a lot of initial drainage. But her response with the DermaFuse patients takes a different path than normal wound care. "In the past, I have always wanted to first debride any yellow sloughy stuff that didn't look good. But, I have found with [DermaFuse] that I can leave that debris. And, removing it can be a trick. It feels like it makes its own little environment. It is almost like a tightly woven web of tissue and product, and it feels like some of the product is well-adhered. I try not to disturb it.

She says some of the remains from the DermaFuse look like wet sand that she can flush out of the wound bed. "But anything that is gripping and hanging on, I try to leave there because it looks like the beginning of the healing matrix. We don't know for sure what is going on, but I often will see good granulation tissue already forming in the area the next time I change the dressing."

What surprises Taylor is that the glass fibers disappear. "Eventually I don't see any remains of the product anymore. Does it dissolve? Does it become part of the tissue? We don't quite know what the whole story is there. But it is just such a neat thing to watch that process," she says beaming with a smile.

Wouldn't the wounds have healed anyway with her experienced TLC? She admits that they might have. But she says that the only way the wounds would have healed so fast is if the patients had used what is called a vacuum-assisted closure system.

A wound VAC system requires a nifty but expensive negative-pressure device that can be aggravating to use. In brief, it is like a little machine, which the patient has to carry around-the-clock, that vacuum packs the wound. The problem is that the VAC equipment may cost $1,000 a week, plus the patient has to drag around the machine with a battery pack that can rundown or even die out at inconvenient times.

Taylor thinks the DermaFuse might be a cheaper, easier way to accomplish the same results. "Don't get me wrong," she says. "I am a major fan of the wound VAC. But, as a nurse, if I can see that tissue healing at a similar rate, I am really happy to see some magic happen in that wound bed that would otherwise require very expensive treatments."

Jung says that among the eight healed wounds, they have been able to document wound closure rates of 0.3 to 0.8 millimeters per day, depending on wound orientation.

Where are the scars?

The apparent lack of scarring from DermaFuse-treated wounds pleases the patients but stuns Taylor. She says she normally expects to see a ropey, hard scar form. "Our patients are elderly and have a lot of skin discoloration and you would think you'd see a dramatic scarring. But, we have healed wounds that show nothing or negligible scarring," she says.

"Seriously," Taylor exclaims.

Taylor does have a theory. She says that after a wound heals, there is another transformation in the skin: the "remodeling phase." This remodeling phase can last up to two years during which the scars can be reduced, in part because the continuing healing process breaks down bonds that are replaced with better, stronger tissue. That is why people sometimes feel that a scar has faded several years after an injury. "But with the glass fibers," Taylor says, "when the wound heals, I immediately am seeing a skin appearance that I would expect to see way out in the future. So, it appears that there is something more efficient about the healing with the fiber."

What's next for DermaFuse? Ted Day and Steve Jung say that beyond working with other PCRMC patients, they will be working with the Center for Wound Healing and Tissue Regeneration, University of Illinois at Chicago, for expanded testing. Taylor was preparing to make a presentation about the trials at a wound care specialists' conference in Dallas, Texas, and Jung will be presenting information at ACerS's upcoming Glass & Optical Materials Division annual meeting in mid-May in Savannah, Ga.

Ted Day is obviously excited about the business prospects for DermaFuse. He says Mo-Sci hopes to supply the materials to one of the larger medical supply companies that are in a better position to guide DermaFuse through full-scale federal human-testing requirements and, if approved, market it to medical professionals.

Day remarks that DermaFuse doesn't fit the typical pattern of Mo-Sci products. "It is the first time a material has presented itself to us as having all these unexplored possibilities, rather than us looking for a material to fill a buyer's particular requirements," he says.

He says he would be extremely happy if DermaFuse turns out to be an inexpensive alternative to treatments, such as wound VAC systems. But, he and Jung say they would be even happier if some of the other applications they are contemplating pan out.

"Can you imagine what it would mean if we can use these borate glass fibers on burn patients," Jung asks. "I'd love to think the fibers could speed those wounds to heal and minimize the scarring."

Day thinks of disasters and traumas. "I'd love to see the day when soldiers can carry packets of this stuff, and just slap it on a battlefield injury. It might begin to protect and sterilize the wound, and it might never have to be removed."

But Taylor loves what she is seeing already. "Sometimes when I am dealing with wounds," she says, "I have to study photographs of the wound from previous visits and put them next to each other to see if anything is improving. But when my eyes alone can tell me, 'Wow – that's a nice big change in the wound since the last time I saw it,' and you don't have to refer back to the last six weeks of photographs to see if we've really been building tissue there – there's nothing better!" ■

Topological constraint theory of glass

Topological constraint theory describes how microscopic physics governs the thermal, mechanical and rheological properties of glass and has proved to be a powerful tool for predicting the composition and temperature dependence of glass properties.

John C. Mauro

A microscopic physical description of the glassy state long has eluded even the top scientists in condensed matter physics because of the complicated noncrystalline nature of glass structure. Currently, many theorists turn to molecular dynamics or other atomistic simulations to determine the structure of various glass compositions. However, although available computing power has increased exponentially during the past several decades, it will be at least another 20 to 30 years before enough computing power is available for direct molecular dynamics simulations of glass on a realistic laboratory time scale. Fortunately, topological constraint theory provides another path forward. It focuses on the important microscopic physics governing the thermal, mechanical and rheological properties of glass, while filtering out unnecessary details that ultimately do not affect its macroscopic properties. Topological constraint theory has been successful in predicting the composition dependence of glass properties and can be used as a tool to enable the quantitative design of new glass compositions.

Introduction

Although perhaps better known, in general, for his later work on X-ray diffraction in crystals, Zachariasen's only paper on the structure of glass[1] established him, at 26 years of age, as the father of theoretical glass science for the century to come. Zachariasen began his famous 1932 paper on the structure of glass with the humble remark, "It must be frankly admitted that we know practically nothing about the atomic arrangement in glasses." What followed was a brilliantly insightful analysis of glass structure as a disordered network of polyhedral units. The polyhedra themselves define the short-range order of the atomic arrangement in glass, whereas the random connectivity of the polyhedra gives rise to long-range disorder. Based on this picture, Zachariasen postulated four rules of glass formation for an arbitrary oxide compound A_mO_n:

- An oxygen atom is linked to no more than two A atoms;
- The oxygen coordination around A is small;
- The cation polyhedra share corners, not edges or faces; and
- At least three corners are shared (for a three-dimensional network).

Zachariasen's theory essentially amounts to a list of topological conditions for formation of a macroscopic disordered network. These conditions were analyzed in detail by Cooper,[2,3] who determined that Zachariasen's first two rules are sufficient to enable formation of a glassy network. The third and fourth rules are unnecessary from a topological standpoint and may be regarded as just guidelines. A later paper by Gupta and Cooper[4] put Zachariasen's theory on a rigorous mathematical foundation by deriving a general condition for the existence of an infinitely large topologically disordered network. The Gupta–Cooper approach is not restricted to three dimensions, but rather derived for an arbitrary *d*-dimensional space where the concept of polyhedral structural units in three dimensions is generalized to rigid polytopes of arbitrary dimensionality.[5]

At the same time as Cooper's original work on glass network topology, Phillips[6] published a different but equally insightful approach to the same problem, which was later extended and put on a rigorous mathematical basis by Phillips and Thorpe.[7] Although the Phillips–Thorpe and Gupta–Cooper models are equivalent in a mathematical sense, they offer different and complementary insights into the structure of glass. By explicitly considering glass as a network of rigid polytopes, the Gupta–Cooper approach follows more directly from the original work of Zachariasen, who expressed his rules for glass formation in oxide systems through the connectivity of elementary polyhedral units.

The Phillips–Thorpe model, originally considered for non-oxide covalent systems (viz., chalcogenides), takes a more microscopic approach by considering the connectivity of individual atoms in the glass network. Phillips and Thorpe predicted that a glass network is optimal (i.e., glass-forming ability is maximized) if the number of rigid two- and three-body constraints equals the number of atomic degrees of freedom, a prediction that has been confirmed by many experimental studies, such as those of Varshneya[8–11] and Boolchand.[12]

In this paper, I provide a brief review of topological constraint theory following the Phillips–Thorpe formulation. Several recent advances are discussed which enable the quantitative design of new glassy materials through consideration of the hierarchy of constraints in a glass-forming network.

Topological constraint theory

According to Phillips–Thorpe theory, glass-forming ability is determined by comparing the number of atomic degrees of freedom with the number of interatomic force field constraints. For a system in three-dimensional space, each atom has three translational degrees of freedom. These degrees of freedom are removed through the presence of rigid bond constraints. If the number of constraints is less than the available degrees of freedom, then the network is considered "flexible." Conversely, if the number of constraints is greater than the available degrees of freedom, the network becomes overconstrained or stressed rigid.

According to Phillips and Thorpe, the optimum glass compositions are those in which the number of constraints exactly equals the degrees of freedom, in which case the glass network is isostatic. In the floppy regime, the atoms may easily arrange themselves into the minimum energy configuration of the crystalline state, whereas, in the overconstrained regime, rigid structures easily percolate throughout the system, also resulting in crystallization.

Because the original Phillips–Thorpe constraint theory was formulated for covalent systems, it considers a combination of rigid two-body (bonding) and three-body (angular) constraints. Figure 1 shows that the two-body constraints correspond to the rigid bond lengths between pairs of atoms, and the three-body constraints correspond to rigid bond angles. With this assumption, the average number of atomic constraints *n* in a system can be expressed as

$$n = \frac{\langle r \rangle}{2} + (2\langle r \rangle - 3) \quad (1)$$

where $\langle r \rangle$ is the average coordination number of atoms in the system.

Although a two-fold coordinated atom corresponds to one angular constraint, each new bond requires the definition of two new angles, so that the total number of angular constraints is $2\langle r \rangle - 3$. The average coordination number itself is defined as

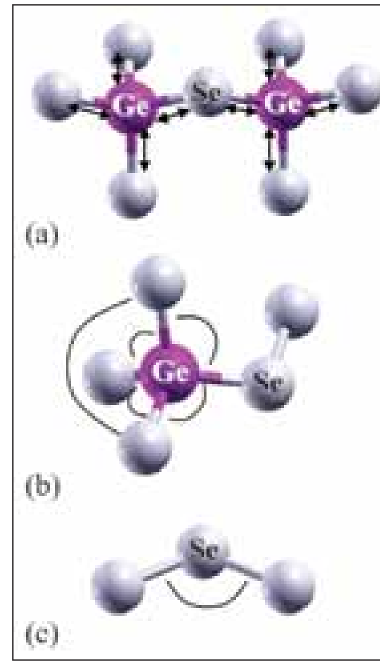


Fig. 1. Basic structural building blocks in covalent germanium-selenium glasses and their associated constraints. (a) Each pairwise bond constitutes a single two-body constraint. (b) There are five independent bond angle constraints (i.e., three-body constraints) for a rigid tetrahedron. (c) A two-coordinated atom, such as selenium, has one rigid bond angle.

$$\langle r \rangle = \sum_i x_i r_i \quad (2)$$

where x_i and r_i are the mole fraction and coordination number, respectively, of each species *i* in the glass. Setting Eq. (1) equal to 3 and solving for $\langle r \rangle$, Phillips and Thorpe obtained the condition for an optimum glass network in three-dimensional space, corresponding with the Maxwell stability criterion for mechanical trusses:

$$\frac{\langle r \rangle}{2} + (2\langle r \rangle - 3) = 3$$
$$\langle r \rangle = 2.4 \quad (3)$$

This critical value of $\langle r \rangle = 2.4$ is called the rigidity percolation threshold, because, at this composition, rigid structures percolate throughout the glass, leading to an isostatic network.[13] The network is flexible with $\langle r \rangle < 2.4$, and the network is stressed rigid with $\langle r \rangle >$

2.4. It is exactly isostatic at ‹r› = 2.4.

Phillips–Thorpe constraint theory has met with much success in predicting critical behavior of chalcogenide systems about the rigidity percolation threshold.[8–13] It also has been extended to oxide glasses,[14,15] glassy metals[16] and proteins,[17,18] among other systems.

Temperature-dependent constraints

The original Phillips–Thorpe theory for covalent glasses considers all two- and three-body constraints to be rigid, leading to a universal rigidity percolation threshold of ‹r› = 2.4. The theory is designed for a fully connected network at absolute zero temperature, $T = 0$. However, the rigidity of a given constraint depends on the temperature of the system, specifically in terms of the amount of available thermal energy compared with the amount of energy required to break a constraint. The temperature dependence of constraints is illustrated in Figure 2. In the limit of low temperature, all constraints are rigid, because there is insufficient thermal energy to break any type of bond. In the high-temperature limit, all constraints are effectively broken, because bonds can break easily and reform with all the available thermal energy.

Recently, Gupta and Mauro[19,20] have extended Phillips–Thorpe theory to account quantitatively for the effect of temperature. Their work agrees with the analysis of Naumis,[21] who determined that the major contribution to configurational entropy in glass-forming systems is due to the presence of floppy modes. The configurational entropy decreases as temperature decreases and floppy modes vanish (i.e., they become rigid). Finally, the low-temperature glassy state has no available degrees of freedom and, hence, a vanishing of configurational entropy.[22,23] Figure 3 shows example calculations demonstrating this effect. Molecular dynamics simulations support the theory.[24]

The Gupta–Mauro temperature-dependent constraint theory is especially useful for predicting the composition dependence of macroscopic properties, such as glass transition temperature[19,20] and fragility[25] (a measure of the non-Arrhenius scaling of dynamics, as defined by Angell[26]). The advantage of constraint theory is that it is a straightforward pen-and-paper calculation based on a counting of constraints. This technique already has been applied to derive analytical expressions for the composition dependence of glass transition temperature in oxide and non-oxide systems.

For example, Figure 4 shows ternary diagrams for glass transition temperature and fragility in the ternary Na_2O-CaO-B_2O_3 system.[27] Such calculation would be impossible using traditional atomistic modeling techniques, such as molecular dynamics, because these techniques are currently unable to capture essential structural features, such as the boron coordination change with composition. Also, molecular dynamics simulations are much too time consuming to be applied for compositional studies.

Recently, the temperature-dependent constraint approach has been extended by Smedskjaer et al.[28,29] to provide a predictive model for the composition dependence of glass hardness. Figure 5 shows that constraint theory provides a quantitatively accurate solution to this previously unsolved problem in condensed-matter physics.

Another notable success of temperature-dependent constraint theory is its application to modeling the temperature dependence of liquid viscosity via the Mauro–Yue–Ellison–Gupta–Allan (MYEGA) equation for liquid viscosity:[30]

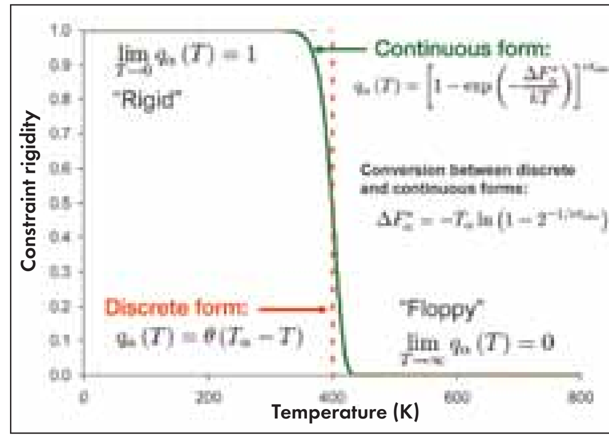


Fig. 2. Each type of bond constraint α in temperature-dependent constraint theory is assigned a constraint onset temperature, T_α. At high temperatures ($T > T_\alpha$), there is enough thermal energy to overcome the bond constraint. Therefore, it is considered floppy, i.e., $q_\alpha(T) \rightarrow 0$. Conversely, at low temperatures ($T < T_\alpha$), the constraint is rigid, i.e., $q_\alpha(T) \rightarrow 1$. Following Gupta and Mauro,[19] the temperature dependence of constraints can be written in either continuous or discrete forms. The discrete form, a simple unit step function, is useful for deriving analytical formulas for the composition dependence of properties, such as glass transition temperature and hardness. The continuous form is useful for obtaining numerical solutions for liquid fragility.[20] Here, ΔF_α^* is the free energy to break constraint α, k is Boltzmann's constant and νt_{obs} is the product of vibrational frequency and observation time.

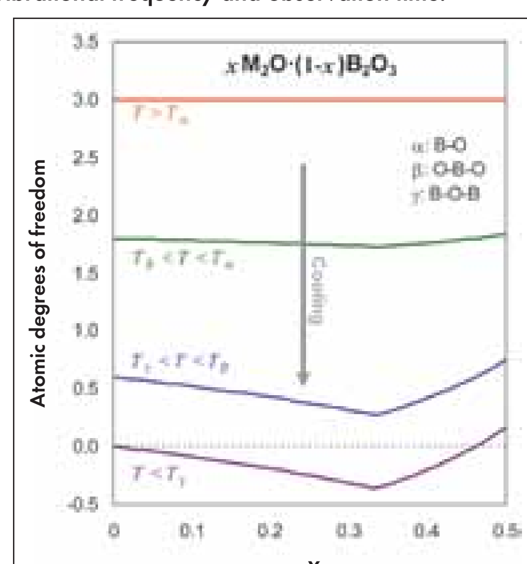


Fig. 3. Plot of average atomic degrees of freedom as a function of alkali concentration in a binary alkali borate system. At high temperatures ($T > T_\alpha$), all constraints are floppy. Therefore, the number of atomic degrees of freedom is three for all compositions. As the system is cooled, the first constraint to become rigid is the linear B—O bond constraint ($T_\beta < T < T_\alpha$). Continued cooling leads to a freezing of the O—B—O bond angles ($T_\gamma < T < T_\beta$) followed by the B—O—B bond angles ($T < T_\gamma$) in the solid glassy state. Reproduced from Mauro et al.[20]

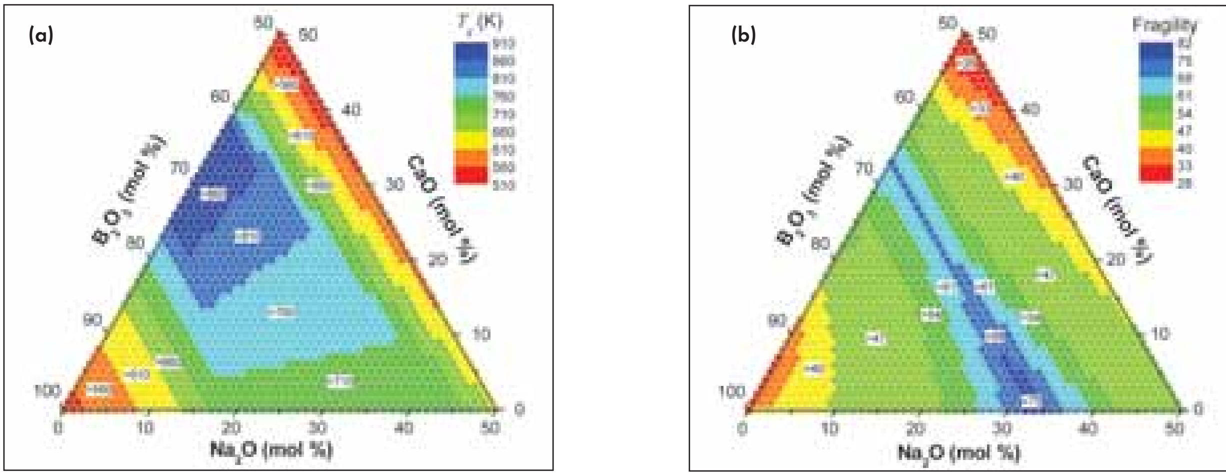


Fig. 4. Calculation of the composition dependence of (a) glass transition temperature $T_g(x,y)$ and (b) fragility $m(x,y)$ for the $xNa_2O \cdot yCaO \cdot (1 - x - y)B_2O_3$ system. $T_g(x,y)$ is calculated analytically based on the discrete form of temperature-dependent constraint theory, whereas $m(x,y)$ is calculated numerically based on the continuous form of the theory. Constraint theory is an effective method for the quantitative design of new glass compositions. Reproduced from Smedskjaer et al.[27]

$$\log_{10}\eta(T,x) = \log_{10}\eta_\infty + \frac{K(x)}{T}\exp\left(\frac{C(x)}{T}\right) \quad (4)$$

The MYEGA equation provides a significantly improved description of the temperature dependence of viscosity compared with the standard Vogel–Fulcher–Tammann (VFT) equation, while maintaining the same number of fitting parameters. Here, η_∞ is the extrapolated viscosity in the infinite temperature limit, and $K(x)$ and $C(x)$ are composition-dependent parameters indicative of the activation barrier for viscous flow and the temperature dependence of the constraints, respectively. Complete details of the MYEGA equation are provided in Ref. 30.

Linking molecular dynamics and constraint theory

The implicit assumption of constraint theory is that we know enough about the structure of a given glass to identify the important structural units and associated constraints. Often the best source of this information comes from structural characterization, such as nuclear magnetic resonance experiments. For example, recent NMR experiments[31] of the germanium-selenium system at various temperatures reveal the important structural units of this system as well as the composition and temperature dependence of the constraints.

In the absence of direct experimental measurements, it is often useful to turn to molecular dynamics simulations. Although the simulations themselves may not provide the direct results regarding macroscopic properties, such as hardness, they can provide important structural information and the energies associated with various types of constraints. Two methods proposed to link molecular dynamics with constraint theory – one by Mauro and Varshneya[32,33] and another by Micoulat[34,35] – provide that accurate interatomic potentials are known if one deals with classical molecular dynamics.

In their molecular dynamics simulations of the germanium–selenium system, Mauro and Varshneya[32] provided the first direct evidence for a rigidity percolation threshold from atomistic simulations. Their approach is based on calculating the normal modes of vibration associated with a given configuration of atoms. The high-frequency modes correspond to deeper energy wells and rigid constraints, whereas the low-frequency modes are indicative of shallow wells cor-

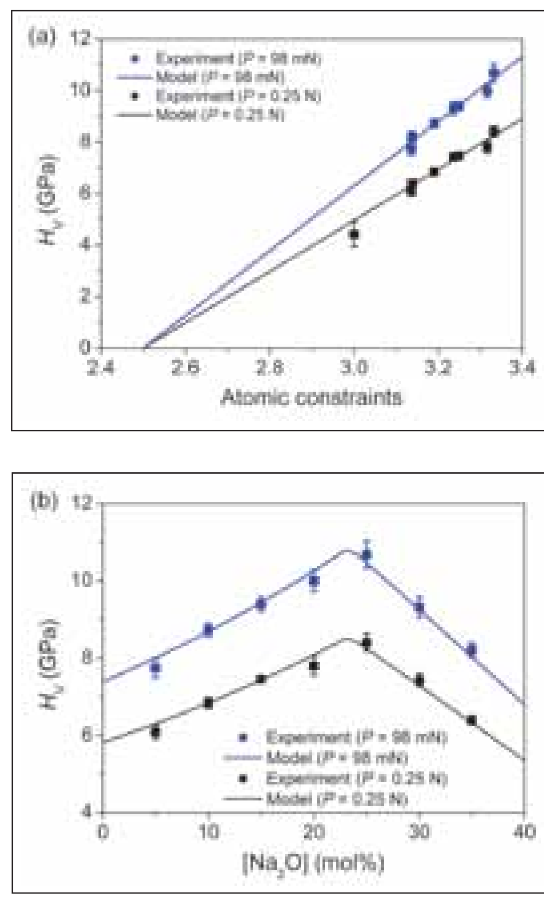


Fig. 5. Predicted versus measured Vickers hardness (H_V) for $xNa_2O \cdot 10CaO \cdot (89 - x)B_2O_3 \cdot 1Fe_2O_3$ (mole percent) glasses at loads (P) of 98 millinewtons and 0.25 newtons. Hardness is plotted as a function of (a) the average number of atomic constraints in the glass at room temperature and (b) the concentration of Na_2O (x). The solid lines represent model predictions using temperature-dependent constraint theory. Reproduced from Smedskjaer et al.[28]

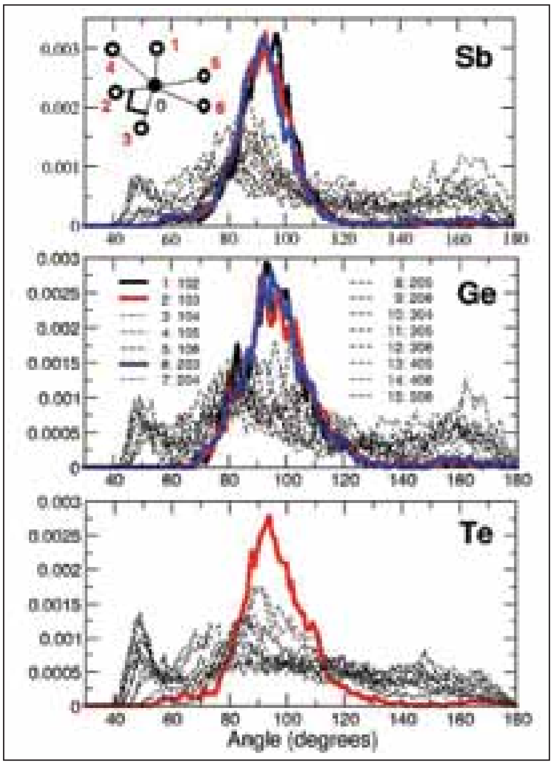


Fig. 6. In heavier chalcogenides, such as germanium-antimony-telluride glasses, where the 8-*N* (octet) rule does not apply in a straightforward fashion, constraint counting can be achieved using molecular dynamics. From an accumulated trajectory of $GeSb_2Te_4$, one selects a central atom 0, and, for a given number of neighbors (here equal to six), all possible partial bond angle distributions between sets of neighbors (e.g., marked as 203) are computed for germanium-, antimony- and telluride-centered atoms (102, 103, 104, etc., see panel for germanium). Results show that germanium and antimony have three intact constraints (sharp colored distributions) although their coordination number is four (one would expect seven constraints according to the standard counting procedure). Although the coordination of tellurium is found to be larger than two, consistent with experimental data, this leads only to one intact angular constraint, as for sulfur and selenium. Special thanks to M. Micoulaut for providing this figure.

responding to floppy constraints.

In the Mauro–Varshneya approach, each mode is classified as either rigid or floppy depending whether it falls above or below a certain threshold for rigidity. This threshold depends on the temperature of the system, with a higher threshold required for higher temperatures. Therefore, this approach captures the composition and temperature dependence of the constraints. Also, the eigenvectors associated with each normal mode reveal the exact atomic motions involved with a particular constraint, because each element of the eigenvector is associated with the *x*, *y* or *z* motion of a particular atom. Because the eigenvectors are orthonormal, all of the constraints considered are mutually independent, i.e., there is no risk of overcounting dependent constraints.

Micoulaut[24,34,35] has proposed an alternative approach designed specifically for angular constraints. Here, bond-stretching constraints are routinely computed from the number of neighbors, whereas a more subtle analysis is needed to quantify angular constraints based on calculating the standard deviation of partial bond angle distributions for a glassy system. In his simulations, Micoulaut found that the standard deviations show a bimodal distribution indicating either floppy or rigid behavior.

This technique clearly identifies which bond angles are floppy (having a high standard deviation) versus rigid (having a low standard deviation), such as depicted in Figure 6. A key advantage of the Micoulaut technique is its computational efficiency for large systems. These features can be followed with composition and temperature. A particularly interesting finding of this work is that, to elucidate the nature of constraints, one must consider the nearest neighbors around network formers and modifiers, such as alkali ions in oxide glasses. When applying this technique, one must be careful to count only independent constraints, because not all bond angles are mutually independent.

Self-organization and the intermediate phase

The original Phillips–Thorpe theory predicts a single optimized glass composition, where the microscopic structure is isostatic (i.e., having the same number of bond constraints as atomic degrees of freedom). However, more recent experiments by Boolchand[36–40] reveal a second transition providing a finite width to these isostatic compositions and offering not only a single optimized glass composition, but a whole range of such compositions, as depicted in Figure 7. The exploration of this so-called intermediate phase has been a large focus of recent experimental and modeling work in understanding constraint theory.

The original experimental work of Boolchand is based on the technique of modulated differential scanning calorimetry, in which a small sample of glass is subjected to a linear heating or cooling path modulated with a sinusoidal variation of amplitude. The resulting signal of the MDSC can be divided in two contributions: reversing heat flow that tracks the sinusoidal modulation and nonreversing heat flow that is indicative of aging behavior in the glass transition range and captures most of the kinetics. occurring in this temperature interval.

The Boolchand experiments have shown that many oxide and non-oxide glassy systems exhibit a minimum in nonreversing heat flow over a range of compositions within the intermediate phase. However, the signature of the intermediate phase is not restricted to calorimetric data, because optical measurements have shown that two vibrational thresholds have been found at the boundary of the intermediate phase.[41] Subsequent experiments also have shown signatures of the intermediate phase in ionic conductivity data.[40] For selected systems, the centroid of the intermediate phase coincides with a minimum in molar volume, underscoring space-filling tendency.[42] The intermediate phase for several different glassy systems is shown in Figure 8.

The intermediate phase is attributed to a self-organization of the glassy network, where the network attempts to achieve an isostatic condition even if that means introduction of defects in either the short-range or intermediate-range structures. To account for these effects, the Phillips–Thorpe model

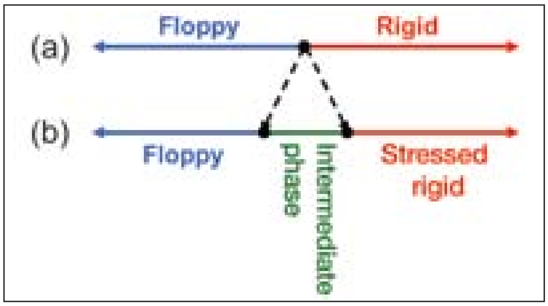


Fig. 7. (a) Traditional Phillips–Thorpe constraint theory with a single rigidity percolation threshold separating floppy and rigid compositions. (b) According to Boolchand's results, the rigidity percolation threshold is really two thresholds yielding an intermediate phase of finite width between the floppy and stressed rigid phases. The intermediate phase corresponds to a range of compositions that can self-assemble in optimally constrained (i.e., isostatic) configurations. Beyond a certain limit, additional constraints cannot be accommodated by changes in clustering or intermediate-range order, and then the system enters a stressed rigid phase.

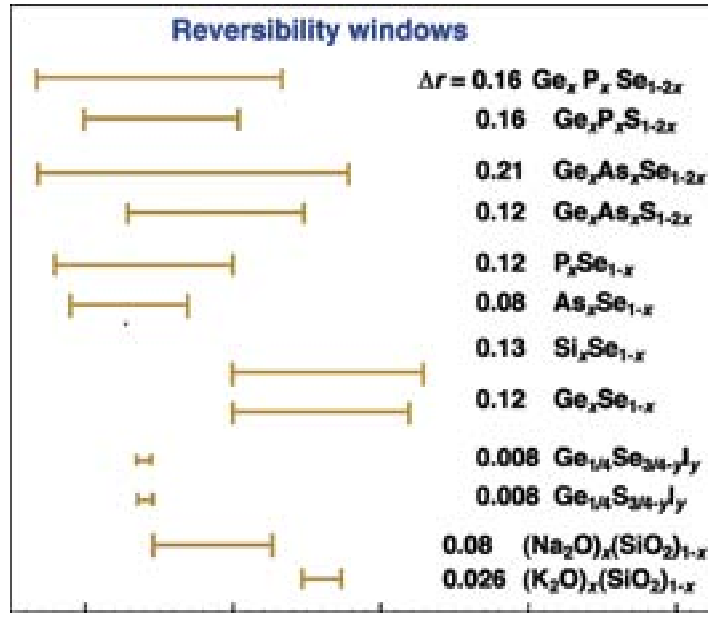


Fig. 8. Observed reversibility windows from modulated DSC experiments for various glass systems. The reversibility window corresponds to the intermediate-phase compositions, here shown as a function of average coordinate number. Window centroids in group IV selenides are at ‹r› > 2.40, whereas group V selenides are at ‹r› < 2.40. Ternary alloys encompass both regions of ‹r› space. Special thanks to P. Boolchand for providing this figure.

has been extended by Micoulaut and Phillips[43–47] to consider various configurations of clusters within a glass. In the Micoulaut–Phillips approach, clusters are constructed of increasing size, the probability of each cluster depending on the energy associated with the elementary units.

The more favorable configurations are those leading to an isostatic condition, which gives an overall lower free energy of the system. This self-organization of various cluster configurations enables the intermediate-range ordering necessary to produce the intermediate phase. The optimized configurations of the glass within the intermediate phase also mean there is less driving force for relaxation and, hence, a minimum in nonreversing heat flow. The stress-free nature also has been shown from Raman pressure experiments.[48]

The discovery of the intermediate phase has not been without controversy. In particular, Simon[49,50] has shown that the integration of the nonreversing heat flow from MDSC does not correspond exactly to the enthalpy of aging through the glass transition. Subsequent work by Carpentier et al.[51] has provided a thorough analysis of relaxation using MDSC.

Also, currently, there is no clear evidence from NMR[31] or neutron diffraction[52] data to discern the structural signatures of the intermediate phase. For example, recent NMR measurements of Lucas[53] have led to a proposed model of germanium-selenium glass structure composed of selenium-rich (flexible) and $GeSe_2$-rich (stressed rigid) nanophases in which no intermediate phase would be possible. Nevertheless, Micoulaut and Malki[54] have shown direct evidence for a characteristic dynamical length scale associated with the intermediate phase in fast-ion-conducting glasses.

In the current author's opinion, the existence of such controversy serves as great evidence for the amount of exciting research that is yet to be done in this area. No matter what the final outcome, we are sure to learn much along the way to further our understanding of the glassy state in terms of structure and properties.

Conclusions and further reading

Topological constraint theory is arguably the most powerful tool available today to predict the relationship between the composition and structure of a glass and its measurable properties. Because constraint theory focuses on the key physics that governs the glassy state, viz., the network of bond constraints, it effectively bypasses the limitations associated with traditional atomistic modeling techniques, such as molecular dynamics. However, there remains much work to be done regarding the theoretical and applied aspects of constraint theory, such as the extension to new compositions and properties of interest. One cannot help but be excited by the future prospects of this approach, which is poised to make the computational design of new glassy materials a reality.

Readers interested in learning more about constraint theory are encouraged to check out the new book, *Rigidity and Boolchand Intermediate Phases in Nanomaterials*, edited by Micoulaut and Popescu.[55] It provides an excellent overview of recent advances in constraint theory, including generous doses of experimental and modeling work. This book is a celebration of the constraint theory approach to glass science, following the original work of Phillips and Thorpe, and of the exciting theoretical and experimental work that has been published in the ensuing decades. The book is written in a very readable and accessible fashion, making it an ideal introduction to the field for newcomers. It also makes an excellent reference for those who are already well versed in the field. Perhaps the most exciting feature of this book is that the diverse range of chapters offers essentially a blueprint for future discoveries yet to be made. In many ways, this book is Micoulaut and Popescu's invitation for all of us to come and join the fun!

Acknowledgments

The author thanks D.C. Allan, P. Boolchand, P.K. Gupta, R.J. Loucks, P. Lucas, M. Micoulaut, G.G. Naumis, J.C. Phillips, M. Potuzak, S. Sen, M.M. Smedskjaer, A.K. Varshneya and Y.Z. Yue for many inspiring discussions over the years in the area of topological constraint theory.

About the author

John C. Mauro is Research Associate in the Science and Technology Division, Corning Incorporated, Corning, N.Y., where he has conducted fundamental research in glass science, statistical and computational physics, photonics and optical communication systems.

Mauro earned a B.S. in Glass Engineering Science (2001), B.A. in Computer Science (2001) and Ph.D. in Glass Science (2006) from Alfred University. The Pennsylvania State University and the International Commission on Glass awarded Mauro the 2010 Woldemar A. Weyl International Glass Science Award. Mauro also is the recipient of the 2011 V. Gottardi Prize from the International Commission on Glass.

References

[1]W.H. Zachariasen, "The Atomic Arrangement in Glass," *J. Chem. Soc.*, **54**, 3841–51 (1932).

[2]A.R. Cooper, "Zachariasen's Rules, Modelung Constant and Network Topology," *Phys. Chem. Glasses*, **19**, 60–68 (1978).

[3]A.R. Cooper, "W.H. Zachariasen – The Melody Lingers On," *J. Non-Cryst. Solids*, **49**, 1–17 (1982).

[4]P.K. Gupta and A.R. Cooper, "Topologically Disordered Networks of Rigid Polytopes," *J. Non-Cryst. Solids*, **123**, 14–21 (1990).

[5]P.K. Gupta, "Rigidity, Connectivity, and Glass-Forming Ability," *J. Am. Ceram. Soc.*, **76**, 1088–95 (1993).

[6]J.C. Phillips, "Topology of Covalent Non-Crystalline Solids I: Short-Range Order in Chalcogenide Alloys," *J. Non-Cryst. Solids*, **34**, 153–81 (1979).

[7]J.C. Phillips and M. F. Thorpe, "Constraint Theory, Vector Percolation and Glass Formation," *Solid State Commun.*, **53**, 699–702 (1985).

[8]D.R. Swiler, A.K. Varshneya and R.M. Callahan, "Microhardness, Surface Toughness and Average Coordination Number in Chalcogenide Glasses," *J. Non-Cryst. Solids*, **125** [3] 250–57 (1990).

[9]A.N. Sreeram, D.R. Swiler and A.K. Varshneya, "Gibbs–DiMarzio Equation to Describe the Glass Transition Temperature Trends in Multicomponent Chalcogenide Glasses," *J. Non-Cryst. Solids*, **127**, 287–97 (1991).

[10]U. Senapati and A.K. Varshneya, "Configurational Arrangements in Chalcogenide Glasses: A New Perspective on Phillips' Constraint Theory," *J. Non-Cryst. Solids*, **185**, 289–96 (1995).

[11]U. Senapati, K. Firstenberg and A.K. Varshneya, "Structure–Property Inter-Relations in Chalcogenide Glasses and Their Practical Implications," *J. Non-Cryst. Solids*, **222**, 153–59 (1997).

[12]P. Boolchand, R.N. Enzweiler, R.L. Cappelletti, W. A. Kamitakahara, Y. Cai and M.F. Thorpe, "Vibrational Thresholds in Covalent Networks," *Solid State Ionics*, **39**, 81–89 (1990).

[13]M.F. Thorpe, "Continuous Deformations in Random Networks," *J. Non-Cryst. Solids*, **57**, 355–70 (1983).

[14]R. Kerner and J.C. Phillips, "Quantitative Principles of Silicate Glass Chemistry," *Solid State Commun.*, **117**, 47 (2000).

[15]J.C. Phillips and R. Kerner, "Structure and Function of Window Glass and Pyrex," *J. Chem. Phys.*, **128**, 174506 (2008).

[16]P.K. Gupta and D.B. Miracle, "A Topological Basis for Bulk Glass Formation," *Acta Mater.*, **55**, 4507–15 (2007).

[17]J.C. Phillips, "Constraint Theory and Hierarchical Protein Dynamics," *J. Phys.: Condens. Matter*, **16**, S5065–S5072 (2004).

[18]J.C. Phillips, "Scaling and Self-Organized Criticality in Proteins: Lysozyme c," *Phys. Rev. E*, **80**, 051916 (2009).

[19]P.K. Gupta and J.C. Mauro, "Composition Dependence of Glass Transition Temperature and Fragility. I. A Topological Model Incorporating Temperature-Dependent Constraints," *J. Chem. Phys.*, **130**, 094503 (2009).

[20]J.C. Mauro, P.K. Gupta and R.J. Loucks, "Composition Dependence of Glass Transition Temperature and Fragility. II. A Topological Model of Alkali Borate Liquids," *J. Chem. Phys.*, **130**, 234503 (2009).

[21]G.G. Naumis, "Energy Landscape and Rigidity," *Phys. Rev. E*, **71**, 026114 (2005).

[22]J.C. Mauro, P.K. Gupta and R.J. Loucks, "Continuously Broken Ergodicity," *J. Chem. Phys.*, **126**, 184511 (2007).

[23]J.C. Mauro, R.J. Loucks and S. Sen, "Heat Capacity, Enthalpy Fluctuations, and Configurational Entropy in Broken Ergodic Systems," *J. Chem. Phys.*, **133**, 164503 (2010).

[24]M. Bauchy and M. Micoulaut, "Atomic Scale Foundation of Temperature-Dependent Constraints in Glasses and Liquids", unpublished work.

[25]M.M. Smedskjaer, J. C. Mauro and Y. Yue, "Ionic Diffusion and the Topological Origin of Fragility in Silicate Glasses," *J. Chem. Phys.*, **131**, 244514 (2009).

[26]C.A. Angell, K.L. Ngai, G.B. McKenna, P.F. McMillan and S.W. Martin, "Relaxation in Glassforming Liquids and Amorphous Solids," *J. Appl. Phys.*, **88**, 3113–57 (2000).

[27]M.M. Smedskjaer, J.C. Mauro S. Sen and Y. Yue, "Quantitative Design of Glassy Materials Using Temperature-Dependent Constraint Theory," *Chem. Mater.*, **22**, 5358–65 (2010).

[28]M.M. Smedskjaer, J.C. Mauro and Y. Yue, "Prediction of Glass Hardness Using Temperature-Dependent Constraint Theory," *Phys. Rev. Lett.*, **105**, 115503 (2010).

[29]M.M. Smedskjaer, J.C. Mauro S. Sen, J. Deubener and Y. Yue, "Impact of Network Topology on Cationic Diffusion and Hardness of Borate Glass Surfaces," *J. Chem. Phys.*, **133**, 154509 (2010).

[30]J.C. Mauro, Y. Yue, A.J. Ellison, P.K. Gupta and D.C. Allan, "Viscosity of Glass-Forming Liquids," *Proc. Natl. Acad. Sci. U.S.A.*, **106**, 19780–84 (2009).

[31]E.L. Gjersing, S. Sen and R.E. Youngman, "Mechanistic Understanding of the Effect of Rigidity Percolation on Structural Relaxation in Supercooled Germanium Selenide Liquids," *Phys. Rev. B*, **82**, 014203 (2010).

[32]J.C. Mauro and A.K. Varshneya, "Modeling of Rigidity Percolation and Incipient Plasticity in Germanium-Selenium Glasses," *J. Am. Ceram. Soc.*, **90**, 192–98 (2007).

[33]J.C. Mauro and A.K. Varshneya, "Multiscale Modeling of Arsenic Selenide Glass," *J. Non-Cryst. Solids*, **353**, 1226–31 (2007).

[34]M. Micoulaut, J.-Y. Raty, C. Otjacques and C. Bichara, "Understanding Amorphous Phase-Change Materials from the Viewpoint of Maxwell Rigidity," *Phys. Rev. B*, **81**, 174206 (2010).

[35]M. Bauchy, M. Micoulaut, M. Celino and C. Massobrio, "Angular Rigidity in Tetrahedral Network Glasses," in review (2010).

[36]P. Boolchand, D.G. Georgiev and B. Goodman, "Discovery of the Intermediate Phase in Chalocogenide Glasses," *J. Optoelectron. Adv. Mater.*, **3**, 703–20 (2001).

[37]P. Boolchand, X. Feng and W.J. Bresser, "Rigidity Transitions in Binary Ge-Se Glasses and the Intermediate Phase," *J. Non-Cryst. Solids*, **293-295**, 348–56 (2001).

[38]P. Boolchand, G. Lucovsky, J.C. Phillips and M.F. Thorpe, "Self-Organization and the Physics of Glassy Networks," *Philos. Mag.*, **85**, 3823–38 (2005).

[39]Y. Vaills, T. Qu, M. Micoulaut, F. Chaimbault and P. Boolchand, "Direct Evidence of Rigidity Loss and Self-Organization in Silicate Glasses," *J. Phys.: Condens. Matter*, **17**, 4889 (2005).

[40]D.I. Novita, P. Boolchand, M. Malki and M. Micoulaut, "Fast-Ion Conduction and Flexibility of Glassy Networks," *Phys. Rev. Lett.*, **98**, 195501 (2007).

[41]P. Boolchand, X. Feng and W.J. Bresser, "Rigidity Transitions in Binary Ge-Se Glasses and the Intermediate Phase," *J. Non-Cryst. Solids*, **293-295**, 348–56 (2001).

[42]C. Bourgel, M. Micoulaut, M. Malki and P. Simon, "Molar Volume Minimum and Adaptive Rigid Networks in Relationship with the Intermediate Phase in Glasses," *Phys. Rev. B*, **79**, 024201 (2009).

[43]M. Micoulaut, "Rigidity Transitions and Constraint Counting in Amorphous Networks: Beyond the Mean-Field Approach," *Europhys. Lett.*, **58**, 830 (2002).

[44]M. Micoulaut and J.C. Phillips, "Ring Statistics and Rigidity Transitions in Network Glasses," *Phys. Rev. B*, **67**, 104204 (2003).

[45]M. Micoulaut, "Rigidity and Intermediate Phases in Glasses Driven by Speciation," *Phys. Rev. B*, **74**, 184208 (2006).

[46]M. Micoulaut and J.C. Phillips, "Onset of Rigidity in Glasses: From Random to Self-Organized Networks," *J. Non-Cryst. Solids*, **353**, 1732–40 (2007).

[47]M. Micoulaut, "Constrained Interactions, Rigidity, Adaptive Networks and their Role for the Description of Silicates," *Am. Mineral.*, **93**, 1732–48 (2008).

[48]F. Wang, S. Mamedov, P. Boolchand, B. Goodman and M. Chandrasekhar, "Pressure Raman Effects and Internal Stress in Network Glasses," *Phys. Rev. B*, **71**, 174201 (2005).

[49]S.L. Simon and G.B. McKenna, "Quantitative Analysis of Errors in TMDSC in the Glass Transition Region," *Thermochim. Acta*, **348**, 77–89 (2000).

[50]S.L. Simon, "Temperature-Modulated Differential Scanning Calorimetry: Theory and Application," *Thermochim. Acta*, **374**, 55–71 (2001).

[51]L. Carpentier, O. Bustin and M. Descamps, "Temperature-Modulated Differential Scanning Calorimetry as a Specific Heat Spectroscopy," *J. Phys. D: Appl. Phys.*, **35**, 402–408 (2002).

[52]M.T.M. Shatnawi, C.L. Farrow, P. Chen, P. Boolchand, A. Sartbaeva, M.F. Thorpe and S.J.L. Billinge, "Search for a Structural Response to the Intermediate Phase in Ge_xSe_{1-x} Glasses," *Phys. Rev. B*, **77**, 094134 (2008)

[53]P. Lucas, E.A. King, O. Gulbiten, J.L. Yarger, E. Soignard and B. Bureau, "Bimodal Phase Percolation Model for the Structure of Ge-Se Glasses and the Existence of the Intermediate Phase," *Phys. Rev. B*, **80**, 214114 (2009).

[54]M. Micoulaut and M. Malki, "Direct Evidence of a Characteristic Length Scale of a Dynamical Nature in the Boolchand Phase of Glasses," *Phys. Rev. Lett.*, **105**, 235504 (2010).

[55]M. Micoulaut and M. Popescu, Eds., *Rigidity Transitions and Boolchand Intermediate Phases in Nanomaterials*. INOE, ■

A report on the Indo-U.S. Joint Center for Biomaterials for Health Care

by Bikramjit Basu and Thomas Webster

During the past few decades, materials for biomedical applications have received much attention in the scientific community, primarily because biomaterials are capable of replacing, reconstructing and regenerating human/animal body tissues for long-term use, with little toxic or inflammatory effects.

Biomaterials, as well as their applications as artificial organs, are, therefore, recognized as an emerging area for material scientists, biotechnologists, chemists, engineers and medical professionals. Traditionally, biomaterials have been created by largely trial-and-error processes. For example, titanium was initially considered for orthopedic applications because it is lightweight and strong (clearly important for artificial joint applications).

This approach has sufficed to date to help restore organ function and at least partially return a quality of life to persons suffering from various diseases. However, all of the implants currently used today to treat body ailments – from orthopedics to the vasculature – have limited lifetimes, which are often less than that of the patient. Moreover, there is room to improve the functionality and the quality of life of the patient.

Clearly, approaches other than trial-and-error-engineering are needed to design even better implants for the coming generations.

Center created

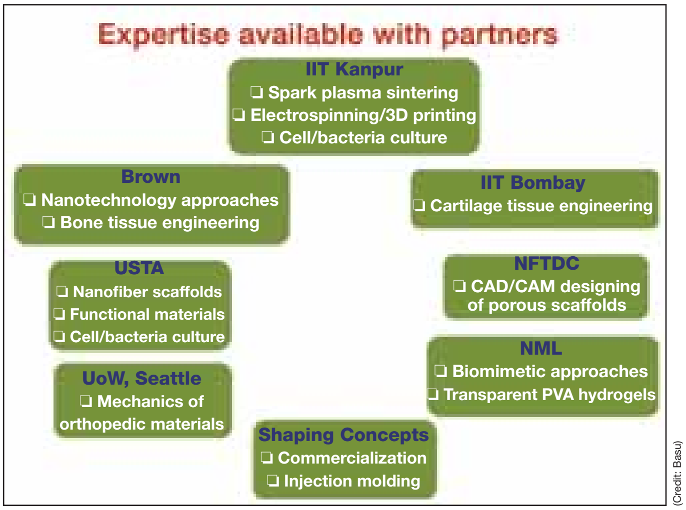
For these reasons, Indo–U.S. Science and Technology Forum established the Public–Private Networked R&D Center on Biomaterials for Health Care with these writers – Bikramjit Basu as director and Thomas Webster as codirector – in November 2008. S.P. Mehrotra, Department of Materials Science and Engineering, IIT Kanpur, is the nodal coordinator of the center.

The R&D Center includes the participation of

- Two academic institutes from India (IIT Kanpur and IIT Mumbai);
- Three academic institutes from United States (Brown University, University of Texas, San Antonio, and University of Washington, Seattle);
- Two national research labs from India (National Metallurgical Laboratory and the Non-Ferrous Technology Development Center); and
- One private U.S. company (Shaping Concepts LLC located in Texas).

The Center for Biomaterials for Health Care is the largest of all the Indo–U.S. research centers currently funded by IUSSTF. The Center's projects range from mimicking the natural chemical and nanostructure of natural tissues to creating improved biomaterials to developing sensors that can determine in real time in-situ events surrounding implants (to ensure their success).

In particular, the general aim of the Center for Biomaterials for Health Care has been to combine innovative material science concepts (including nanotechnology) with biological science approaches to develop implants that can last the lifetimes of the patients and to return those patients to the lifestyles



Complementary expertise available with center partners.

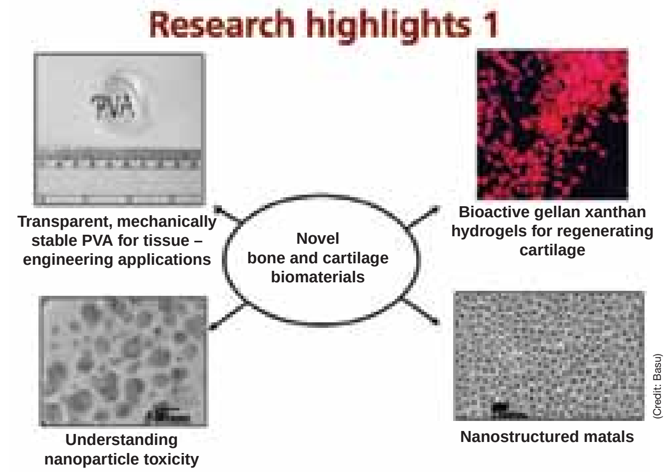


Illustration showing the research highlights of Center activities in the area of bone-tissue engineering applications.

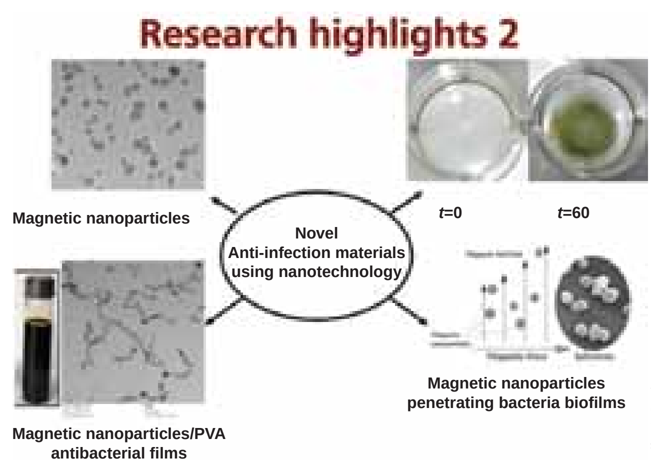


Illustration showing the research highlights of Center activities in the area of materials with anti-infection properties.

they were accustomed to before they suffered from a medical ailment.

While deciding the key objectives of the center, the complementary expertises of various partners were considered.

Center focus

After careful thought, participants decided to focus the activities for of the Center in the following areas:

- Creating metal-, ceramic- and polymer-based hard tissue replacement (orthopedic implant) materials, with particular emphasis on nanobiomaterials;
- Creating polymer-based scaffold materials for tissue engineering applications; and
- Formulating strategies based on novel manufacturing routes to produce complex-shaped implant materials.

They have been more than 20 exchange visits of senior researchers and young Ph.D. students between India and the U.S. The Center has worked toward achieving the overall objective: combine the cutting edge technologies of fabrication and testing of materials science with the knowledge of biological sciences in order to come up with strategies to develop shaped implant materials in some of the emerging material systems for the purpose of the enhancement of public health.

Since its inception almost two years ago, the Center has demonstrated a synergistic flow and utilization of scientific concepts, technological ideas and expertise in an international team of recognized scientists.

Some of the notable achievements include

- Understanding genotoxicity and gene profiling of osteoblast cells treated with hydroxyapatite-based nanobioceramic composites;
- Developing polymer-based scaffold materials for cartilage tissue engineering application;
- Injection molding of polymer–ceramic hybrid biocomposites; and
- Fabricating materials with uniform and gradient porosity using CAD/CAM-based manufacturing routes as well as 3D printing.

Details of work

In particular, the Center oversaw the joint development of HA-based electroconductive composites for bone replacement applications. IIT Kanpur created the composites using the spark plasma sintering route, and the research group of Amar Bhalla and Ruyan Guo at UTSA evaluated their functional properties. Using fluorescent-activated cell sorting and reverse-transcription polymerase chain reaction techniques, researchers at Brown University investigated the cellular apoptosis at genome level of HA-based nanoceramic composites fabricated using the SPS route at IIT Kanpur.

IIT Kanpur researchers used electrospinning techniques to develop poly(vinyl alcohol)–carbon nanofibers and poly(lactic-co-glycolic acid)–CNF hybrid biocomposites, while cardiomyocyte cell-fate processes are studied at Brown University in the context of their potential applications as synthetic patches to treat heart diseases. NML (Jamshedpur) has developed PVA-based transparent hydrogels for corneal tissue engineering applications followed by Brown University's in-vitro study of such materials.

Also, IIT Bombay synthesized hydrogel scaffolds for minimally invasive cartilage tissue engineering applications. Brown researchers then investigated the cell adhesion and differentiation of chondrocyte cells in an external electric field.

In collaboration with the research

(Credit: Basu)

▲ National Metallurgical Laboratory's Suparbha Nayar (extreme left), and authors Webster and Basu (in center wearing ties, left and right, respectively) with the researchers of Brown University's School of Engineering.

▲ Basu with Joo L. Ong (extreme right) and other faculty and researchers of Department of Biomedical Engineering at University of Texas at San Antonio.

group of Rajendra K. Borida, IIT Kanpur successfully adapted a 3D-printing approach to obtain porous high-density polyethylene (a method that can be extended to various material systems). Based on the composition formulated at IIT Kanpur, Shaping Concepts created hybrid polymer–ceramic biocomposites to explore the commercial scale production of complex-shaped materials.

Electrospun fibrous scaffolds have been synthesized at IIT Kanpur and tested for fine-scale compositional analysis using Mauli Agrawal 's UTSA research group's X-ray photoelectron spectroscopy and micromechanical-property evaluation facilities.

More information about the Center for Biomaterials for Health Care research activities is available on the center's website www.iitk.ac.in/indo_us_biomaterials. More information about the Indo–U.S. Science and Technology Forum is available at www.indousstf.org.

About the authors

Bikramjit Basu is a professor in the Department of Materials Science and Engineering, Indian Institute of Technology Kanpur, India

Thomas Webster is a professor in the School of Engineering and Department of Orthopedics, Brown University, Providence, R.I. ■

2011 GLASS & OPTICAL MATERIALS DIVISION ANNUAL MEETING

www.ceramics.org/gomd2011

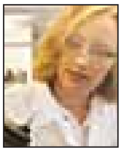
Invitation to attend GOMD 2011

We invite you to join more than 300 of your colleagues in Savannah, Ga., to discuss your research and share knowledge about the physical properties and technological processes important to glasses, amorphous solids and all optical materials. GOMD 2011 includes sessions headed by technical leaders from industry, government laboratories and academia that cover the latest advances in glass science and technology as well as a focused examination of the amorphous state.

GOMD 2011 is designed for those involved or interested in the scientific research and development, application and manufacturing of all glass types.

Award winners:

2011 Norbert J. Kreidl Award


Christensen

Recipient: **Randilynn Christensen**, MSE, Iowa State University

The Mixed Glassformer Effect in Sodium Borophosphate Glass

2011 George W. Morey Award


Greaves

Recipient: **Neville Greaves**, Department of Materials Science and Metallurgy, University of Cambridge

Glass Structure, Ion Transport and the Pareto Principle

2011 Stookey Lecture of Discovery


Day

Recipient: **Delbert E. Day**, Curators' Professor of Ceramic Engineering and Senior Research Investigator, Graduate Center for Materials Research, Missouri University of Science and Technology

Repairing the Body with Glass

Thank you sponsors:

Poster Session Sponsor

Journal of Non-Crystalline Solids

Welcome Reception Cosponsor

Applied Glass Science

Lanyard Sponsor

American Elements

Award sponsors:

Coe College

Corning

PPG

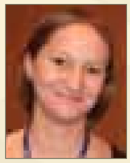
Schott

2011 GOMD Annual Meeting

www.ceramics.org/gomd2011

GOMD 2011 program chairs

Joseph V. Ryan
joe.ryan@pnl.gov
Pacific Northwest National Lab



Amanda Brennecka
alyoung@sandia.gov
Sandia National Labs

GOMD schedule-at-a-glance

Sunday, May 15, 2011	
Registration	3:00 – 7:00 p.m.
Welcome Reception	6:00 – 8:00 p.m.
Monday, May 16, 2011	
Registration	7:00 a.m. – 7:00 p.m.
Stookey Lecture of Discovery	8:00 – 9:00 a.m.
Concurrent Technical Sessions	9:20 a.m. – Noon
Lunch on Own	Noon – 1:00 p.m.
Concurrent Technical Sessions	1:00 – 5:40 p.m.
Poster Session	6:30 – 9:30 p.m.
Tuesday, May 17, 2011	
Registration	7:30 a.m. – 7:00 p.m.
George W. Morey Award	8:00 – 9:00 a.m.
Concurrent Technical Sessions	9:20 a.m. – Noon
Norbert J. Kreidl Award for Young Scholars*	Noon – 1:00 p.m.
Lunch on Own	Noon – 1:00 p.m.
Concurrent Technical Sessions	1:00 – 5:40 p.m.
Conference Dinner	7:00 – 10:00 p.m.
Wednesday, May 18, 2011	
Registration	7:30 a.m. – 5:30 p.m.
Concurrent Technical Sessions	8:00 a.m. – Noon
Lunch on Own	Noon – 1:00 p.m.
Concurrent Technical Sessions	1:00 – 5:40 p.m.
Thursday, May 19, 2011	
GMIC Symposium**	7:00 a.m. – 2:30 p.m.
Registration	7:30 a.m. – Noon
Concurrent Technical Sessions	8:00 a.m. – Noon
Short Course**	1:30 – 5:30 p.m.
Friday, May 21, 2011	
Short Course**	8:00 am – 5:00 p.m.

*Free boxed lunches will be available to attendees on a first come, first served basis.
**Separate registration is required for these events.

Symposium I: Glass Science

Lead Contact: John Mauro

Session A: Atomistic Modeling of Glass Structures and Interfaces

Organizer: Jincheng Du

Session 1	**May 18, 2011**	**1:00 –6:00 p.m.**

Session B: Glass Structure and Properties

Organizer: Randall E. Youngman

Session 1	**May 17, 2011**	**9:20 a.m. – Noon**
Session 2	**May 17, 2011**	**1:20 – 5:20 p.m.**

Session C: Glass Corrosion

Organizers: Stéphane Gin, Pierre Frugier

Session 1	**May 17, 2011**	**9:20 a.m. – Noon**
Session 2	**May 17, 2011**	**1:00 – 5:20 p.m.**

Session D: Ancient Glasses

Organizer: Denis Strachan

Session 1	**May 18, 2011**	**10:20 a.m. – Noon**

Session E: Non-silicate Glasses

Organizers: Andriy Kovalskyy, Juejun (J.J.) Hu

Session 1	**May 16, 2011**	**9:20 a.m. – Noon**
Session 2	**May 16, 2011**	**1:00 – 3:20 p.m.**

Session F: Glass-Ceramics

Organizer: Amanda Brennecka

Session 1	**May 16, 2011**	**3:20 – 5:20 p.m.**

Session G: Surface and Interfacial Phenomena

Organizer: Carlo G. Pantano

Session 1	**May 18, 2011**	**8:00 – 10:20 a.m.**

Fundamentals of Glass Science and Technology Short Course

Professional engineers, scientists, administrators and students who wish to rapidly acquire a general idea of glass or append their education in materials engineering should attend. Taught by Arun K. Varshneya, course topics include commercial glass families, glassy state, nucleation and crystallization, phase separation, glass structure, glass technology, batch calculations, glassmelting and glass forming, glass properties and engineering principles, and elementary fracture analysis.

Symposium II: The Amorphous State

Lead Contact: Joseph V. Ryan

Session A: The Glass Transition and Relaxation in Glasses and Glass-Forming Liquids

Organizer: Prabhat K. Gupta

Session 1	May 16, 2011	9:20 a.m. – Noon
Session 2	May 16, 2011	1:00 – 5:40 p.m.
Session 3	May 17, 2011	9:20 a.m. – Noon

Session B: Model/Experiment: Links and Limits

Organizer: David Drabold

Session 1	May 17, 2011	1:00 – 5:40 p.m.

Session C: Topology and Rigidity

Organizers: Pierre Lucas, John Mauro

Session 1	May 18, 2011	8:00 a.m. – Noon

Session D: Medium-Range Order

Organizer: Paul Voyles

Session 1	May 18, 2011	1:00 – 5:40 p.m.

Session E: Amorphous Metals

Organizer: Joseph V. Ryan

Session 1	May 18, 2011	3:20 – 5:40 p.m.
Session 2	May 19, 2011	8:00 – 10:00 a.m.

Session F: Spin Glasses

Organizers: John McCloy, Kostya Trachenko

Session 1	May 19, 2011	8:00 a.m. – Noon

Session G: Water and Glass

Organizer: Minoru Tomozawa

Session 1	May 16, 2011	3:20 – 5:40 p.m.

Symposium III: Optical Materials and Devices

Lead Contact: Adam J. Stevenson

Session A: Optical Absorption

Organizer: Mark Davis

Session 1	May 17, 2011	1:00 – 4:40 p.m.

Session B: Photosensitivity and Photomodification

Organizers: Pierre Lucas, Kathleen Richardson

Session 1	May 16, 2011	3:20 – 5:40 p.m.

Session C: Optical Ceramics

Organizers: Adam J. Stevenson, Robert J. Pavlacka

Session 1	May 16, 2011	9:20 a.m. – Noon
Session 2	May 16, 2011	1:00 – 3:20 p.m.

Session D: Active Optics

Organizer: David Scrymgeour

Session 1	May 17, 2011	9:20 a.m. – Noon

Session E: Optical Coatings

Organizer: S. K. Sundaram

Session 1	May 18, 2011	1:00 – 5:20 p.m.

Session F: Sensors and Scintillators

Organizer: Mary Bliss

Session 1	May 18, 2011	10:20 a.m. – Noon

Session G: Solar Energy and Photocatalysis

Organizers: Matthew T. Lloyd, Dana C. Olson

Session 1	May 18, 2011	8:00 – 11:40 a.m.

Session H: Ion Conductors and Energy Storage Materials

Organizer: Steve W. Martin

Session 1	May 16, 2011	9:20 a.m. – Noon
Session 2	May 16, 2011	1:00 – 3:20 p.m.

Glass Manufacturing Industry Council Symposium

Glass Recycling in America has achieved only a fraction of its potential. Glass is the only common product material with an endless life cycle, yet most glass in the United States is not reused. Barriers to a more robust recycling utilization include technical and economic issues. Many constituents have an interest in the state of glass recycling, including city and state governments, waste processors, glass industry suppliers and glass manufacturers. This symposium brings all stakeholders together to understand how to achieve more robust and successful recycling of glass in America.

Symposium IV: Glass Technology

Lead Contact: **Jim Marra**

Session A: Glasses for Energy and Environmental Applications

Organizer: **Amanda Billings**

Session 1	**May 19, 2011**	**8:00 – 11:20 a.m.**

Session B: Glass Strength

Organizers: **Elam Leed** **Richard K. Brow**

Session 1	**May 18, 2011**	**8:00 – 10:20 a.m.**

Session C: Glasses for Medicine and Biotechnology

Organizer: **Brad Tischendorf**

Session 1	**May 19, 2011**	**10:20 a.m. – Noon**

Session D: Glassmelting and Glass Processing

Organizer: **Rajiv Tiwary**

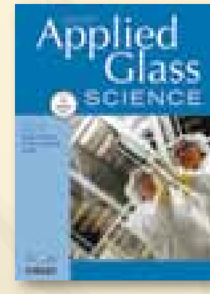
Session 1	**May 18, 2011**	**1:00 – 3:20 p.m.**

Session E: Liquid Synthesis and Sol–Gel-Derived Materials

Organizer: **Gang Chen**

Session 1	**May 18, 2011**	**3:20 – 5:40 p.m.**

International Journal of Applied Glass Science



Edited by David Pye
Coedited by Mario Affatigato

Copies of the newest *IJAGS* will be available at GOMD 2011.

Launched March 2010, the *International Journal of Applied Glass Science* endeavors to be an indispensable source of information dealing with the application of glass science and engineering across the entire materials spectrum.

Order your print subscription www.ceramics.org/ijags

Poster Session & Student Poster Competition

Organizer: **Robert A. Schaut**

Poster abstracts will be accepted for all sessions and symposia. Students are encouraged to enter their presentations in the annual poster competition for professional recognition and cash awards!

Session 1	**May 16, 2011**	**6:30 – 9:30 p.m.**

$225 savings end May 16!

Ceramic Leadership Summit 2011

August 1–3, 2011 • Hyatt Regency Baltimore • Baltimore, Md.

Super Early Bird pricing ends May 16
Sign up now to save $225. Access the complete technical program at **www.ceramics.org/cls2011**

The Ceramic Leadership Summit 2011 will discuss business opportunities, emerging technologies and critical areas for scientific advancement and process innovations that challenge the ceramic materials community. The meeting consists of four general sessions and three concurrent tracks. CLS 2011 provides the unique opportunity to participate in facilitated discussions, to address nontechnical issues that help shape the future of ceramics and to interact with other leaders from the ceramics and glass materials community.

TUESDAY, AUG. 2, 2011

GENERAL SESSION 1

10:00 a.m. to noon

Advancing Materials Technology in a Complex World

Corporate leaders provide their perspectives on the global economic, technological and environmental challenges and opportunities facing the ceramic materials and technologies community. Each talk will be followed by a facilitated dialogue with Summit participants.

Wolfgang Rossner

Advanced Ceramics for Sustainability – View from Siemens Corporate Technology

Speaker: Wolfgang Rossner, Technology Leader Ceramics, Siemens AG Corporate Technology

The predicted mega trends, such as climate change, population growth, demographic change and scarcity of resources, require more sustainable global development. Thus, sustainability is a highly demanded property and a powerful innovation driver for technologies. Within this context advanced materials are expected to provide new solutions for the environment, economy and society. Advanced ceramics can contribute to achieving higher sustainability by improving the efficiency, functionality and lifetime of technical systems. Stimulated by their multidisciplinary character, ceramic materials can open options for new solutions, e.g., for power generation, energy saving and energy storage or for self-adapting components using more "intelligent" materials.

Krishan L. Luthra

Emerging Applications and Challenges in Using Ceramics at General Electric

Speaker: Krishan L. Luthra, Technology Leader, Ceramics & Metallurgy, GE Global Research

Ceramics play a critical role in performance of many energy systems, including gas turbines, batteries and SOFCs. Ceramic matrix composites can lead to improved performance of gas turbines for land-based and aircraft engines, because of their lighter-weight and higher-temperature capabilities. Key components of SOFCs also are ceramics: the yttria stabilized zirconia electrolyte and the perovskites cathode. High-energy-density sodium-metal halide battery is another emerging application relying on a β-alumina electrolyte and other ceramics. Key challenges in commercializing these applications are component life and cost. This talk will discuss applications and challenges in use of ceramics in these three applications, focusing on CMCs.

GENERAL SESSION 2

1:30 to 3:15 p.m.

Entrepreneurial Case Studies

Start-up businesses are an integral part of the ceramic materials community. Many entrepreneurs have started with research focus and successfully transitioned into launching and/or managing a business. Three tech-savvy leaders of ceramics-related companies provide case studies on building businesses based on materials technology. The case studies will be followed by a facilitated panel discussion.

Bart Riley

Ted Day

Marina Pascucci

Speaker: Bart Riley, Cofounder, CTO, A123 Systems

Speaker: Ted Day, President, Mo-Sci Corporation

Speaker: Marina Pascucci, President, CeraNova Corporation

Know someone at your company, institution or university who is a rising star? Nominate that person to be a part of the Future Leaders Program at the Ceramic Leadership Summit. Participants will build leadership development plans that they can take away and continue working on throughout the year. To nominate young professionals or for more information, contact Megan Bricker at mbricker@ceramics.org.

Ceramic Leadership Summit 2011

CLS 2011 features three concurrent tracks: Energy Innovations, Business of Ceramics and Innovative Applications for Ceramic Materials. Leaders from a variety of organizations will present opportunities and challenges in the ceramics and glass materials community. **Register at www.ceramics.org/cls2011 before May 16 to save $225.**

TUESDAY, AUG. 2, 2011

GENERAL SESSION 3

3:45 to 5:15 p.m.

Business Opportunities and Strategies in Emerging Markets

Speaker: Thomas A. Cole, VP of Business Development, Ceradyne, Inc.

WEDNESDAY, AUG. 3, 2011

3:15 to 5:00 p.m.

CLOSING GENERAL SESSION


Thomas Peterson


Alexander Michaelis

Connecting Research, Technology and Manufacturing

Research and innovation are critical to development of technology that can transform the world. What are some of the programs in the United States and in Europe that make a connection among research, technology and manufacturing? How do these programs or similar programs help the ceramic materials community?

Speaker: Thomas W. Peterson, Assistant Director for Engineering, National Science Foundation

Speaker: Alexander Michaelis, Director, Fraunhofer Institute for Ceramic Technologies and Systems

ENERGY INNOVATIONS

8:30 to 9:25 a.m.

Advances in Solid-State Batteries

Speaker: Kevin S. Jones, University of Florida

9:30 to 10:25 a.m.


John Olenick

Ceramic Components for Fuel Cells and Other Energy Applications

Speaker: John Olenick, ENrG Inc.

Since 1960, the planet has changed due to increasing levels of carbon dioxide in the atmosphere. Similar increases over the next 50 years will reach a level beyond that which is comfortable for all species. At the same time, the global demand for energy, water and food will soar. Today's commercialization efforts of fuel cell technology and other advanced energy methods can be an important piece of the overall solution to provide more clean energy. Ceramic components are becoming increasingly important in the Cleantech market space providing means for ion transport, thermal management, catalysis of gases and liquids, power generation, energy storage, hydrogen purification and storage generation of light, and energy from waste processes.


Terry Michalske

1:00 to 1:55 p.m.

Small Modular Reactors

Speaker: Terry Michalske, Laboratory Director, Savannah River National Laboratory

2:00 to 2:55 p.m.


Mark Verbrugge

Material Needs in Alternative & Renewable Energy for the Automotive Industry

Speaker: Mark Verbrugge, General Motors Research & Development Center

Primary concerns associated with lithium-ion batteries and high-volume traction applications are associated with cost, life (cycle and calendar) and performance over a wide temperature range. Despite these concerns, it is well recognized that soon lithium-ion batteries will be used in a variety of electrified vehicles, spanning from engine start/stop applications to hybrid electric vehicles to pure electric vehicles. Hence, it is critically important to understand phenomena governing the durability of lithium ion-cells within the context of traction applications and to indentify improved electrode materials. We focus the technical part of this talk on (1) the combined mechanical and chemical degradation of lithium-ion electrode materials, including recent theoretical and experimental methods to clarify the governing phenomena and (2) new materials offering promise for high-energy and high-power applications.

BUSINESS OF CERAMICS

8:30 to 9:25 a.m.


Thomas Abraham

Emerging Nanomaterials and Nanotechnology Applications, Industry Trends and Current and Future Markets

Speaker: Thomas Abraham, Innovative Research and Products Inc.

With large-scale current and potential use of nanostructured materials (and nanotubes) in applications, such as chemical mechanical polishing (CMP), magnetic recording and ferrofluids, sunscreens, catalysts, biodetection/labeling, packaging, drug delivery, cancer treatment, imaging, conductive coatings, optical fibers, FEDs, chips and nanocomposites, the nanotechnology industry is taking off with commercial markets. This presentation provides an overview of the markets for nanomaterials (including ceramic nanomaterials) and nanotechnology segments, such as nanoelectronics, nanophotonics, nanomagnetics, nanopatterning and lithography, nanomedicine, and nanoenabled packaging, energy generation and storage devices.

HYATT REGENCY BALTIMORE

300 Light Street, Baltimore, MD 21202
402-592-6464 | 888-421-1442

Room Rates

Single/Double/Triple/Quad– $199.00 plus tax
Government– $161.00 (Access code: ACSGOV0711)

Cut-Off Date: July 8, 2011

Make reservations at **www.ceramics.org/cls2011**.

10:45 to 11:40 a.m.


Kevin See

The Market Outlook for Energy-Related Technologies

Speaker: Kevin See, Lux Research

Emerging markets provide great opportunity for materials suppliers and researchers, because they spur the growth of new supply chains for novel applications. Here we review the drivers creating opportunities for ceramic materials in several areas, including electric vehicles, advanced coatings and composites, and water treatment. In order to sort through the hype surrounding these markets, we will examine trends in each and discuss the economic, regulatory and technical factors that affect adoption now and in the future.

1:00 to 2:55 p.m.


Allen Oppenheimer

Business Valuation

Speaker: Allen Oppenheimer, A.M. Oppenheimer Inc.

Business owners will get practical tools and learn how to package their business to make it attractive to a buyer; how to maximize the future potential of the business; how to increase sales through marketing/market research; how to organize and plan; how to substantiate goodwill; and much, much more! In addition, the step-by-step process will cover practical aspects of the sale-of-business process; how to transfer a business to family and employees using an ESOP; how to target and attract suitable buyers; how to negotiate an increase in price on the basis of favorable deal structuring; practical examples on the sale-of-business process and much more.

INNOVATIVE APPLICATIONS FOR CERAMIC MATERIALS

9:30 to 10:25 a.m.

Glass & Ceramics for Advanced Biomedical Applications

Speaker: Steve Jung, Mo-Sci Corporation

10:45 to 11:40 a.m.


Louis Mattos Jr.

Advance in Glass Strength and Its Impact on Society

Speaker: Louis Mattos Jr., The Coca-Cola Company

Glass is prized for its ability to transmit light, be formed into miraculous shapes and resist chemical corrosion. But today's commercial glass fails to tap 99.5 percent of its theoretical strength and has one major flaw – it breaks. The vision of the Usable Glass Strength Coalition is to bridge the gap between the laboratory strength of glass and the usable commercial strength of glass, enabling dramatic innovations in design and sustainability. We will discuss the challenge and promise of forming a precompetitive research coalition of industry, university and government agencies to support a fundamental research agenda to significantly improve the usable strength of glass.

1:00 to 1:55 p.m.


Michael Hoffman

Ceramic Applications in the Automotive Industry

Speaker: Michael J. Hoffmann, Karlsruhe Institute of Technology (KIT)

SCHEDULE OF EVENTS

Concurrent Sessions: Energy Innovations (EI), Business of Ceramics (BC) and Innovative Applications for Ceramic Materials (IA)

MONDAY, AUGUST 1, 2011

5:00 to 7:00 p.m. – Welcome Reception and Networking Event

TUESDAY, AUGUST 2, 2011

8:45 to 9:30 a.m. – Coffee

9:45 to 10:00 a.m. – Opening Remarks

10:00 a.m. to noon – Advancing Materials Technology in a Complex World

Noon to 1:30 p.m. – Networking lunch

1:30 to 3:15 p.m. – Entrepreneurial Case Studies

3:15 to 3:45 p.m. – Coffee

3:45 to 5:15 p.m. – Business Opportunities and Strategies in Emerging Markets

7:00 to 9:00 p.m. – Conference Dinner

WEDNESDAY, AUGUST 3, 2011

7:30 to 8:30 a.m. – Coffee

8:30 to 9:25 a.m.
- Advances in Solid-State Batteries (EI)
- Emerging Nanomaterials and Nanotechnology Applications, Industry Trends and Current and Future Markets (BC)
- Ultrahigh Temperature Ceramics for Extreme Environmental Applications (IA)

9:30 to 10:25 a.m.
- Ceramic Components for Fuel Cells and Other Energy Applications (EI)
- Raw Materials Trends Impacting the Ceramics and Glass Community (BC)
- Glass & Ceramics for Advanced Biomedical Applications (IA)

10:25 to 10:45 a.m. – Coffee

10:45 to 11:40 a.m.
- Will Solar Energy Be Widely Adopted? (EI)
- The Market Outlook for Energy-Related Technologies (BC)
- Advance in Glass Strength and Its Impact on Society (IA)

11:40 a.m. to 12:45 p.m. – Networking lunch

1:00 to 1:55 p.m.
- Small Modular Reactors (IE)
- Business Valuation, Part 1 (BC)
- Ceramic Applications in the Automotive Industry (IA)

2:00 to 2:55 p.m.
- Material Needs in Alternative & Renewable Energy for the Automotive Industry (EI)
- Business Valuation, Part 2 (BC)

2:55 to 3:15 p.m. – Coffee

3:15 to 5 p.m. – Connecting Research, Technology, and Manufacturing

Register by June 24, 2011, to save $125.

2nd Advances in Cement-Based Materials: Characterization, Processing, Modeling and Sensing

July 24–26, 2011
Nashville, Tennessee, USA
www.ceramics.org/cements2011

The American Ceramic Society www.ceramics.org

Register now to attend Cements 2011, hosted July 24–26, 2011, by Vanderbilt University in Nashville, Tenn. The meeting is co-organized by the Cements Division of ACerS and the Center for Advanced Cement-Based Materials. Authors will present oral and poster presentations on cement chemistry and nano/microstructure, advances in multiscale material characterization, alternative cementitious materials and material modification, multiscale concrete durability, advances in computational material science and chemo/mechanical modeling of cement-based materials as well as smart materials and sensors.

Tutorial

This year's tutorial is "Geochemical speciation modeling and transport processes applied to cement-based materials" and will feature Barbara Lothenbach from EMPA, the Swiss Federal Laboratories for Materials Science and Technology. The Della Roy Lecture, sponsored by Elsevier, will be given by Karen Scrivener, professor and head of the Laboratory of Construction Materials at Ecole Polytechnique Fédérale de Lausanne (Switzerland) and founder of the Nanocem Consortium.

Hotel Information

Marriott Nashville at Vanderbilt University
2555 West End Avenue
Nashville, TN 37203
Phone: 615-321-1300/1-800-285-0190
Fax: 615-340-5142

When making a reservation by phone, please mention The American Ceramic Society room block to secure the special conference rate.

Rate:
$139.00 Single/Double Occupancy

Cut-Off Date:
June 24, 2011

Tentative Schedule

FGH = Vanderbilt University's Featheringill Hall

Sunday, July 24, 2011

Registration	Noon to 6:00 p.m.	FGH Atrium
Tutorial	1:00 to 4:30 p.m.	FGH Auditorium
Poster Session & Reception	4:30 to 6:00 p.m.	FGH Atrium

Monday, July 25, 2011

Registration	7:30 a.m. to 6:30 p.m.	FGH Atrium
Technical Session	8:30 to 10:00 a.m.	FGH Auditorium
Break	10:00 to 10:30 a.m.	FGH Atrium
Technical Session	2:00 to 3:30 p.m.	FGH Auditorium
Cements Division General Business Meeting	3:30 to 4:30 p.m.	FGH Auditorium
Della Roy Lecture & Reception	4:30 to 6:30 p.m.	FGH Auditorium & Atrium

Tuesday, July 26, 2011

Registration	7:30 a.m. to 4:00 p.m.	FGH Atrium
Technical Session	8:30 to 10:00 a.m.	FGH Auditorium
Break	10:00 to 10:30 a.m.	FGH Atrium
Technical Session	10:30 a.m. to Noon	FGH Auditorium
Technical Session	2:00 to 3:30 p.m.	FGH Auditorium
Break	3:30 to 4:00 p.m.	FGH Atrium
Technical Session	4:00 to 4:45 p.m.	FGH Auditorium

Sponsorship

For Corporate Sponsorship opportunities, contact Patricia Janeway at pjaneway@ceramics.org or 614-794-5826.

Journal of the American Ceramic Society preview

All ACerS members are provided free *online* access to the *Journal of the American Ceramics Society* (searchable to 1918). Go to www.ceramics.org, enter your username and password and then go to the "Publications and Resources" menu. *Print* subscriptions to this journal (not free to members) are also sold online by Wiley–Blackwell Publishing, www.wiley.com.

New papers are posted to the "Online Early" page as soon as they are ready for publication, even before the issue is printed. Below are samples of what's coming.

Oxidation Resistance of Hafnium Diboride Ceramics with Additions of Silicon Carbide and Tungsten Boride or Tungsten Carbide

Carmen M. Carney, Triplicane A. Parthasarathy and Michael K. Cinibulk

These researchers from Air Force Research Laboratory and UES Inc. used field-assisted sintering to prepare dense samples of HfB_2–SiC, HfB_2–SiC–WC and HfB_2–SiC–WB, where the WB and WC additives were incorporated by solid solution. They report that the additives did not alter the oxidation kinetics of the HfB_2–SiC until 2000°C, when a 30 percent thinner scale formed.

Enhanced Electromechanical Properties and Temperature Stability of Textured $(K_{0.5}Na_{0.5})NbO_3$-Based Piezoelectric Ceramics

Yunfei Chang, Stephen Poterala, Zupei Yang and Gary L. Messing

This team of Chinese and American researchers used templated grain growth to produce textured $(K_{0.5}Na_{0.5})_{0.98}Li_{0.02}NbO_3$ and $(K_{0.5}Na_{0.5})(Nb_{0.85}Ta_{0.15})O_3$ ceramics that exhibited high texture quality and enhanced piezoelectric response compared with randomly oriented ceramics. The team reports that the KNLN showed higher piezoelectric properties and higher phase transition temperatures, making it an attractive material in device applications.

Crystallization Process for Superionic $Li_7P_3S_{11}$ Glass-Ceramic Electrolytes

Keiichi Minami, Akitoshi Hayashi and Masahiro Tatsumisago

These Japanese researchers used a two-step heat-treatment process to enhance the crystallinity of $Li_7P_3S_{11}$ crystals in a glass-ceramic. They report that the glass-ceramic exhibits high conductivity at room temperature.

Quantitative Analysis of Crack Closure Driven by Laplace Pressure in Silica Glass

Gaël Pallares, Antoine Grimaldi, Matthieu George, Laurent Ponson and Matteo Ciccotti

This French and American research team reports that it has developed an original technique – using atomic force microscopy – for measuring the physical properties of liquid condensation in silica glass crack tips in moist atmosphere.

Low-Loss Microwave Dielectrics in the $(Mg_{1-x}Co_x)_{1.8}Ti_{1.1}O_4$ (x = 0.03–1.00) Solid Solutions

Cheng-Liang Huang, Yu-Wei Tseng and Yuan-Cheng Kuo

These National Cheng Kung University researchers used a conventional solid-state method to prepare $(Mg_{1-x}Co_x)_{1.8}Ti_{1.1}O_4$ (x = 0.03–1.00). They report that the lattice parameters, cell volume and $Q\times f$ varied linearly with x. The researchers propose the material as a promising dielectric material for ultra-high-frequency applications.

Fatigue Threshold R-Curve Behavior of Grain Bridging Ceramics: Role of Grain Size and Grain-Boundary Adhesion

Sarah Gallops, Theo Fett and Jamie J. Kruzic

These researchers from Germany and the United States studied the fatigue threshold behavior of polycrystalline alumina having fine and coarse microstructures and under moist air and dry nitrogen-gas environments. They report that the fine-grained microstructure showed higher fatigue thresholds at short crack sizes and that the coarse-grained microstructure demonstrated higher fatigue thresholds at long crack sizes.

Damage Development in an Armor Ceramic Under Quasi-Static Indentation

Eleanor A. Gamble, Brett G. Compton, Vikram S. Deshpande, Anthony G. Evans and Frank W. Zok

This research team from University of California at Santa Barbara and Cambridge University assessed the capabilities of a mechanism-based model for inelastic deformation and damage in structural ceramics that accounts for lattice plasticity, microcrack growth and coalescence and granular flow following comminution. The team reports that the most discriminating metric in the assessment is the spatial extent of subsurface damage following indentation. In contrast, surface profiles of indents are dictated largely by lattice plasticity and, thus, provide minimal additional insight into the inelastic deformation resulting from microcracking or granular flow.

Int'l Journal of Applied Ceramic Technology preview

All ACerS members are provided free *online* access to the *International Journal of Applied Ceramic Technology*. Go to www.ceramics.org, enter your username and pasword and then go to the "Publications & Resources" menu. *Print* subscriptions to this journal (not free to members) are sold online by Wiley–Blackwell Publishing, www.wiley.com.

New papers are posted to the "Online Early" page as soon as they are ready for publication, even before the issue is printed. Below are samples of what's coming.

SiAlON–SiC Sandwich Structures with Tailored Surface Compression

Kyle Hoff, David J. Green, Youngho Jin, Earle Ryba and John R. Hellmann

This Pennsylvania State University research team evaluated the feasibility of producing high-hardness ceramic sandwich structures – SiAlON faces and SiC cores – with compressive residual stresses in the faces. The team reports that it was necessary to hybridize the SiAlON faces by adding SiC particles to reduce the thermal expansion mismatch between the face and the core and to avoid cracking during processing.

Nanostructured, Infrared-Transparent Magnesium-Aluminate Spinel with Superior Mechanical Properties

Thomas Mroz, Lee M. Goldman, Andrew D. Gledhill, Dongsheng Li and Nitin P. Padture

These researchers from Surmet Corp. and Ohio State University fabricated nanostructured magnesium aluminate spinel with a highly uniform grain-size distribution for infrared window/dome applications using Y_2O_3 sintering additive. They report that this spinel has high room-temperature strength, reliability, improved erosion and thermal-shock resistance, and near-theoretical in-line infrared transmission.

Physicochemical Properties and Biocompatibility of Tricalcium and Dicalcium Silicate Composite Cements after Hydration

Maryam Mazrooei Sebdani and Mohammad Hossein Fathi

This research team from People's Republic of China explored various proportions of Ca_3SiO_5 and Ca_2SiO_4 composite cements and evaluated their physicochemical properties and in-vitro biocompatibility after hydration. The team reports that the composites exhibited better strength and shorter setting time than pure Ca_3SiO_5 or Ca_2SiO_4 and that composite hydration products could induce formation of apatite layers on surfaces in simulated body fluid.

Development of a Test Technique to Determine the Thermal Diffusivity of Large Refractory Ceramic Test Specimens

James G. Hemrick, Ralph B. Dinwiddie, Erick R. Loveland and Andre Prigmore

This Oak Ridge National Laboratory team has developed and validated a technique to use a high-intensity plasma arc lamp to measure thermal diffusivity of bulk refractory materials at elevated temperatures. They report that the new technique resolves sample size and inherent problems of current standardized test methods.

Hexagonal-Boron Nitride as a New Ultraviolet Luminescent Material and Its Application

Kenji Watanabe and Takashi Taniguchi

Watanabe and Taniguchi report that high-purity *h*-BN crystals grown by the solvent growth method exhibit electronic excitation states near the band gap that are governed by optically allowed exciton effects. The excitonic luminescence bands can be used for far-ultraviolet plane light-emitting devices excited by field emitters.

Depression Effects of Al on Oxidation of Diamond During Sintering of Diamond/Borosilicate Glass Composites

Xianghong Zhang, Yanhui Wang, Jianbing Zang, Xiaozhe Cheng, Xipeng Xu and Jing Lu

This research team from People's Republic of China used aluminum powder as an oxygen getter to inhibit the oxidization and improve the wettability of diamond grits by the matrix during sintering of diamond/glass composites. The team reports the aluminum powder decreases volume expansion rate and increases bending strength.

Fabrication and Characterization of Anode-Supported $BaIn_{0.3}Ti_{0.7}O_{2.85}$ Thin Electrolyte for Solid Oxide Fuel Cell

Mathilde Rieu, Pankaj Kumar Patro, Thibaud Delahaye and Etienne Bouyer

This international research team fabricated SOFC anode-supported half cells using a NiO–8YSZ anode support and a $BaIn_{0.3}Ti_{0.7}O_{2.85}$ electrolyte thin film. The team reports that the cermet electrode had a homogeneous microstructure with a well-defined anode/electrolyte interface, was stable at high temperature and retained dimensional control with no surface defects.

Calendar of events

May 2011

2–4 ➨ INTERTECH 2011 – Hyatt Regency O'Hare, Chicago, Ill.; www.intertechconference.com

2–5 ➨ Int'l Symposium on Olfaction and Electronic Nose 2011 – Rockefeller University, New York City, N.Y.; www.engconf.org/11as.html

3–4 Structural Clay Products Division Meeting – Gettysburg, Pa.; www.ceramics.org/clay11

8–12 Engineering Ceramics 2011 – Smolenice Castle, Slovakia; www.engcer11.sav.sk

10–12 Green Refractory for a Low-Carbon World: 1st China International Refractory Production and Application Conference – White Swan Hotel, Guangzhou, China; www.mc-ccpit.com/ref2011/en/index.asp

12–15 Advances in Applied Physics and Materials Science 2011 Congress – Mirada Del Mar Hotel, Antalya, Turkey; www.apmas2011.org

15–19 GOMD 2011: Glass & Optical Materials Division Spring Meeting – Hilton Savannah DeSoto Hotel, Savanna, Ga.; www.ceramics.org/gomd2011

16–20 Mineral Processing: An Introduction to the Principles – Colorado School of Mines, Golden, Colo.; www.csmspace.com/events/minproc

17–19 Plant Maintenance & Design Engineering Show 2011 – Place Bonaventure, Montreal, Canada; www.pmds.ca

24–26 RAPID 2011 & 3D Imaging Conference & Exposition – Hyatt Regency, Minneapolis, Minn.; www.sme.org/rapid

26–29 Ceramics China 2011 – Import and Export Fair Complex, Guangzhou, China; www.ceramicschina.com.cn

June 2011

5–7 Society of Manufacturing Engineers Annual Conference – Hyatt Regency, Bellevue, Wash.; www.sme.org/

5–8 ➨ Fractography of Glasses and Ceramics VI – Jacksonville, Fla.; www.fractographyvi.com/index.html

8–10 ACerS Southwest Section Annual Meeting – Omni Mandalay Hotel, Las Colinas (Dallas-Irving), Texas; www.ceramics.org/sections/southwest-section

19–23 ➨ 12th Conference of the European Ceramic Society – City Conference Center, Stockholm, Sweden; www.ecers2011.se

26–July 1 7th Int'l Dendrimer Symposium 2011 – Gaithersburg, Md.; www.mrs.org/meetings

27–July 1 Semiconductor Technology for Ultra Large Scale Integrated Circuits and Thin Film Transistors – Hong Kong, China; www.engconf.org/11ax.html

24–28 ECCM15, the 15th European Conference on Composite Materials – Lido, Venice, Italy; www.eccm15.org

July 2011

10–14 ➨ PACRIM9: The 9th Int'l Meeting of Pacific Rim Ceramic Societies – Cairns, Australia; www.austceram.com/pacrim9.asp

10–14 ➨ 9th Int'l Conference on Advances in the Fusion and Processing of Glass (held in conjuction with PACRIM9) – Cairns, Australia; www.austceram.com/pacrim9.asp

21–24 27th Convention of Mexican Ceramics Industry – Cancun Palace Hotel, Cancun, Mexico; www.soceram-norte.com.mx/

24–26 Cements Division/Center for Advanced Cement-Based Materials Annual Meeting – Vanderbilt University, Nashville, Tenn., www.ceramics.org/divisions/cements-division

28–29 ➨ NSF Ceramic Materials PI Workshop 2011 – Arlington, Va.; www.ceramics.org/nsfworkshop

August 2011

1–3 Ceramic Leadership Summit 2011 – Hyatt Regency, Baltimore, Md.; www.ceramics.org/cls2011

7–11 ➨ Int'l Workshop on Piezoelectric Materials and Applications 2011 for Clean Energy Systems – Hotel Roanoke, Roanoke, Va.; www.cpe.vt.edu/ehw

21–25 7th Int'l Conference on Borate Glasses, Crystals and Melts – Dalhousie University, Halifax, Nova Scotia, Canada; www.regonline.com/borate7

28–Sept. 1 ➨ Korean Ceramic Society and Korean Powder Metal Institute Sintering 2011 – Jeju Island, Korea; www.sintering2011.org

September 2011

12 ACerS Pittsburgh Section Annual Golf Outing – Lenape Heights Golf Course, Ford City, Pa., Las Colinas (Dallas-Irving), Texas; www.ceramics.org/sections/pittsburgh-section

12–14 imX Interactive Manufacturing Experience – Las Vegas Convention Center, Las Vegas, Nev.; www.imxevent.com

13–14 Nanopolymers 2011 – Radisson Blu Scandinavia Hotel, Düsseldorf, Germany; www.ismithers.net/conferences/XNAN11/nanopolymers-2011

20–22 Hi Temp Conference (Netzsch North America Instruments) – Millennium Hotel, Boston, Mass.; www.hitemp2011.com

October 2011

2–7 ➨ EPD 2011: 4th Int'l Conference on Electrophoretic Deposition – CasaMagna Marriott Hotel, Puerto Vallarta, Mexico; www.engconfintl.org/11ab.html

16–20 ➨ MS&T'11: Materials Science & Technology 2011 Conference and Exhibition – Greater Columbus Convention Center, Columbus, Ohio; www.matscitech.org

16–20 ACerS Annual Meeting and Awards Banquet – Renaissance Downtown Hotel, Columbus, Ohio; www.ceramics.org

Dates in **RED** denote new entry in this issue.

Entries in **BLUE** denote ACerS events.

➨ denotes meetings that ACerS cosponsors, endorses or otherwise cooperates in organizing.

Erica Marden
Guest columnist

Biomaterials innovation: Student exposure to 'bio' and health fields needed

In the next year I hope to make the transition from materials to medicine. As an undergraduate student studying materials science and engineering at Pennsylvania State University I am planning on applying to medical school next year.

My interest in biomaterials led me to the MatSE department where I began research my freshmen year. By working with a postdoctoral researcher, I learned about the different characterization techniques for testing polymeric artificial heart membranes. A Research Experience for Undergraduates opportunity in soft materials at Penn State gave me the opportunity to develop my own investigation. I worked collaboratively with the MatSE and the food science departments to create complexes using amylose isolated from potatoes. My senior thesis project, developed from this research, has possible implications as a drug delivery system.

I have enjoyed my exposure to biomaterials in my coursework. My junior design class project focused on developing a technique to prevent degradation of colloidal nanoparticles used as deliver agents for chemotherapeutics. An elective course also gave me exposure to materials selection criteria for implant devices and practical medical applications.

But, I wish that a stronger emphasis on healthcare applications of materials could be incorporated into traditional materials science and engineering ceramics courses. Materials science and engineering may soon be responsible for helping to solve some modern medical dilemmas. We are pushing the boundaries to find more effective treatments for cancer and HIV. Other serious health concerns include the overuse of antibiotics, leading to drug-resistant strains of bacteria, which pose a challenge to pharmacologists. The expertise of materials scientists and engineers may offer new insights to treat these rapidly evolving bacterial strains. . For example, creating more effective ways of manufacturing drugs and providing targeted in-vivo delivery may rely on viewing medicine from a nanomaterials perspective.

Materials scientists and engineers are finding solutions to offer medicine worldwide. One of the biggest problems with diseases such as malaria and tuberculosis is distributing unstable pharmaceuticals or vaccines. Innovations in materials science and engineering may soon find ways to store vaccines in hot climates or increase the stability time of sensitive medicine while driving down costs. Glass or piezoelectric materials may provide imaging techniques that decrease radiation exposure while providing higher image quality. And, there are endless possibilities for tissue engineering in the future.

I wish that materials science and engineering curriculums reflected these exciting opportunities and focused more heavily on collaboration with biological fields. Surprisingly, I have been required to take classes in all of the basic sciences except biology. And, I know from speaking with students in materials programs across the country, that this practice is common. But, incorporating an introductory course in biotechnology, biochemistry, molecular biology or agriculture sciences could help expose students to an entirely different side of materials that is often underemphasized in traditional ceramics curriculums. We know that organisms can design and build materials with extreme precision and that some organic materials exceed the mechanical properties we can design. Studying these biological systems may highlight new opportunities for material advancements.

I am hopeful that the construction of a new Millennium Science Complex at Penn State will encourage more collaboration and coursework with the biological sciences. The building will house faculty from the MatSE, chemistry and biology departments under one roof. Characterization institutes from each department will be housed in a central location, and hopefully this proximity will encourage research and coursework collaborations. Many other schools have begun to establish interdisciplinary graduate school programs that focus on combining expertise in materials with computer science, math, physics, chemistry or biology. Ideally, these programs will soon carry to the undergraduate level so that students may have more flexibility in choosing ceramics courses that provide a broader perspective on biological applications.

I am pursuing medicine to incorporate my interest in science and technology with my love of interacting with and helping people. I am confident that my strong education in materials science and engineering will provide me with a unique perspective on modern medicine. I am optimistic that my work and plans will lead me into medicine and, eventually, collaborations on future medical materials. Hopefully, I can add to the amazing biomaterial and biomedical work by ceramists worldwide that needs to be reflected in future undergraduate ceramic curriculums.

Marden is a senior at Penn State. She is the vice president of her college's student council and the secretary of her Keramos chapter.

classified advertising

Career Opportunities

CERAMICS PROCESS ENGINEER

LiqTechNA, Inc. in North St. Paul suburb seeks experienced Ceramics Engineer to further develop its manufacturing processes. Visit our website www.liqtechna.com. Send resumes to HR, grolek@usfamily.net.

Sales Engineer We are seeking an experienced sales professional with a background in industrial applications. The successful candidate will have five years experience in industrial sales (material sales a plus), a bachelor's degree in a technical discipline, and proven facilitation and leadership skills. Please send resume, cover letter and salary requirements to NEWTEX resume@newtex.com.

The American Ceramic Society www.ceramics.org

Senior Editor

Are you an experienced science writer or reporter (with a credentialed background in one of the physical sciences or engineering) with a strong understanding of digital and prepress publishing processes? The American Ceramic Society is hiring a Senior Editor to report, write and develop print, video and online content, and assume some production management responsibilities. This full-time position is located in the ACerS headquarters office in Columbus (Westerville), OH and offers competitive compensation plus a strong growth potential for the right candidate. Information on the position requirements and application process can be found on the ACerS Career Center at: www.ceramics.org/careers/

RWTH RHEINISCH-WESTFÄLISCHE TECHNISCHE HOCHSCHULE AACHEN — JARA Jülich Aachen Research Alliance — JÜLICH FORSCHUNGSZENTRUM

Focusing Expertise – Shaping the Future: The Jülich Aachen Research Alliance (JARA) is an innovative cooperation model between RWTH Aachen University and Forschungszentrum Jülich. This Alliance brings together an internationally respected university of technology and one of the leading national research centres in Europe. The following position for a director is for the JARA-Energy section.

The Institute of Energy and Climate Research (IEK) at Forschungszentrum Jülich conducts research on pioneering technologies for energy conversion and storage and examines the consequences of energy use and the related emissions. Materials for energy technologies constitute a key topic of research activities at IEK.

Forschungszentrum Jülich, in a joint procedure with RWTH Aachen University, is seeking a scientist as

DIRECTOR

for the institute division „Materials Synthesis and Processing"
at the Institute of Energy and Climate Research (IEK)

In accordance with the „Jülich Model", the successful applicant will also be appointed professor (grade W3) of „materials synthesis for energy technologies" in the Faculty of Georesources and Materials Engineering at RWTH Aachen University.

Current and future priorities of research work at this institute division comprise the development of new materials and innovative manufacture and joining processes for solid oxide fuel cells (SOFCs), functional layers for efficient power plants, gas separation membranes for zero-emission power plants, and electrochemical storage.

The successful candidate will have relevant broad expertise in the area of the manufacture of ceramic materials and composite materials, as well as of their further processing to components and demonstrators. For the manufacture of composite materials and functional layers, physical, chemical and thermal coating techniques and powder-based processes will be used. These processes shall be supported by relevant modelling activities.

An internationally respected institute division with excellent facilities awaits the successful candidate, who as director, will be responsible for personnel and the scientific focus of a highly motivated research team of almost 100 individuals. The majority of these positions are financed by third-party funded projects.

The director will be expected to consolidate the process- and materials-related spectrum of the institute and expand it on a high scientific level. The ability and willingness to introduce the subject field into teaching and research are also assumed. Particular emphasis is laid on collaboration with scientific cooperation partners both at home and abroad and with industry.

Prerequisites for the position are a PhD and postdoc qualification or comparable scientific achievements. Further requirements include the ability to head an institute and teach at a university, as well as a proven readiness to acquire third-party funds.

Applications from women are particularly welcome. The implementation of equal opportunities is a cornerstone of staff policy at Forschungszentrum Jülich and RWTH Aachen University for which both institutions have received the „TOTAL E-QUALITY" award. Applications from women will be given preference in the case of equal suitability, qualifications and experience, unless special reasons concerning the person of a male candidate outweigh these considerations. Attention is drawn to Art. 8, para. 1, of the Equal Opportunities Act of the Federal State of North Rhine-Westphalia (LGG).

Applications from suitable candidates with disabilities are explicitly encouraged. This also holds for those with similar incapacities in the sense of Art. 2 SGB IX. RWTH Aachen University has been named as a „disability-friendly" employer for its commitment to training and employing disabled people.

Applications comprising a curriculum vitae, list of publications and a short summary of past and planned scientific projects should be sent, **preferably by email**, by 30 May 2011 to

Board of Directors
Forschungszentrum Jülich GmbH
52425 Jülich
Germany
berufungen@fz-juelich.de

Further information at
www.fz-juelich.de
www.fb5.rwth-aachen.de
www.jara.org

classified advertising

Business Opportunities

Established Industrial Ceramic Manufacturer looking to acquire similar manufacturing companies.

If interested in selling your Company, please send your contact and Company info to:
P.O. Box 8152
New Castle, PA
16107

Your information will not be shared.

Business Services

consulting/engineering services

Richard E. Mistler, Inc. Morrisville, PA 19067

- Consultation
- Slip Development
- Table Top Tape Casters

800-641-1034

- Development Machines
- Product Machines

www.drblade.com email: tapecast@juno.com

Fused Quartz . Alumina . Zirconia

Custom Fabrication Services

- Special Quartz Tubes
- Custom Quartzwares
- Cutting, Machining, Surface Finishing

AdValue Technology

DELKIC & ASSOCIATES
INTERNATIONAL CERAMIC CONSULTANTS

• Worldwide Services •
• Energy Saving Ceramic Coatings & Fiber Modules •

FERIZ DELKIĆ
Ceramic Engineer
P.O. Box 1726, Ponte Vedra, FL 32004
Phone: (904) 285-0200
Fax: (904) 273-1616

custom finishing/machining

SONIC-MILL®
MACHINING THE UNMACHINABLE

Your best source for:

Multi-Hole Drilling—Ideal for gas discharge plates used in plasma etching and related applications. Whether it's ten holes or thousands of holes, we machine them perfectly and precisely.

Deep-Hole Drilling—Ideal for optical fiber preforms and similar applications. We can drill high-quality, pre-polished, long, deep holes in most technical ceramics and glass materials.

Machine Sales—Acquire your own drilling capabilities when you invest in Sonic-Mill® sinker or rotary ultrasonic drilling equipment, custom suited to your manufacturing applications.

Located in Albuquerque, New Mexico, USA

505.839.3535 www.sonicmill.com

Contract Machining Service Since 1980

- *Utmost Confidentiality*
- *Alumina to Zirconia including MMC*
- *Exacting Tolerances*
- *Complex shapes to slicing & dicing*
- *Fast & reliable service*

PremaTech
ADVANCED CERAMICS™

160 Goddard Memorial Dr. Worcester, MA 01603 USA

Tel: *(508) 791-9549* • Fax: *(508) 793-9814*
• E-mail: *info@prematechac.com*
• Web site: *www.PrematechAC.com*

Customer service is the paramount goal of Technical Products, Inc., the world's largest distributor of Corning's Macor, a machinable glass-ceramic with outstanding thermal, mechanical, electrical and chemical properties (needs no post firing). TPI offers fabrication and technical assistance along with stock items of rods, bars, sheets and disc, ready to ship in 1-3 business days. Macor can be machined in intricate shapes and precision parts while withstanding high temperatures, up to 1000ºC, demonstrating high electrical resistivity and dielectric strength. Applications include semiconductor, defense, medical, scientific and aerospace.

TECHNICAL PRODUCTS, INC.
262-335-3635 Fax: 262-335-3606
www.technicalproductsinc.com
Email: tpi@technicalproductsinc.com

Custom Machined Insulation

Zircar Zirconia, Inc.

Alumina & Zirconia Fiber Insulation

- **Lab Furnace Reline Kits**
- **Custom Setters and Trays**
- **Crystal Growth Stations**
- **Fuel Cells and Reformers**
- **Heat Exchangers**
- **Applications up to 2200°C**

Call (845) 651-3040
Web: www.zircarzirconia.com
Email: sales@zircarzirconia.com

custom/toll processing services

PPT
POWDER PROCESSING & TECHNOLOGY, LLC

Your Source for Powder Processing

We specialize in:
- Spray Drying
- Wet and Dry Milling
- Calcining and Sintering

Typical Applications:
- Catalysts
- Electronics
- Ceramics
- Fuel Cells

www.pptechnology.com

laboratory/testing services

liquidations/used equipment

maintenance/repair services

AMERICAN CERAMIC SOCIETY bulletin MAY 2011

ADVERTISER INDEX

Advertiser	Page No.
ACCCO Inc./Burley Clay Products 800-828-7539 remmert@accco-inc.com • www.accco-inc.com	55
AdValue Technology 502-514-1100 sales@advaluetech.com • www.advaluetech.com	54
American Ceramic Society, The www.ceramics.org	11, 23, 22, 40
American Elements www.americanelements.com	Back cover
Centorr/Vacuum Industries Inc. 800-962-8631 sales@centorr.com • www.centorr.com/cb	56
Corning Incorporated www.corning.com/careers	Inside back cover
Delkic & Associates 904-285-0200	54
Deltech Inc. 303-433-5939 • www.deltechfurnaces.com	Inside front cover
Emhart Glass 573-437-2132 www.emhartglass.com	9
Evans Analytical Group 315-431-9900 inquiries@eaglabs.com • www.eaglabs.com	55
Forschungszentrum Juelich berufungen@fz-juelich.de	53
Geller Microanalytical Laboratory www.gellermicro.com	55
Harper International Corp. 716-684-7400 info@harperintl.com • www.harperintl.com	55
Harrop Industries Inc. 614-231-3621 sales@harropusa.com • www.harropusa.com	3, 55, 56
I Squared R Element Co. sales@isquaredrelement.com www.isquaredrelement.com	9
LiqTech North America Inc grolek@usfamily.net • www.liqtechna.com	53
Mohr Corp. 810-225-9494 sales@mohrcorp.com • www.mohrcorp.com	56
MS&T'11 www.matscitech.org	30
Netzsch Instruments NA LLC 781- 272-5353 nib-sales@netzsch.com • www.netzsch.com	5, 55
Newtex Industries resume@newtex.com	53
Powder Processing & Technology 219-462-4141 x224 asukovich@pptechnology.com www.pptechnology.com	54
PremaTech Advanced Ceramic 508-791-9549 info@prematechac.com • www.prematechac.com	54
Quality Executive Search Inc. 440-899-5070 qesinfo@qualityexec.com • www.qualityexec.com	53
Richard E. Mistler Inc. 800-641-1034 tapecast@juno.com • www.drblade.com	54
Sem-Com Co. 419-537-8813 sem-com@sem-com.com • www.sem-com.com	55
Sonic Mill 505-839-3535 • www.sonicmill.com	54
Specialty Glass Inc. 813-855-5779 info@sgiglass.com • www.sgiglass.com	55
Technical Products Inc. 262-335-3635 tpi@technicalproductsinc.com www.technicalproductsinc.com	54
VIOX Corp. 206-763-2170 glass@viox.com • www.viox.com	55
West Penn Testing Group 724-334-4140 www.westpenntesting.com	55
Zircar Zirconia Inc. 845-651-3040 sales@zircarzirconia.com www.zircarzirconia.com	54

Advertising Sales

Pat Janeway, Associate Publisher
pjaneway@ceramics.org
ph: 614-794-5826 • fx: 614-794-5822

Europe

Richard Rozelaar
media@alaincharles.com
ph: 44-(0)-20-7834-7676
fx: 44-(0)-20-7973-0076

Classified Advertising/Services

Pat Janeway
pjaneway@ceramics.org
ph: 614-794-5826 • fx: 614-794-5822

600 N. Cleveland Ave, Suite 210
Westerville, OH 43082

At Corning, possibilities become real, including yours.

If exploring the power of ideas is a lifelong passion, Corning, the world leader in specialty glass and ceramics, is a company where you'll find the culture, resources, and experiences to turn your ideas into realities.

We are currently seeking candidates for the following positions.

Research Associate: Reliability & Measurements
Job ID# 166632

Theoretical mechanic/ fracture mechanics expert, with substantial expertise/ experience with software for modeling of complex mechanics problems. Initiate research and extend capabilities and fundamental understanding of mechanical testing capabilities.

Required Education: Ph.D. Materials Science, Fracture Mechanics, Glass, and Ceramics Science
Experience: 5 to 10 years

Research Scientist: Fractography
Job ID# 166205: Fracture and Failure Analysis Engineer

Advanced skills in root cause analysis utilizing fractographic interpretation of brittle materials to determine failure mode(s). Knowledge of materials, mechanics, test methods, and manufacturing processes is necessary.

Required Education: B.S. or equivalent in Materials, Mechanics or Reliability
Experience: 3 years experience required

Senior Research Scientist: Mechanical
Job ID# 166534

Support glass development projects as the mechanical lead, conducting research on the mechanics of glass for the various glass manufacturing processes. Expertise in mechanics of brittle materials, reliability and failure analysis.

Required Education: Ph.D. in Material Science, Ceramic/ Glass, Mechanical Engineering or equivalent
Experience: 10 years of project leadership experience or equivalent required

Senior Research Scientist: Reliability & Measurements
Job ID# 166441

Ensure products meet early-design performance requirements related to reliability and functionality by developing basic understanding of product and material performance under application conditions.

Required Education: M.S. Materials, Mechanics or similar
Experience: 5 years experience required

To learn more and apply, visit our careers website at: www.corning.com/careers
Reference job identification number(s) listed above.