Students solving real-world materials science problems

By Kate Baldwin, editor


(Credit: Peter Wray, ACerS)

Today's materials science students are getting more out of higher education than what the classroom alone can offer them. From solving problems and developing ideas in industry to K–12 outreach, these students are taking their education to another level through community involvement.

Through student programs, such as Material Advantage, Keramos and ACerS President's Council of Student Advisors (PCSA), students participate in outreach programs to inspire the next generation. In **Jaime George's** article, "Making outreach easy with portable demonstration kits," you'll discover how a group of PCSA delegates developed a set of simple demonstrations that fit into an easy-to-carry case. Also, **Tricia Nicol** sums up a trip by Material Advantage students to Washington D.C., where they advocated to raise awareness and support for science, math and engineering at the Science–Engineering–Technology Congressional Visits Day.

It's never too early to start making connections in industry. **Erica Marden** discusses some of the different ways undergraduate students collaborate with industries to solve real-world problems in "The value of undergraduate design courses." And, in "Better sound through cooperation," **Salem Maud** discusses how a group of Virginia Tech students is helping industry-partner **Taylor Guitars** design a glass-ceramic saddle. In addition, MSE students are helping to develop better ways to cure cancer, such as Penn State sophomore **Stephen Weitzner** and his research group working on the development of nanoscale drug delivery carriers for pancreatic cancer treatment. (Also, be sure to check out **Randilynn Christensen's** Kreidl-Award-winning paper in Research Briefs, page 19.)

With the help of student groups and inspiring teachers, MSE undergraduates and graduates are stretching the boundaries of the classroom. Dedicated, hard-working students are making important connections in the working world early in their college careers, and many of them also are doing their part to teach the next wave of students about their love of this fascinating field. ■

Portable demo kits make outreach easy

By Jaime George

As materials scientists, we understand the importance of outreach in our field. Outreach efforts introduce many middle and high school students to the concept of materials engineering and are crucial in recruiting students into the major. These outreach efforts are often conducted by current students within the field, usually in conjunction with Keramos and Material Advantage chapters.

One of the most effective ways of reaching high school students (and actually getting them to listen) is to allow them to participate in demonstrations of materials science. While this may be easy at a university setting where there are laboratories and an abundance of potential demonstrations on hand, it is much harder to take these demonstrations on the road.

The President's Council of Student Advisors decided to make outreach easier by creating a small, portable kit that would contain materials sci-

Scientific exploration for younger learners

(Credit: Kristen Brookshire)

Brookshire helps elementary school students develop interests in science as part of her school's outreach program.

At an age in life where recess is the favored class (with lunchtime a close second) and scientific myths about cooties running rampant through the hallways, taking a less serious look at science is a great way to capture the attention of our future scientists. As a physics student at Willamette University a small liberal arts college in Oregon, I was given the challenge of captivating the attention of 40 distracted eight-to ten-year-old kids for two hours every week through the Willamette Science Outreach Program. William Webber, who had a strong passion for community enrichment and civic duty, founded the WSOP program.

The WSOP program provides a one-year Webber Scholarship to four undergraduate women students in science and math programs at Willamette University. Each year, the four students visit a local elementary school to get them excited about science and give them a first glimpse at the scientific method. The main goal of this program is not to focus on one area of science, but to spark the interest of young learners toward scientific discovery and exploration. Each lesson is structured around the scientific method: ask a question; construct a hypothesis; test the hypothesis; and draw a conclusion. Thus, it is not the task that is critical, but rather the development of critical thinking.

My favorite example of this is the "Marshmallow Catapult," in which the students learn about levers. There is nothing like flinging marshmallows across a room in the quest for optimum catapult construction to get kids excited. This combination of learning, play and individual exploration through a structured method keeps science fun and children engaged.

In the end, after more than a dozen days shared with these students, I am sure no one remembered that a shower uses 2.5 gallons of water a minute, that the jelly bean game was actually a demonstration of invasive species or why exactly it was that a pumice stone floats, but they took away a new way of looking at the world. They now know a different way to question the things that are going on around them. They found out that science is more than just a bunch of confusing facts to memorize and long tests. Many of the students even boasted of plans to become a scientist in the future, too. It is so important to remember that science is fun and hands-on and exciting – especially in the eyes of the youngest learners. ■

– Kirsten Brookshire

Fig. 1 After using tile nippers to break the safety glass, students can see the difference between how strengthened glass (front) and unstrengthened glass (back) break.

Fig. 2 These students are participating in one of the demonstrations that will be included in the kit. The students are learning the strength of safety glass, which is thermally tempered, compared with the strength of glass that hasn't been tempered.

ence demonstrations intended for high schools. Ideally, the kit would include a variety of demonstrations for ceramics, polymers, metals and glass as well as detailed instructions on the execution of each of the demonstrations, scientific background on the principle or property shown and instructions on how to replace items from the kit as they are used. The materials would be either reusable or easy to replace locally, and the kit would be small – perhaps in a portable case that one person could carry. And finally, the kit would be as inexpensive as possible.

The first order of business to get this idea started was to decide what demonstrations the kit would contain. The PCSA delegates started to ask students from different materials science programs what outreach demonstrations they did and which ones were the most effective. The submissions were sorted by the property or principle that was demonstrated and the feasibility of including it in the kit. Eventually, the list was narrowed down to 10 demonstrations that would teach different principles. The concepts that the PCSA delegates decided would be represented in the kits are strength improvement of tempered glass; ability of refractory ceramics to protect against heat; annealing of metals to remove dislocations; superconducting ceramics; piezoelectricity and applications; effect of material composition on properties; how glass fibers are made; how microstructure affects mechanical properties; how temperature affects materials; and shape memory effect.

For each of the demonstrations, a list was compiled of what materials would be needed, and the hunt began to find the best place to purchase the items. The next step in implementing the plan was to find funding. With the generous help of The American Ceramic Society, the National Institute of Ceramic Engineers and several other donors, the PCSA's efforts have come to fruition. A prototype of the demo kit has been successfully assembled and several more will be assembled soon. These initial demo kits will be distributed to selected schools that are chosen from an application process. The schools will use the kits for a trial period and provide feedback to the PCSA, who will make adjustments to the kit if necessary. Following the adjustment stage, the demo kits will be available for student groups or individuals to purchase at the cost of the materials.

One demonstration that will be included in the kit will demonstrate how safety glass, which is used in car windows, has improved mechanical properties over standard sheet glass. Sheet of tempered glass and standard glass are covered in contact paper, which keeps the pieces intact after the glass is broken. For the purpose of the demonstration, the glass sheets can be suspended between two blocks of wood. Students can stand on the safety glass and will see that it doesn't break. Next, a steel ball can be dropped onto both sheets of glass, and the students will see that the safety glass survives, while the unstrengthened glass breaks (Figure 1).

The outreach volunteers can explain the concept of compression and tension layers and how this leads to increased strength. Finally, tile nippers can be used to make a cut in one corner of the safety glass sheet and the entire piece will break into small pieces. Once again, the idea of tension and compression can be used to explain the difference in how the pieces broke. Students from Missouri University of Science and Technology performed this demonstration to a group of other university students and faculty at the Materials Science and Technology conference (Figure 2).

These kits will be effective in helping with outreach efforts and can be enjoyed by students of all ages. The demo kits provide the opportunity to garner interest in science and engineering, introduce students and teachers to the field of materials science and help with university recruitment efforts. For more information about the demonstration kits, contact Cory Bomberger, ACerS PCSA chair, at cory.bomberger@gmail.com or by phone at 570-447-3469.

About the author

Jaime George received her B.S. in biomedical materials engineering science from the Kazuo Inamori School of Engineering at Alfred University. She is currently a second year Ph.D. student at Missouri S&T, where she works on bioactive borate glasses. She has been active in Material Advantage and Keramos since 2006 and is serving her third year as a PCSA delegate. ■

'The times they are a-changing,' and Olivia Graeve is helping to make it happen

By James P. Kelly

I have been attending Alfred University as a ceramic engineering student off and on from 2002 until now, and the atmosphere has been excitingly dynamic. I have fond memories of many professors, now either retired or in positions elsewhere, who have touched the lives of many current and soon-to-be professionals. While it is nice to think about good memories of past professors, it also is important to look forward. All of the faculty members who have left the school of engineering have opened a door for fresh minds and new ideas to enter. Alfred University has provided new opportunities by hiring new faculty, including the addition of associate professor Olivia Graeve.

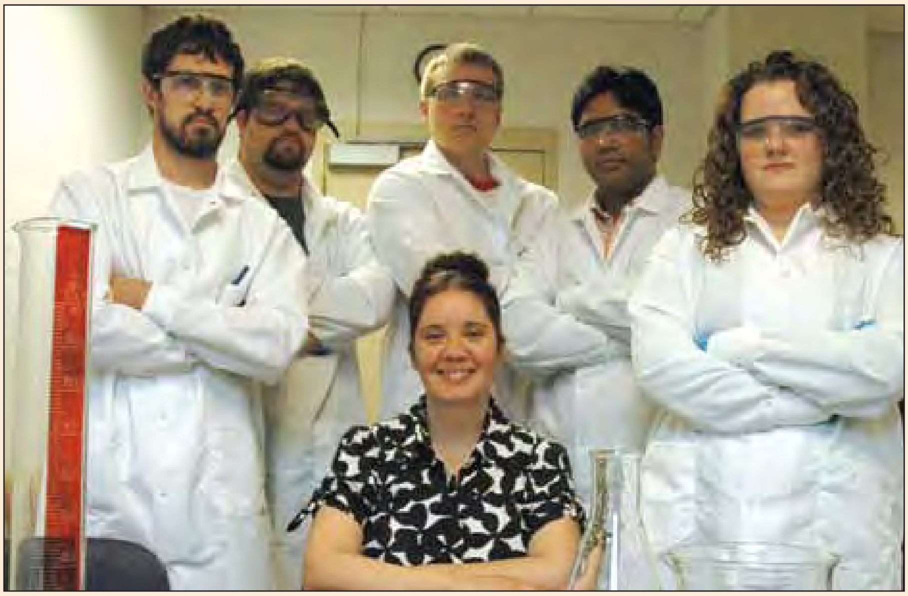
As a student, I embrace the changes that are being made at Alfred University, and I am excited about the new possibilities that have been emerging. I was very enthused to hear that Graeve was forming the Nanomaterials Processing Laboratory at Alfred in 2008. While I was finishing my M.S. degree, I approached Graeve and discussed my future goals with her. Since then she has been helping me facilitate these goals.

I have taken one of my graduate courses with Graeve and learned not only a few things about electron microscopy, but also that she is a competent teacher. She is prepared for each class, organized, provides adequate information with practical examples and makes students work hard (a recipe for a great academic environment).

I have been excited about Graeve's research from the time she interviewed for a faculty position at Alfred. I had been developing my interest in ceramic processing and in non-oxide ceramics. I wanted to take my interests further and study the processing of nano-non-oxides, and Graeve had the perfect project for me to accomplish this.

The Nanomaterials Processing Laboratory focuses on the design and fundamental understanding of synthesis and sintering processes that have the potential for delivering nanostructured materials. Graeve's research group has experience with nanopowder synthesis techniques, including reverse micelle synthesis, combustion synthesis, solvothermal synthesis, precipitation methods, high-energy milling and variations of these techniques to synthesize materials such as lutetium oxyorthosilicate, alumina, barium aluminum silicate, hydroxyapatite, carbides, borides, zirconia, titania, zinc oxide, metals and amorphous metal alloys. Graeve also is interested in spark plasma sintering to consolidate these materials.

I highly respect Graeve's efforts as an advisor. She is intimately involved in her projects. As a group, we meet on a weekly basis to discuss research progress. She also encourages regular meetings with our research committees. I think all of this is to be expected from an advisor, but it is going beyond this that makes working with Graeve a unique and pleasurable experience for me.



Left to right (standing): James Kelly, Brandon Williams, Mike Saterlie, Raghunath Kanakala, Kate Glass, and Olivia Graeve (seated).

More than anything else, I appreciate the opportunities that Graeve has created for me and the encouragement she has given me to pursue research beyond my thesis work. I lead multiple projects and assist with other projects (teamwork). I have the opportunity to participate in writing a book chapter with her and to submit a patent application. She has given me many presentation opportunities directed at several audiences, and she encourages me to apply for and participate in unique opportunities. Graeve, along with her colleagues, is bringing a new and refreshing perspective to Alfred University, and I am glad to be a part of it.

About the author

James P. Kelly received his B.S. and M.S. degrees in ceramic engineering from Alfred University, graduating cum laude and with institutional honors. He is currently working on his Ph.D. in ceramic engineering at Alfred University. He is a member of Material Advantage, Materials Research Society, Keramos Ceramic Engineering Fraternity, Tau Beta Pi National Honor Society and the Honor Society of Phi Kappa Phi. His current research interests include the synthesis, processing, consolidation and characterization of non-oxide ceramics and composites. ■

A scientific adventure at Boise State

By Steven Letourneau

I first met Rick Ubic when I joined the Boise State Center for Materials Characterization in 2007, shortly after he arrived in Boise from the University of London. With an extensive background in electron microscopy, Ubic has helped shape my future in crystallography and crystal chemistry using the transmission electron microscope.

Before pursuing my undergraduate degree, I had worked for three years in the semiconductor industry in a TEM analysis laboratory . Having a TEM background made me a great candidate to work with Ubic's research on structure–property relationships in dielectric materials. I first started working on a project investigating the influence of calcium on Sr_2MgTeO_6 doubled perovskites in collaboration with Ubic's colleagues in India and Germany. My introduction to this field was exciting because of the complex problem solving needed to determine crystal symmetry. Electron diffraction is an especially powerful tool for investigating oxygen octahedral tilt systems in complex perovskites and can be combined with other types of diffraction techniques to solve for a complete atomic model.


(Credit: Steven Letourneau)

Rick Ubic, left, with Letourneau.

This work improved my understanding of TEM analysis, and my knowledge of X-ray and neutron diffraction techniques. Determining crystal structures of such complex perovskites can be challenging because of the potential for cation ordering, which is a function of differences in ionic size and charge, cation displacements, and octahedral tilting – all of which are functions of composition.

Following a methodical approach to analysis under Ubic's guidance has given me a better understanding of crystal systems as well as an epistemological process for tackling all research and determining what can and cannot be proven unambiguously. Coauthoring two papers with him also has given me great exposure to publication writing as a student and has helped me generally in my course assignments.

Ubic's influence in the college has greatly added to the availability and use of all electron microscopy tools. He created and still teaches the introduction and advanced TEM classes, encouraging graduate and undergraduate students to understand and use the TEM. He also has been an integral part in the development of the BSCMC. In the past four years he has acquired $654,000 in funding for the Center in sample preparation instruments and analytical tools as well as external funding for two postdoctoral research associates and several graduate and undergraduate students. His relationship with students is very open, and he is always happy to chat with them about topics academic and social in nature. His openness is most apparent when he meets with students for class questions. From personal experience, I have always found him to be very helpful when answering questions, because he helps each student through a problem until they fully understand the process for obtaining a solution.

About the author

Steven Letourneau grew up in Madison, Wisconsin, where his interest in science began. After obtaining an associate's degree in electron microscopy from a Madison-area technical college, he worked at Micron Technology Inc., a semiconductor company based in Boise, Idaho. He left to pursue his B.S. in materials science and engineering at Boise State University, where he was employed in the Boise State Center for Materials Characterization. He plans to start his graduate studies at the University of Illinois at Urbana-Champaign this fall. ■

Penn State professor inspires students

By Andrew Paul

As a young student in pursuit of a career in materials science, my first priority was to delve into the research that is propelling the field forward. The numerous opportunities at Penn State University made the decision of which group to join difficult, but in the end, I decided to get involved with a new professor on campus, Roman Engel-Herbert.

Engel-Herbert began pursuing a degree in physics at Friedrich-Schiller University in Jena, Germany. He completed his graduate studies at the Paul-Drude Institute for Solid State Electronics and later received his Ph.D. in semiconductor physics from Humboldt University in Berlin. After being titled visiting scientist at the University of Waterloo in Canada and doing postdoctoral work at the University of California Santa Barbara, Engel-Herbert ventured to Penn State to advance his career and, most passionately, his research.

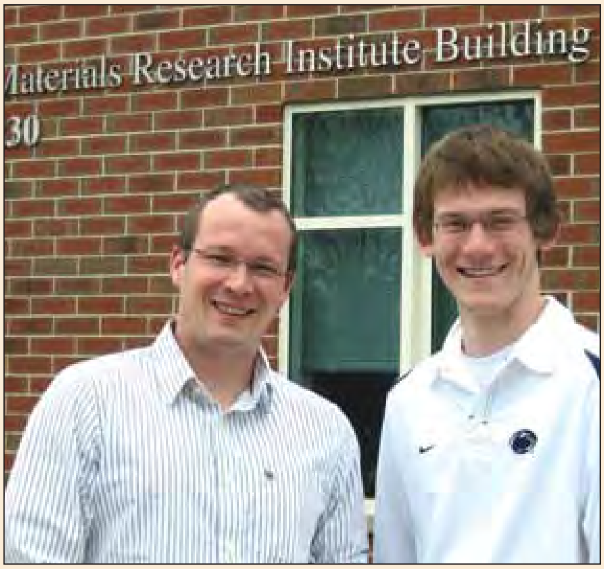
Engel-Herbert's current research goal is to improve the quality of complex oxide thin films. Synthesizing complex oxides requires a level of quality comparable with the production of silicon. The research efforts undertaken by material scientists in the electronic industry and academia have driven silicon to its intrinsic property limits, and oxide thin films may be the next alternative. Because the stoichiometry of oxide thin films has been improved and their defect concentrations reduced, they have become a viable option. However, many techniques used to make these oxide thin films are highly energetic and result in too many defects to make practical use of the material. Engel-Herbert's method to reduce the point defect concentrations combines the applications of molecular beam epitaxy with metal-organic chemical vapor deposition. These low-energy deposition techniques show potential and have led to a more controlled growth of oxide thin films.

The instruments necessary for this research are undoubtedly exciting, but they have not arrived yet! The construction on the new lab housing these precious tools will be completed in August. Now a new challenge comes barreling down onto our new professor at Penn State – organizing and assembling a new lab. Most students do not have the opportunity to be a part of the development of a new lab, and I am very privileged to be involved in this unique process. The organization and labor necessary to handle this daunting task is intense, and hopefully, I can relieve some stress that will fall on Engel-Herbert's shoulders.

In conjunction with this opportunity that Engel-Herbert has provided me, I also am taking his course in solid-state materials. This course focuses on solid structures and the manipulation of their electronic properties. This is the first class of its kind that I have taken, and it has raised many questions that retain my curiosity.

The class is a challenge for Engel-Herbert's students and for him as well. One of the biggest challenges he faces is teaching students with varying knowledge of the subject. Sophomores to seniors participate in the classroom, and engaging the entire class can prove difficult, especially when there is no previously established course material. After every class, students line up to ask questions ranging from the basics of the day's lecture to the potential outcomes of the material covered. When asked what rewards warranted the time put into teaching the course, he responded, "The progression of the students and their 'Aha!' moments discovering new information motivates me to teach."

I can see that his motivation also stems from his enthusiasm, which was first unveiled to me when I asked to get involved. Our first meeting lasted three hours! The dedication he had to teach me from the beginning amazed me. I never thought a professor would invest that much time into an undergrad, and I immediately knew why Penn State chose him for the job. The excitement he shares with his students attests to his passion in discovering new techniques and processes to share with the scientific community. He is an inspiration to his students, and hopefully one day, I can be as successful in sharing my experiences with those around me.



(Credit: Andrew Paul)

Paul, right, gets motivation from Engel-Herbert's enthusiasm.

About the author

Andrew Paul is a second year undergraduate student pursuing a B.S. in materials science and engineering at the Pennsylvania State University. His interest is in the field of ferromagnetic materials. ■

Thermodynamics professor takes a refreshing approach

By Kirsten Brookshire

Beginning a graduate program can be, and was certainly for me, a scary endeavor. A new level of academic performance is expected, and, in my case, another challenge was added because I chose a field very different from my undergraduate program. This left me with a background and academic foundation not perfectly suited to the new course work. Because of this, having outstanding professors to guide me and help me along the way was critical for my success. One particular professor, Bill Warnes, stands out in my academic career for his ability to engage students at all levels, maintain a fun class dynamic in even the most mundane and tiresome classes and continue to be current with the demands and learning styles of today's students.

At Oregon State University, many of the materials science courses are known as "slash" classes. This means that graduate and undergraduate students are placed in the same learning dynamic and must be challenged simultaneously, and yet separately, in every class period. For me, taking thermodynamics for the third time did not seem like an exciting addition to my already overloaded schedule for the term. With the prospect of sitting alongside undergraduates who would be seeing most of this material for the first time, thoughts of the never-ending two-hour lectures from my past flashed back to me. However, I was pleasantly surprised to find that this wouldn't be the case at all.

By the end of the first lecture, I was excited to see more. I already had learned new things and had been shown them in new ways. As I glanced around the room, I was surprised to see a classroom of fully engaged students across all academic levels. Warnes' ability to blend the foundation of thermodynamics with more challenging concepts and problems left few underwhelmed, or overwhelmed, and I was hooked.

Beyond a seamless ability to blend two levels of learning into one lecture period, making thermodynamics fun brought a new excitement to this course. Yes, I actually used thermodynamics and fun in the same sentence! I remember walking into that stuffy, dreary lecture hall in September, bright and early, for my very first graduate course. The Flanders and Swann song "First and Second Law" was playing in the background, already setting the tone for the rest of the quarter.

When I asked Bill how he managed to get students excited about thermodynamics, a course simply tossed off as a necessary evil by most engineering types, he replied, "I am always surprised to read in my teaching evaluations that many students have enjoyed the class. … I try to keep the tone light and inject some humor and be aware that, especially for undergraduates, my course is not the only course they are taking and is probably not even the most important to them."

This attitude toward teaching was refreshing, because many professors tend to feel their class is the only class worth anything at a school. By understanding that we all are busy and quite possibly not as excited about thermodynamics as he is, Warnes was able to focus on information we would be able to apply to our own research or academic pursuits.

Many professors who have been teaching as long as Warnes – since the Bronze Age, as he would put it – now seem out of touch. Many lose sight of the changing dynamic of the demands placed on current students and the new modes of learning that are most effective in today's academic environment. As he put it, "the average student has a very different set of pressures to deal with than was common when I was a student. For instance, I see many more students with families of their own and ones working part-time." Understanding new pressures and not teaching despite them, but rather understanding and working with them, ensures all students will take away knowledge from the course – not merely a passing grade. He is also cognizant of the new technologies available as lecture enhancements in the classroom. He incorporates various levels of multimedia, from simple PowerPoint images and plots to in-class demonstrations of Mathematica as a problem-solving tool. However, Warnes has not overdone it. There is much to be said about chalkboard and chalk lecturing. This slower method of teaching has helped me to excel in his courses. I find myself getting lost in classes where the professors have gone too far into the world of technology, flashing slide after slide of equations and notes without giving me a moment to absorb and reflect on the new information. I feel Warnes is aware of all learning styles (visual, auditory and hands-on), and his lectures reflect his desire to engage across all of these.

Brookshire, left, and Warnes.

I am happy to have had the opportunity to sit in his classroom and to be taught, in my opinion, by one of the best. We can learn a great deal from those who walked before us. When asked what advice he would give me as a student and future educator he said, "To know that the best way to learn anything is to teach it. Your graduate degree has taught you how to think and how to learn. Don't be afraid to make mistakes (and admit your mistakes). The biggest satisfaction comes from recognizing that the light bulb has turned on for a student, and knowing that you at least showed them where the switch was hiding in the dark."

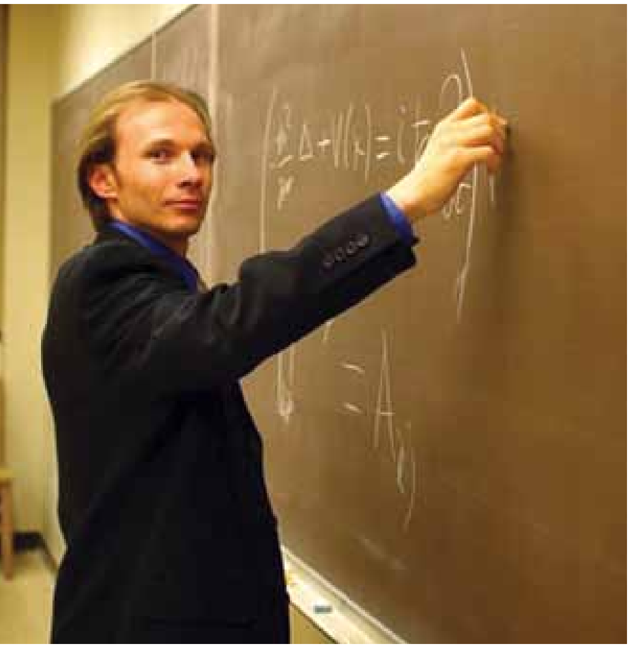
About the author

Kirsten Brookshire is a graduate student at Oregon State University in the materials science and engineering program. Her research is in unipolar fatigue of PZT on highly (100) textured LNO seed layers. She has a B.A. in physics from Willamette University in Salem, Oregon. ■

International student perspective: Life and higher education in Ukraine

By Pavlo Rudenko

I still remember my first few steps on American soil and the first awkward situation that happened involving a difference in culture. Right after landing at Seattle International Airport, I was preparing to take part in the final ritual of any long flight and went about checking several stalls in the restroom. I noticed that they all had unusually high water levels, making me think that they might all be broken. At some point in my restroom reconnaissance, I came to the realization that the normal toilet water levels in the United States were simply higher than in Ukraine. This is just one example of the many innocuous differences that we do not expect when we move somewhere new.



(Credit: Pavlo Rudenko)

Rudenko

Educational systems also reflect the culture of a place (although the comparison to toilet water levels is not meant to reflect my thoughts on education). And now, more than five years later, being in my "all-but-dissertation" status, it is much easier to compare the two educational systems and to provide insight to the various challenges that such a transition might impose on some international students. It also might help to better explain some cultural differences.

While undergraduate school in Ukraine has similarities to the U.S. undergraduate system, it has its share of differences as well. The Ukrainian higher education system is greatly inherited from the former Soviet Union and consists of separate student preparation programs. The class schedules are absolutely fixed inside of the program, and if students graduate with a certain specialization, they have taken all the classes listed for that specialization. So, unlike most American higher education programs, students never have to choose which classes to take, or wonder whether they have all the classes and credits needed to graduate. Additionally, in Ukraine, there are only two types of classes: lectures and practical classes that include problem solving sessions and laboratory courses.

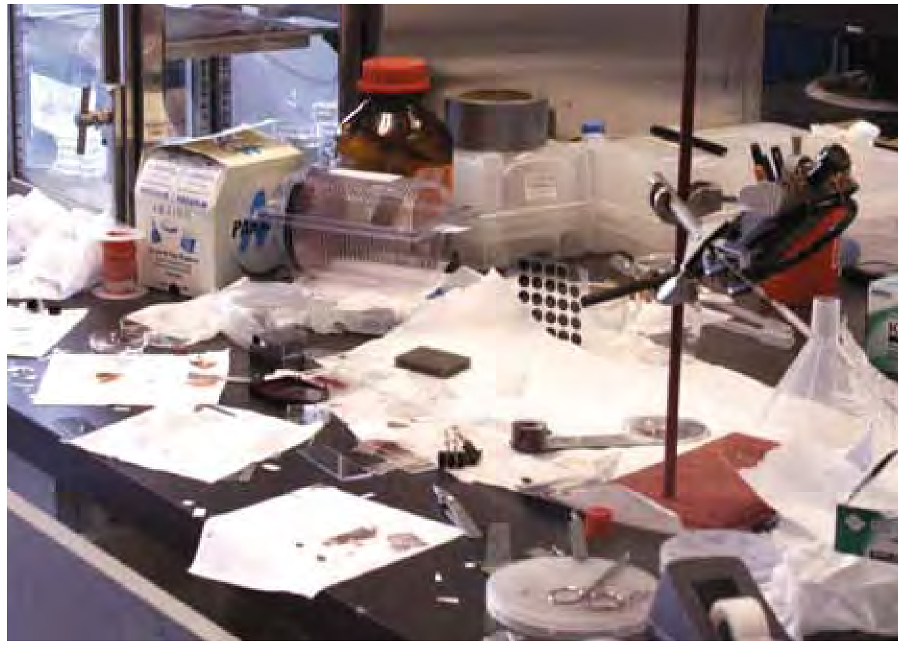
For the first few years in a program in Ukraine, students take core lecture classes from their department along with many other students with similar specializations. There are usually around 100–200 people in the same classroom. After those first two years, students have to pick a specialization. Following that decision, the lecture class size reduces substantially to groups of around 20 people who are all working on the same specialization.

Because classes are the same for everybody, scheduling is very simple. Every day there are four "pairs." A pair consists of two 45-minute classes (5 minute shorter than classes in the U.S.). There is a 5-minute break in between the two classes in a pair, followed by a 15-minute break before the next pair begins. Every working day there are two pairs in the morning and two after an hour-long lunch break. Lectures are usually in the morning, with virtually no interaction with other students. Lectures have no graded assignments and the grade is defined only at final examination, which is at the end of the term. In a typical examination, students enter the examination room and pull a "ticket," on which there are two to four questions or problems. Students have some time to prepare their answer, and then they sit down with their lecturer, one-on-one, and present their solution or derive some equations. Typically, this is followed by additional questions from the lecturer. At the end of this test, students receive their grade for the whole semester.

Practical classes are always conducted in smaller groups and have a very high involvement level because students solve problems, and answer questions and present or work out solutions in front of the class. This method allows students to know how well they are performing, and exactly where they stand compared with other students. This is quite different from the U.S., where the grades or performance level of others is confidential. Practical classes also have graded homework or assignments, but these aren't usually turned in until the end of the term. The assignments are pass/fail, and a passing grade permits the student to participate in the final examination.

One other big difference is that in Ukraine, all males have to serve in the military. However, if accepted to a university, male students qualify for a military profession with the title of "reserve officer," provided that they agree to dedicate one weekday every week and two summer breaks to military training. Usually, the military training starts the third year (after choosing the program specialization). On the military training weekday, there are still four pairs, but they are about whichever military profession the student chooses. As a reserve officer, it is presumed that the topics learned are secret information, so all notes must be kept in a separate case with a big white stripe on it, and they can never leave the military department. For two summers, students live in the barracks on a military base for three months of boot camp, where they get hands-on military experience. Daily drills are conducted to learn about the equipment and organization. If a student passes military training, he is then able to get an officer rank along with his college diploma. However, the testing and certification is completely separate from the university, and there is a different acceptance rate. If men do not pass military training, they will have to serve one and a half years as a private in the military. Achieving reserve officer status is competitive and rewarding.

In the fourth and final academic year, students do their diploma thesis work with an advisor chosen by them, which is followed by an oral defense in front of peers and professors. The grade is then requested from a committee by the advisor. Typically, after graduation, the best students receive job placement and some receive offers to get a graduate degree. Graduate degrees in Ukraine do not have any classes associated with them and consist only of original research in the student's chosen topic.


(Credit: Peter Wray, ACerS)

There is an exceptionally high level of interaction and openness between the students within their specialization programs in Ukraine. By the time a student graduates, they get to know the others in their cohort very well, and many remain friends forever. It happened with me, and when my close friend suggested I apply to study in the U.S., I agreed to give it a fair chance, but that is another story.

About the author

Pavlo Rudenko is a Ph.D. candidate in the Materials Science and Engineering department at Washington State University. He currently is working on solid nanoparticle-based, environmentally friendly additives to lubricating oils. After graduation he plans to participate in a technology-based start-up. ■

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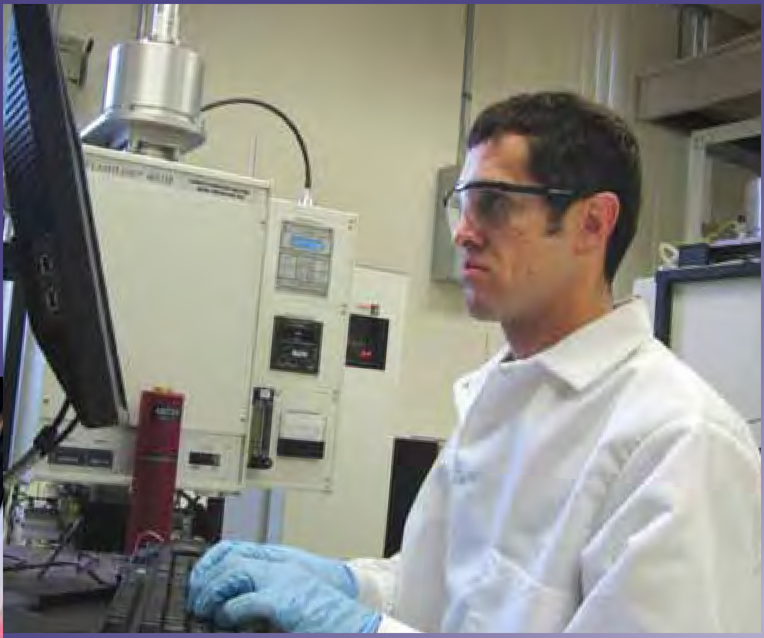

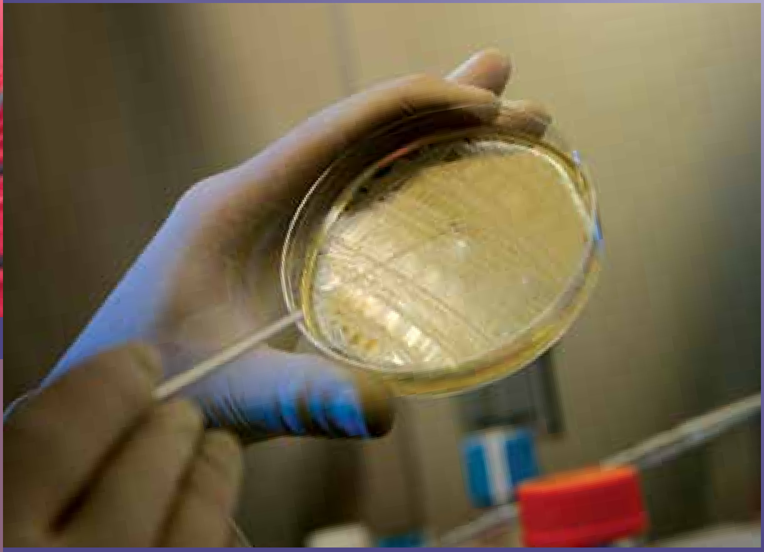

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Advice from a departing graduate student

By Stan Dittrick

The first thing that comes to mind about being a graduate student is how different it is from being an undergraduate student. The major differences between undergraduate school and graduate school are focus and independence.

In my experience, it was a little overwhelming at first to find my focus, there are few guidelines. I ended up joining a group working on orthopedic implants and decided to anodize tantalum to form tantalum pentoxide in the form of nanotubes. I have had adhesion problems with this approach. Figure 1 shows the top layer of tantalum pentoxide nanotubes coming apart like string cheese. My thesis is titled "Understanding Wear Behavior of CoCrMo Coatings on Ti_6Al_4V and Tantalum Coating on Titanium for Load-Bearing Implants."

Most graduate classes are more independent and have less busy work than undergraduate classes. However, they do not have less work overall. Often there is more control over what the student wishes to work on, which allows for greater focus on the student's interests. At the undergraduate level, professors have many students and a much more general curriculum. At the graduate level, they have just a few students or maybe only one. Professors spend more time hand crafting the graduate student's education to fit his or her goals and research. Class requirements are more flexible, but students shouldn't expect to have much of a social life in graduate school. I always had more to do than I could possibly finish.

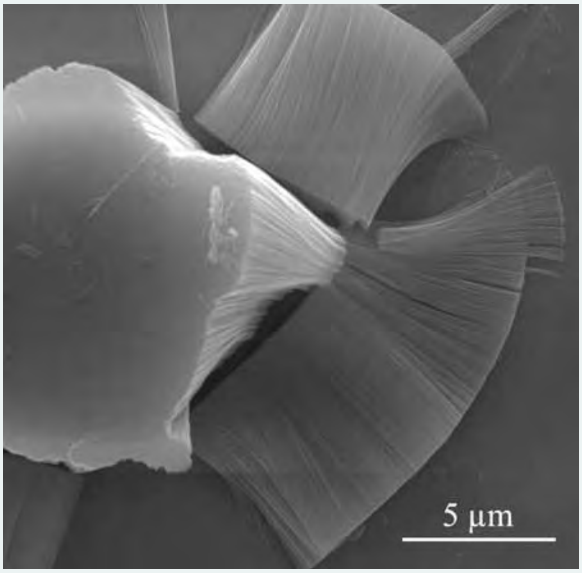


Fig. 1 Top layer of tantalum pentoxide nanotubes is coming apart like string cheese.

Research is an intimate part of graduate life. It is important for students to find an advisor who is interested in the same things and who allows them to work on related research, but it is essential to find one they can work well with. A good advisor for one person may not be a good advisor for another. The only way to find out is to talk with people. While it is important to interview advisors, talking to his or her graduate students may be more informative when learning about the advisor's style. Graduate students who work the hardest are more likely to be successful, so just because students are overworked does not necessarily mean they have a bad advisor. When searching for an advisor, keep in mind how self-motivated you are, and determine if you need someone to push you every step of the way or stand back and let you work. I chose my advisor, Amit Bandyopadhyay, after taking one of his classes. He was available when I needed him, but encouraged me to be independent as well.

Research proceeds quickly some of the time and slowly most of the time. Usually, the obstacles are broken equipment and waiting for parts or supplies. Because it is impossible to anticipate most of these problems, the best solution is to work on multiple projects at once so there is always something to do when obstacles occur. To keep a consistent research schedule, I tried to set aside time for research even if I had other school deadlines to meet. If I did want to use my regularly scheduled research time to work on other tasks, I would make up the time later. This kept me from putting off research unnecessarily.

An important part of staying on track with research is having regular meetings with your advisor. The way to get the most out of meetings with your advisor is to be prepared. Have recent data and results with you even if that is not necessarily the reason for the meeting. That way you can get feedback on what you are working on and won't have to come back later for another meeting.

A major goal of graduate school is to write a thesis. Don't take this lightly. Get serious about your thesis research right away. The sooner you start, the more you can learn, the better the project is and the more impressive your accomplishments will be out of graduate school.

You can't work on your research all day every day, and outside interests provide some balance to life. It is easy to find clubs for many different interests on campus. These clubs are always looking for new members. While they take up valuable time, they help you keep your sanity. I was part of the local chapter of Material Advantage and enjoyed a number of their functions. In addition to having fun, I was able to make some business contacts with the regional group, and they paid my way to Washington, D.C., to speak with my congressional representatives.

In graduate school, I have learned how to take the initiative and be successful. I have developed good contacts for the future, and my fellow group members and I have learned how to get funding to pursue our goals. There are always setbacks, but with the right advisor and some determination, those obstacles can be overcome.

About the author

Stan Dittrick received his B.S. in chemistry from Western Washington University. He is a departing graduate student in the materials science and engineering department at Washington State University. He is currently looking for work in the field of materials science. ■

Research and teaching assistantship experiences: Two perspectives

Teaching and research assistant positions (TA/RA) can be fun and rewarding or just plain terrible. The key factors determining the quality of the position are the student and the professor. Other factors, such as the time required for grading papers, class preparation, lab setup/cleanup and actual teaching, can be unwanted tasks, or they can provide the background and experience to prepare a student for a career in research, industry or academia.

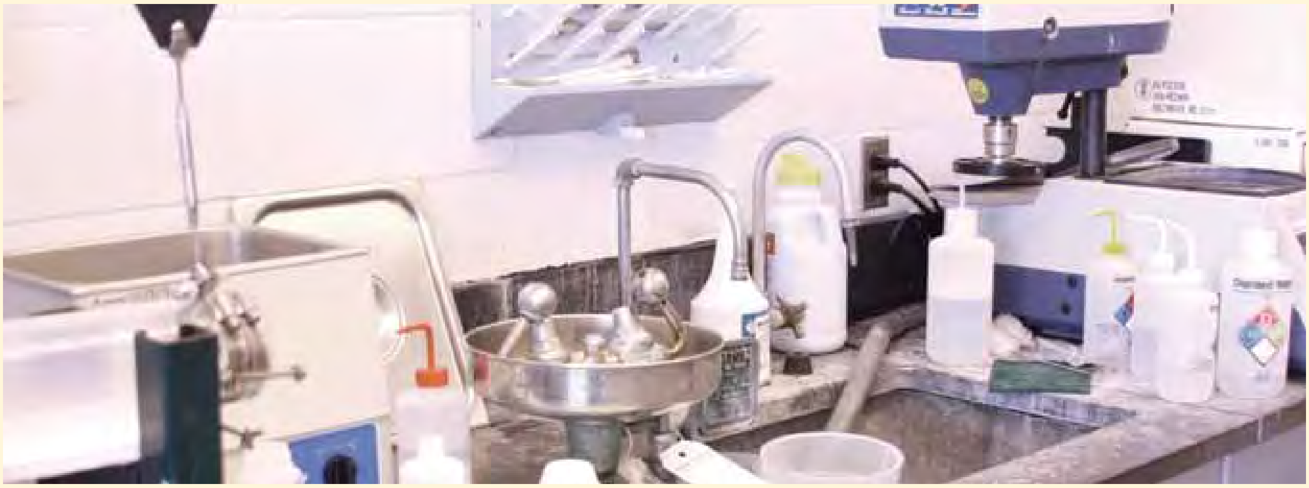
William Garrett, Colorado School of Mines

Will Garrett, a Ph.D. student in materials science, says he was quite fortunate to be a foundry TA at the Colorado School of Mines. "Since most of my research happens in the foundry, being a foundry TA has not put too many inconvenient constraints on my time. The preparation for teaching the foundry course section on die casting helped me learn the basic science behind die casting and is closely related to my research. Thankfully I haven't been cursed with a TA assignment where I need to grade papers or in a course unrelated to my research." ■

Anonymous, Colorado School of Mines

Another materials science graduate student at the Colorado School of Mines (who wishes to remain unnamed) has not had such a positive TA experience. His position was outside of his field and involved a lot of paper grading: "My TA assignments over the past few years have been primarily with classes and topics that have little bearing toward my research. In fact, what is supposed to be a three-hour assignment has often turned into a 10–15 hour per week commitment. I have spent a lot of time teaching topics without the solid knowledge base needed to be successful. This is part of graduate school – not all of the TA positions are going to fit the interests and research subjects of the available graduate students."

Being a TA is a part of life for most graduate students. Your experience is bound to titillate and frustrate and hopefully provide some skills and knowledge to further your career. Take ownership and speak with the professors and department personnel to ensure you get an assignment that fulfills your needs. ■



(Credit: Peter Wray, ACerS)

Development of metal oxide gas sensor arrays for detection of off-gases in steel industry

By Travis Busbee

A research team of undergraduate students at The Ohio State University is working on a project developing thick-film metal oxide sensor arrays for detecting off-gases in the iron and steel industry. The team consists of five undergraduate students (Travis Busbee, Daniel Chmielewski, Mike Ramsdell, Steve Allen and Beth Yoak) is directed by graduate student Mark Andio and advised by Patricia Morris and Sheikh Akbar from the materials science and engineering department. The project was selected from the Ferrous Metallurgy Education Today Design Grant Program, which is sponsored by the Association for Iron and Steel Technology. The goal of this program is to encourage more students to choose materials-science-related fields, and this project has a focus on ceramic research for a metallurgical application.

(Credit: Travis Busbee)

Group members (left to right): Dan Chmielewski, Mike Ramsdell, Steve Allen, and Travis Busbee (Beth Yoak not pictured).

An array of chemiresistive gas sensors based on thick-film metal oxides is being developed for sensing reducing gases, such as carbon monoxide, which are abundant in the off-gas of steelmaking furnaces. The sensors consist of an alumina substrate with interdigitated platinum electrodes. The metal oxide particles provide the sensing film between the electrodes. The metal oxides initially being studied include SnO_2, NiO, ZnO, WO_3 and Nb-doped TiO_2.

Metal-oxides printed on alumina sensor substrates with integrated platinum electrodes. Left to right: WO_3, SnO_2, and Nb-doped TiO_2.

Some of the important research being conducted in this project includes investigation of the metal oxide film microstructure for sensor performance and addition of glass frit to the oxide film to improve adhesion properties. The microstructure of the metal oxide film is important for the sensor response, and an open microstructure is beneficial. Screen printing is being used for the metal oxide deposition onto the sensor substrates to aid in the formation of open porosity. To accomplish this, the metal oxide powders were incorporated into a paste that was optimized for compatibility with the screen printer. Solids loading and viscosity of the oxide-laden pastes were adjusted to produce a thick film. The sensors then were fired at the optimal temperature for each material. One obstacle was balancing the firing temperature, glass frit addition and paste composition to sufficiently adhere the film to the substrate without compromising the performance of the sensor.

Characterization of the films was performed to investigate the microstructure of the metal oxide films. X-ray diffraction was used to verify the phase and composition of the films. Scanning electron microscopy also was used to analyze the porosity, uniformity, and particle size of the films.

Currently, we are at the stage of the project in which the sensors will be tested to analyze gases. The resistance of the sensor will be measured as the gas concentrations and furnace temperature are varied in order to obtain information about the sensor sensitivity, response/recovery time and saturation point. The goal is to verify that we have successfully created an array of sensors that will stand up to the high-temperature environment while providing accurate reliable information about the concentrations of the gases we intend to measure.

About the author

Travis Busbee is a third-year undergraduate student at The Ohio State University. He worked at Wright-Patterson Air Force Base for two years in the cell development and engineering group under Morley Stone. He recently received the SMART fellowship through the Department of Defense to continue this research after graduation. ■

Die-castable ceramic-reinforced metal-matrix composites

By William Garrett

Self-propagating high-temperature synthesis, usually a solid-state combustion process, can be used to produce a wide variety of ceramics, intermetallics and composite materials.[1] I have been using this process to make ceramic particulate reinforced aluminum composite materials for commercial die casting processes From a materials and processing perspective, this research is capable of producing recyclable, lightweight, net-shape composite materials on an industrial scale that competes with cast iron for mechanical properties. The SHS method I use to produce these materials can be controlled to produce ceramic phases with narrow particle sizes and specific stoichiometries for many reinforcing phases.

(Credit: William Garrett)

Garrett is working on creating manufacturing processes that incorporate SHS approaches.

Often, SHS materials are expensive, or the final product contains unwanted porosity, but our research group has found that aluminum–titanium carbide composites made by the SHS process can be cost competitive in transportation applications where a lightweight component can pay for itself in fuel savings. My research is focused on the manufacturing process and mechanical properties of these composites, but other members of the research group are looking for lower cost precursor materials than what I am using. My combustion synthesis system reacts titanium and carbon powders to reinforce the aluminum with titanium carbide, but it is possible to reduce the cost even further with reaction systems that use titanium oxide instead of titanium metal.

As a method, SHS is a useful tool for making ceramic and composite materials. With manufacturing technologies and capacity moving overseas, it is important to support research that stands to give the North American die-casting industry a technical edge and advance the state-of-the-art of underutilized technologies, such as SHS.

Some of Garrett's work is at VForge Inc. in Denver, Colo, where induction heating is used to reheat the 55vol% TiC/45vol% Al composite cylinders to 1150°C for the die casting process.

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About the author

William Garrett is currently a Ph.D. student in materials science at the Colorado School of Mines in Golden, Colorado. He earned B.S. degrees in materials science and engineering and mechanical engineering from Washington State University in Pullman, Washington. Before beginning graduate school at Mines, he worked as a research scientist at Powdermet Inc., Euclid, Ohio, developing metal injection molding processes for rhenium alloys, MOCVD processes for refractory metals, cermet thermal spray materials and preceramic polymer-derived composite materials. At the Colorado School of Mines, he works with Professors John Moore and Michael Kaufman on self-propagating high-temperature synthesis and metal-matrix composite materials processing. He expects to graduate this fall. ■

Nonmetal anion doping of anatase

By Victoria Knox

TiO_2, in the form of anatase, is the most widely studied ceramic photocatalyst that also has been commercialized into a product. TiO_2 is relatively inexpensive and abundant. TiO_2 is an oxide semiconductor, which allows for alterations to the defect chemistry. This tends to give a boost to its properties. The reason for the success of TiO_2 relates to the band gap. This is the amount of energy that must be supplied to the material to boost an electron from the valence band of a lower energy across the forbidden band gap to an empty conduction band of higher energy, which allows the electron to conduct electricity. The value for the band gap of TiO_2 is 3.2 electron volts, but it can be lowered into the visible region by doping with nonmetal anions. Currently, much of the work with TiO_2 has been centered on the altering of the defect chemistry of the material to enhance the band gap.

Doping of TiO_2 with nonmetal anions, such as boron, carbon, nitrogen, fluorine and sulfur, to shift the photocatalytic activity of the material into the visible region has been successful. However, doping with nitrogen has been the most effective nonmetal explored. One study found the band gap was reduced by 0.72 electron volts when doping anatase with nitrogen. In the same study, the nitrogen-doped sample exhibited complete methylene blue degradation after 2 hours. This compares well with a commercial standard that completely degrades methylene blue between 1 and 1.5 h. Studies have explored reduction with NH_3, oxidation with TiN, reaction with urea mixtures and various sol–gel synthesis methods. An interesting effect of nonmetal anion doping in anatase is that the sample is white in its parent form and turns yellow upon doping, as shown in Figure 1. Figure 2 shows the anatase crystal structure.

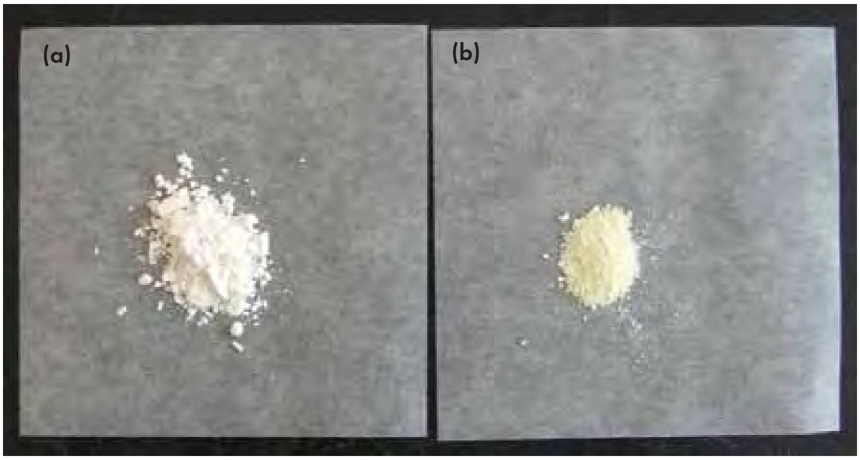
In general, the increase in photocatalytic activity was attributed to a decrease in the size of the band gap of the material through a hybridization of N 2*p* states with O 2*p* states to make a mid-gap energy level just above the O 2*p* valence band maximum. However, it recently has been found that this also could be attributed to occupied states above the N 2*p* valence band. The electronic structure of this material is still highly debated among researchers and is being explored using X-ray photoelectron spectroscopy.

(Credit: Victoria Knox)

Knox

About the author

Victoria Knox completed a B.S. in ceramics engineering at Alfred University and is currently a third-year graduate student at Alfred's Inamori School of Engineering, pursuing a Ph.D. in ceramic engineering. She is a PCSA delegate. Knox's research is concentrated around Aurivillius photocatalysts. ■



(Credit: Victoria Knox)

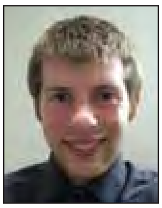
Fig. 1 (a) Anatase in the parent form. (b) Nitrogen treated anatase.

(Credit: Victoria Knox)

Fig. 2 Crystal structure of anatase.

Percolated ceramic composites: Characterization and optimization

By Tim Pruyn



The use of ceramic and glass composites with percolated segregated microstructures of conductive filler have numerous industrial, electronic and military potential applications, such as electromagnetic interference shielding. A problem with adding rigid filler to a ceramic powder compact is that it can often prevent full sintering from occurring.[1] This will degrade many properties of the ceramic and prevent full use of the filler properties.

Our focus is to optimize the green state of ceramic compacts by minimizing the amount of conductive filler needed for percolation and having the composite as close to the percolation threshold as possible before sintering. We evaluate the electrical response of ceramic compacts during dry pressing as a function of applied pressure. The effect of the particle size of the matrix and the size ratios between the matrix and filler particles also are being evaluated.

Semiconductive SiC and insulating Al_2O_3 and borosilicate glass powders have been used for the experiments. To determine the influence of porosity in the ceramic powder compacts, a custom-made die with an insulating outer sleeve was used to conduct dc and ac measurements. A schematic of this die is shown in Figure 1(a). Measurements were performed in-situ as a function of loading and unloading compaction pressure. Direct-current measurements can detect only the combined response from the powders and the porosity. However, from the SiC impedance spectroscopy data, at least two semicircles are observed in the complex impedance plot that allows separation of the two processes.[2] One of these semicircles represents the bulk material property, and the other is likely due to the void space and interfaces. The measured resistances determined from impedance spectroscopy are shown in Figures 1(b) and 1(c). The values in Figure 1(b), show that the resistance is the same for each pressure, even though the overall density of the compact is different. Figure 1(c)shows that the resistance is highly dependent on the overall density of the powder compact. The admittance, modulus and permittivity also were examined and showed behavior highly dependent on these two processes. The impedance behavior of the insulating materials is more sensitive to the compacted microstructure and humidity, and it often displayed trends different from the semiconducting SiC compacted powder.

By understanding the processes that are occurring during powder compaction, a percolated network of filler in the composite can be developed at very low thresholds and

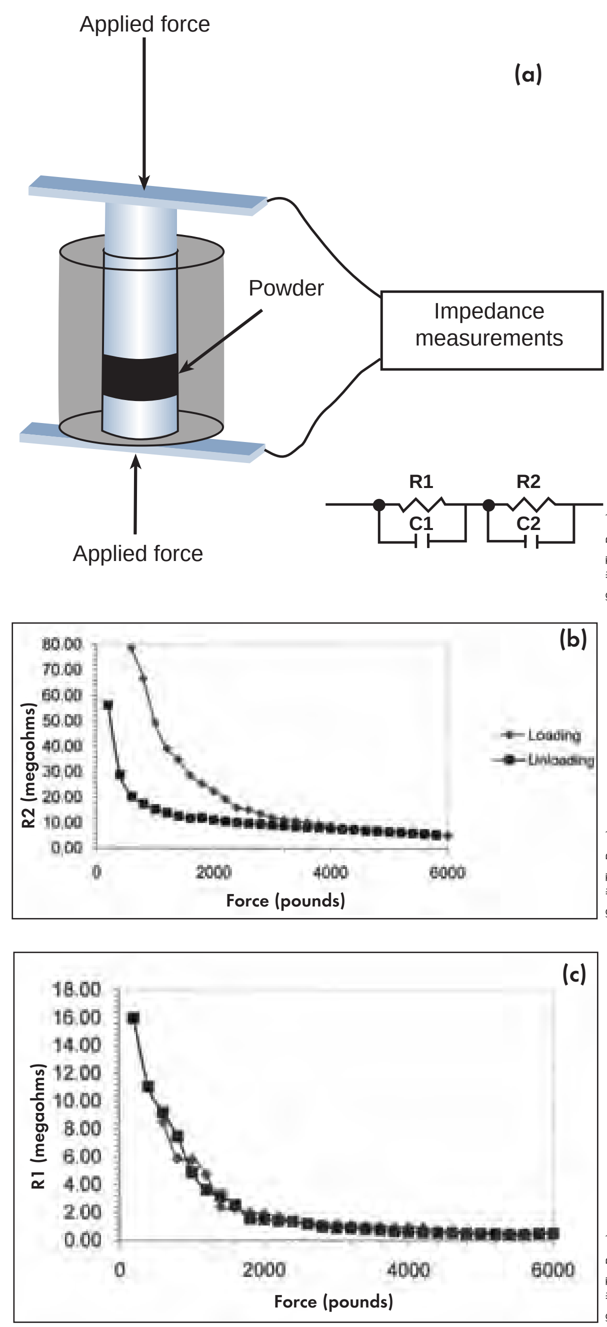


Fig. 1. (a) Schematic of insulating die for impedance measurements. (b) and (c) Measured resistance values obtained from impedance spectroscopy.

can optimize the green state and the final sintered composite.

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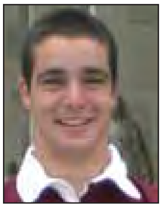
About the author

Timothy Pruyn completed a B.S. in ceramic engineering at Alfred University and is currently pursuing a Ph.D. at Georgia Institute of Technology in materials science and engineering. He is a PCSA officer and a SMART scholar. The focus of his research is the fabrication and characterization of electronic ceramic composites. ■

Better sound through cooperation

By Salem Maud



The glass-ceramics group in the Materials Science and Engineering Department at Virginia Tech is attempting to create a reproducible glass-ceramic saddle for use on guitars. Through a relationship with Hartford University and industry partner Taylor Guitars, the Virginia Tech group is studying the effects of grain size on critical acoustic properties of lithium disilicate. Under the direction of David Clark and Diane Folz, the goal for this project is to develop a relationship between heat treatments and grain size as well as a relationship between stiffness, hardness and grain size. Stiffness is important because it has a direct correlation with the dampening coefficient, a critical property in guitar saddles. Hardness, on the other hand, relates to the saddle endurance, because a harder saddle will have a longer lifetime.

Current industry standard materials used to make saddles include bone and Tusq, a polymer material. The problem with bone saddles is that they are a natural material, which always has variation. Polymers, on the other hand, are much more consistent, but they do not have a big enough damping coefficient and wear much more quickly. Glass-ceramics are a feasible alternative to current industry standards, because they offer the advantage of having similar mechanical properties to bone, while also being reproducible and easily mass produced.

Hartford University is helping with acoustic measurements in their anechoic chamber. These acoustic measurements are critical to the feasibility of the saddles, because they will determine whether the saddles can be used. Taylor Guitars has helped with consulting, letting the Virginia Tech group know what consumers want and what the industry would like to see. Some of the important factors include matching mechanical properties of currently used materials such as bone, the ability to create consistent samples and a lower cost basis.

The Virginia Tech team has incorporated these guidelines and created glass-ceramic saddles by developing a graphite mold, pouring lithium disilicate at 1500°C and then performing heat treatments of annealing, nucleation and crystallization. Annealing was performed at 480°C for at least 8 hours to remove thermal stresses, nucleation was done at 480°C, and crystallization was performed at 675°C.

Varying the grain size and measuring the changes in mechanical properties was approached from several angles. One approach was to vary the number of nuclei by changing the nucleation time. More nuclei should produce smaller grains and vice versa. However, we were unable to produce significant grain size variation with this method. Then we moved to a variation in crystallization time and were finally successful in identifying a relationship between grain size and crystallization.

The Virginia Tech group then identified changes in mechanical properties as a function of grain size. Also, more saddle samples were sent to Hartford University for additional acoustic testing. More work will be done to further optimize the project, including the possibility of microwave processing, creating recipes for specific consumer needs and improving aesthetic appearance.

About the author

Salem Maud is a senior in the Materials Science Department at Virginia Tech. After graduation, he plans to seek a commission in the Army and continue his studies in materials engineering. ■

Targeted amorphous calcium phosphosilicate nanoscale drug delivery carriers for pancreatic cancer treatment

By Stephen Weitzner

The utilization of nanotechnology can improve current drug delivery approaches, especially to cancers.[1] Patients diagnosed with advanced stage pancreatic cancer would greatly benefit from such technologies, because, in its later stages, treatment efficacy is greatly depressed and the chance of survival is decreased accordingly. The current survival rate for pancreatic cancer is extremely low, at 5.6 percent, compared with 26.0 percent for stomach cancer and 65.0 percent for colon and rectal cancer.[2] Pancreatic cancer has classically been treated with the antimetabolite 5-fluorouracil (5-FU). However, through prolonged exposure and repetitious treatment regiments, 5-FU can act as a systemic toxin and may lead to patient debilitation.[3] Needless to say, pancreatic cancer is an extremely challenging disease to treat for doctors and patients.

The toxic nature of 5-FU and the difficulty associated with drug delivery to the pancreas[4] serve as a major impetus for the design of an effective drug delivery system. Such a drug delivery system could operate by shielding 5-FU in targeted nanoscale drug delivery vehicles. Therefore, the amount of 5-FU delivered to pancreatic cancer cells could be increased and an increase in treatment efficacy might be observed. Drug encapsulation also presents the unique opportunity to potentially reduce the toxic effects of 5-FU and provide patients with a more effective and less debilitating treatment option.

Much of my work in the Adair group has been oriented toward the encapsulation of 5-FU in a novel calcium phosphosilicate nanoparticle (CPSNP) system developed at The Pennsylvania State University. The CPSNPs have been used to successfully encapsulate and deliver a variety of organic molecules,[5] and bioconjugation approaches have been developed to target pancreatic cancer cells with this system in in-vitro and in-vivo studies.[6] However, it is not known if the efficacy of pancreatic cancer treatments will increase by utilizing drug-carrying CPSNPs for delivery. Under the guidance of my supervising graduate student, Amra Tabakovic, I set out to encapsulate the antineoplastic drug 5-FU with CPSNPs and compare its effects in-vitro to free 5-FU in a pancreatic cancer cell line. The results of this study will refine our knowledge of encapsulating chemotherapeutics in CPSNPs, in addition to providing some insight into how to improve 5-FU bioavailability.

Currently, 5-FU encapsulation studies are underway, and we have begun to employ basic characterization methods to determine the resultant CPSNP solution's colloidal stability and mean particle size. Similarly, a mass-spectrometry-based characterization method for the CPSNP system is being developed to measure the quantity of drug encapsulated. Depending on the results of the initial encapsulation trials, the CPSNP synthesis method may be revisited to optimize the system for 5-FU encapsulation.

(Credit: Stephen Weitzner)

Weitzner

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About the author

Stephen Weitzner is a sophomore materials science and engineering student at The Pennsylvania State University. His main research interests are in the study of nanomaterials for medical and energy applications, and he intends to pursue a Ph.D. in materials science after graduating in the spring of 2013. ■

The value of undergraduate design courses

By Erica Marden

All undergraduate students pursuing a materials science and engineering degree accredited by the Accreditation Board for Engineering & Technology are required to complete a "capstone project." Some programs fulfill this requirement through senior theses, but most schools have students participate in what are known as "design projects." Design projects give students the opportunity to work in teams, design and accomplish a plan and interact with industry.

Working well in a team is one of the most important skills for any successful engineer to have. However, most undergraduate ceramics courses are not able to incorporate a lot of opportunities for extensive collaboration between students. Design project courses allow students to work together for an entire semester or year along with a faculty advisor. Developing effective group dynamics, dividing tasks and learning to trust and depend on members of the group are all skills acquired through working with a design team (Figure 1). Working with students that have different interests or material focuses also provides a good learning experience. Design projects allow students to interact differently with faculty. Most programs assign each team a faculty mentor who serves as an advisor and project supervisor.

To successfully complete a design project, a thorough plan and schedule must be established and maintained. There are a variety of tools available to help develop and track group progress toward attaining goals. Gantt charts, interactive calendars and Google Docs are just a few of the commonly used organizational tools. Developing planning skills, such as drawing diagrams, can help students work through problems and implement design ideas (Figure 2). Most materials science and engineering programs also require students to address the financial aspect of the design. Tracking finances and taking into account costs associated with a project are considerations not usually discussed in other ceramics courses. Therefore, design courses often introduce business and finance principles.

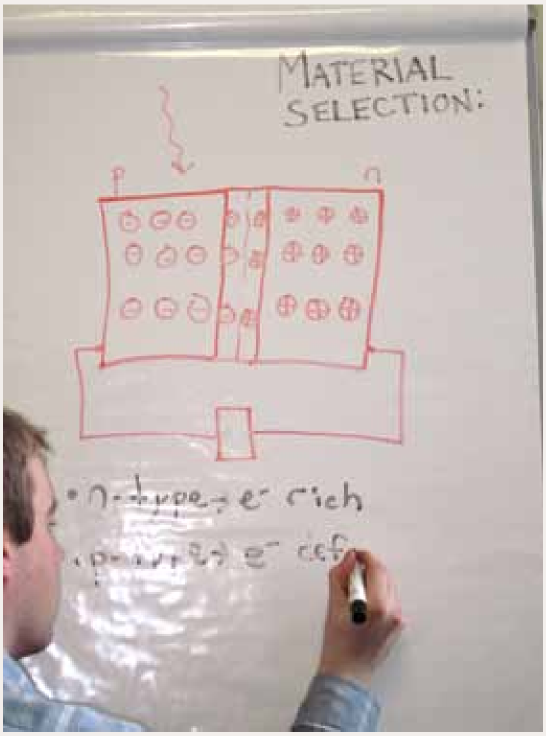
Most design courses rely on local industries or alumni connections to provide problems currently faced by industries. Ceramics industries working on piezoelectric materials, solar cells, energy-efficient building supplies, drug delivery systems and sensors are just a few of the projects that recently have been addressed by ceramics students. Learning how industry and academia can collaborate from the start of one's career can help build strong relationships with companies and propel new research initiatives.

The best part of taking a design course is pulling together knowledge from all of the undergraduate materials science and engineering courses. Most MSE courses focus on specific thermodynamic, kinetic, crystallization, characterization or failure mechanism principles. Materials selection for a specific design consideration requires students to pull together information from their entire undergraduate experience. Examples of some recent ceramic design projects include the investigation of the cause and control of resistor cracking, fixing electrode delamination in ferroelectric ceramics, designing to compensate for differential thermal expansion in photovoltaic components, designing the adhesion of a ceramic lead zirconate titanate sensor to a steel gas line pipe and selecting appropriate materials for an environmentally sustainable home. These are just a few examples of the hundreds of design problems tackled each year by materials science students across the country.

Each school has a unique perspective on the capstone design project. Some programs focus more heavily on the business perspective, some focus on materials selection, some focus on literature review and others focus on actual construction and testing. Virginia Tech requires MSE students to market their design and find corporate sponsors to back their research and construction. Penn State's design course focuses on materials selection. The University of California Berkeley has a culminating course that focuses on lab work, such as constructing and characterizing materials used in semiconductors or testing the impact of corrosion on mechanical properties. Rensselaer Polytechnic Institute's senior design course focuses

(Credit: Erica Marden)

Fig. 1 Penn State students meet to discuss the progress on their design project.



(Credit: Erica Marden)

Students planning the specifics of their design project by using a schematic diagram.

on designing against yielding, fracture, fatigue, creep and other properties versus designing specific products. University of Washington has a year-long design course that even covers topics such as quality control. Each school and program puts a unique spin on the design course, but ultimately every student hopes to attain similar skills.

A common theme for all programs is the additional development of professional skills. Engineers must be effective communicators to convince sponsors to fund research, delegate project tasks and present conclusions or sell a new material. Learning to give strong presentations and improve writing skills is an extremely important aspect of tackling a design project. Interacting professionally with industry collaborators provides experience with making a strong impression and convincing other respected professionals to support your ideas.

Finally, one of the crucial educational benefits of a design course is learning how to consider the guidelines that all engineers agree to follow. As scientists and engineers, we often are trusted with projects that can have huge impacts on others' livelihoods. ABET outlines economic, environmental, sustainability, manufacturability, ethical, health and safety, social and political impacts as crucial aspects to consider when approaching a new problem. It is easy to get caught up in exciting research or, after spending a long time on a project, to lose sight of some of the most important guidelines we must follow. Learning to solve a problem with a multifaceted approach and to look at possible solutions from a variety of perspectives allow students to gain an appreciation for the societal responsibility we take on as engineers.

New social engineering courses and outreach design projects are an excellent opportunity for materials science and engineering students to tackle important problems. Students with a strong ceramics background could prove to offer invaluable advice when working on creating cheaper alternatives to clean water initiatives or offering technology in rural regions. Social and sustainable engineering design projects are becoming increasingly popular, and soon more materials science and engineering programs may integrate problems that simultaneously address industrial and social concerns into the capstone design projects.

About the author

Erica Marden is a senior in the materials science and engineering department at Penn State University and is taking an option in ceramics. She is the vice president of her college's student council, secretary of her Keramos chapter and serves as the chair of the Communications Committee for the PCSA. She is doing her thesis research on amylose polymers. ■

Material Advantage students participate in congressional visits

By Tricia L. Nicol, ACerS liaison to the Material Advantage Student Program

Dozens of Material Advantage student members from around the nation attended the Science-Engineering-Technology Congressional Visits Day events on April 6 and 7, 2011, in Washington, D.C. CVD is actually a two-day event hosted by the SET Working Group, which brings scientists, engineers, researchers, educators, technology executives and students to Washington, D.C., to raise awareness and support for SET. The underlying objective of CVD is to underscore the long-term importance of those fields to the nation through meetings with congressional decision makers. Uniquely designed to have multisector and multidisciplinary involvement, the CVD is coordinated by coalitions of

(Credit: Chris McKelvey, Association for Iron and Steel Technology)

Material Advantage students and advisors hit Capitol Hill for their CVD meetings.

companies, professional societies and educational institutions.

Even though the threat of a government shutdown at the time loomed on Capitol Hill, 39 students and faculty from 15 universities attended this year's SETCVD event. Their experience began with a brunch Wednesday morning that included a fun role-playing session led by Dave Bahr (Washington State University) and Iver Anderson (Iowa State University and Ames National Lab). Some "CVD veterans" joined in the role play, including Robert Shull (NIST) and Kevin Hemker (Johns Hopkins University).

This warm-up event also was a valuable time for the students and professors from around the country to meet and share their perspectives and motivations for raising the funds needed to travel and conduct face-to-face meetings with their elected officials, something many of the participants would be doing for the first time. The students also received a packet of information that contained, among other things, talking points and a one-page leave-behind document to give to congressional office staff.

After the brunch, the group joined the 30 plus other societies that make up the SET Working Group at the Reserve Officers Association Minuteman Memorial Building for briefings from administration officials and congressional staff, focusing sharply on the 2011 and 2012 budgets and congressional perspectives. Speakers during this afternoon briefing were

- Kei Koizumi, assistant director, Federal Research and Development, Office of Science and Technology Policy;
- Patrick Clemens, director of AAAS Research and Development Budget and Policy Program;
- The Honorable Sherwood Boehlert, former chair of the House Science Committee;
- Chris Martin, AAAS Science and Engineering Policy Fellow, Science and Space Subcommittee, Senate Commerce, Science and Transportation Committee;
- Dahlia Sokolov, minority staff director, Subcommittee on Research and Education, House Committee on Science, Space and Technology;
- Julia Jester, majority staff director, Subcommittee on Technology and Innovation, House Committee on Science, Space, and Technology; and
- Jonathan Epstein, majority counsel, Senate Energy and Natural Resources Committee.

Wednesday events concluded with the 2011 George E. Brown Jr. SET Leadership Award Reception and Exhibit. This award, given to a member of Congress who has shown active leadership in the determination of SET policy, has strongly advocated in support of a role for the federal government in research and has taken specific actions to advance SET public policy. This year, the award was presented to two members of Congress: U.S. Senator Kay Bailey Hutchison (Texas) and U.S. Rep. Daniel Lipinski (Illinois).

Thursday activities began with a breakfast where four members of Congress spoke to SETCVD participants. The speakers were U.S.

Representatives Paul Tonko (New York), Judy Biggert (Illinois), Donna Edwards (Maryland) and Frank Wolf (Virginia). Their presentations helped motivate participants for their upcoming meetings. At the conclusion of the breakfast, participants began their scheduled visits with legislators and staff members on Capitol Hill.

Prior to the SETCVD event, organizers gave student participants the responsibility to contact the offices of their representatives and senators, and to arrange appointments for their groups. The students appeared to have taken this assignment seriously, as many important and productive meetings were held. In fact, the three students from Iowa State managed to secure meetings with both of Iowa's senators and all five representatives, a feat that rarely had been accomplished before.

Many of the other groups also were very active, and our Material Advantage groups held more than 50 office meetings before the SETCVD was concluded. Students reported that they preferred setting up their own appointments, because it allowed them to take ownership of their trip to Washington.

Based on feedback from this year's participants, the 2011 SETCVD was a great success. As Mahmood Shirooyeh, graduate student at the University of Southern California, said, "The CVD program provided me with a unique opportunity to meet with our senators and representatives on Capitol Hill. It let me point out to them how crucial the strong federal investment in scientific research and technology, in the midst of deep budget cuts, is in creating jobs and building a better future."

Travis Graham-Wright, undergraduate student from Colorado School of Mines, added, "All three staff people were very excited to meet with us. They were pleasantly surprised that a group of students would take time out of their busy schedules to meet with them. It definitely left an impression that we thought funding for research was important enough to merit taking a trip to D.C., especially getting toward the end of the semester where things get even busier with finals just around the corner. One [staff member] mentioned that it definitely opened his eyes to a new perspective of where federal funding goes and was very appreciative to talk to people directly affected by that funding."

Iowa State's Anderson reported, "I think that the sense of empowerment that came from each student group arranging their own congressional meetings gave this SETCVD event a special enthusiasm that I have not seen before. I also found that my students from Iowa State spoke with a great deal of professional polish at their visits and made an excellent impression on all of the offices that we visited."

Other universities that participated in SETCVD 2011 included Drexel University; Florida International University; Lehigh University; Michigan Technological University; Pennsylvania State University; San Jose State University; University of California, Santa Barbara; University of Illinois at Urbana-Champaign; University of Tennessee Knoxville; and Virginia Polytechnic Institute and State University.

Besides ACerS, the partner societies in the Material Advantage Student Program are the Association for Iron and Steel Technology, ASM International and the Minerals, Metals and Materials Society. ■

PCSA to host student symposium at Electronic Materials and Applications 2012

ACerS President's Council of Student Advisors will host a student symposium entitled "Highlights of Student Research in Basic Science and Electronic Ceramics" at the Electronic Materials and Applications 2012 conference Jan. 18–20, 2012, in Orlando, Fla.

PCSA's EMA 2012 topics include, but are not limited to:

- Nanostructured materials;
- Interfacial effects;
- Novel processing;
- Characterization;
- Electronic materials; and
- Energy materials.

Students working on qualifying topics should continue their research through the summer and prepare an abstract for the Aug. 3, 2011, deadline. Excellent student-written abstracts will be selected for the lunch-hour honor sessions and the students will receive travel grants to attend conference proceedings. Student abstracts can be submitted through the EMA 2012 website at www.ceramics.org/ema2012.

The PCSA symposium at the EMA 2012 conference is hoping to highlight ceramic research from student projects, independent research and design groups. Showcasing undergraduate and graduate student research can help lead to innovation and student involvement in the ceramics community.

The PCSA's symposium offers a unique opportunity for students to present research at a more specialized conference. Electronic ceramics encompass such a wide range of fields and applications that the EMA conference provides students with a broader perspective on the range of research possibilities. Students who attend the conference can look forward to these many exciting professional and research developments.

Other student activities and professional development opportunities will be featured at the EMA conference as well, promising a great networking and educational conference for undergraduate and graduate students.

Finally, students traveling to the symposium also can look forward to the diverse EMA symposia with topics ranging from material applications for energy to ferroelectric and nanocomposite materials. ■