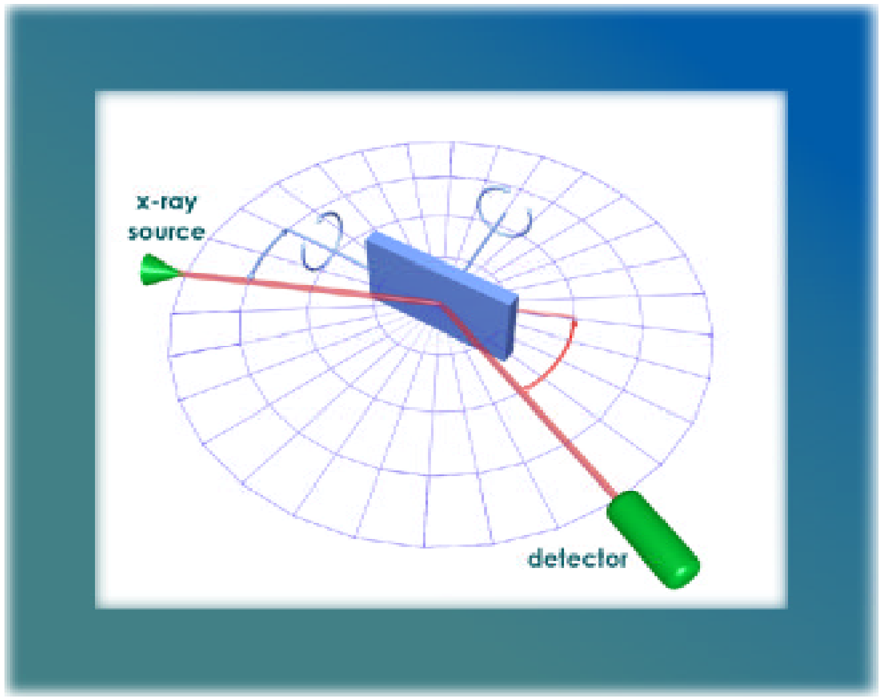
Exploring Materials

at Virginia Tech

Spring 2003, Volume 7, Number 1

News from the Department of Materials Science and Engineering
Virginia Polytechnic Institute and State University



In this issue...

Dwight Viehland Brings New Research to MSE

The schematic shown above depicts new X-ray diffraction equipment which will soon be delivered to the MSE Department, courtesy of the U.S. Navy. Dr. Dwight Viehland recently obtained a Defense University Research and Infrastructure Program (DURIP) to purchase this unit, which he will use to study active and passive materials, such as ferroelectrics and piezoelectrics. Specifically, he will be performing reciprocal space mapping investigations of domain structures.

Reciprocal space mapping allows for the investigation of different diffraction contributions in 2-D intensity maps. The position and intensity distribution in 2-D is determined using a triple-axis diffractometer, which is generally a conventional two-axis diffractometer equipped with an open Eularean cradle. This method requires small angles of divergence for the incident beam and of 2θ for the acceptance of the diffracted beam. Mapping is done by measuring numerous coupled $\omega/2\theta$ Bragg scans for a range of incident angles ω as starting values. Using a two-axis diffractometer, this is achieved by rocking of the cradle. Triple-axis mode configurations can probe specimens using different diffraction geometries. (*Schematic courtesy Benjamin Ruette*)

more about Viehland page 2

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Research Corner

Meet Dwight Viehland

Dwight Viehland joined the Virginia Tech faculty last summer, after four years with the Office of Naval Research. As a research scientist, he designed acoustic materials for use underwater in sonar applications, submarines, and unmanned vehicles. He is the recognized authority on transduction materials for sonar and underwater acoustic communications by the U.S. Navy.

national conferences. He has on-going projects on piezoelectric materials, bringing $550K annually to Virginia Tech.

In other research, he is looking at non-linear elastic materials for use in smart structures, smart skins for humans, and intelligent materials. Another project underway is the development of high performance hydrogen sensors for leak detection in the space shuttle.

Prior to this, Viehland served as an assistant professor in the Materials Science and Engineering Department at the University of Illinois, where he was the research group leader in the area of structure-property relationship investigations of piezoelectric materials.

Dr. Viehland holds bachelor’s degrees in chemistry and ceramic engineering, and a master’s degree, also in ceramic engineering, all from the University of Missouri - Rolla. He earned a doctorate in solid state science from Pennsylvania State University.

Currently, Dr. Viehland is involved in the investigation and development of ceramic and single crystal ferroelectrics and piezoelectrics. To date, he has over 200 peer-reviewed scientific publications and over 40 invited talks at international conferences.

In addition to his own research programs, he has served as a contract monitor of research programs for both the Department of Advanced Research Project Agency and the Office of Naval Research.

In the classroom, Dr. Viehland applies the philosophy of the old farmers who maintained that while you could lead a horse to water, you could never make the horse drink the water. “From your experience and what you’ve learned and digested,” he explains, “you show students how to get the information that’s out there—how to get it in the most simple and elegant way.” The teacher’s role is to “give [students] the road maps, so that they can know how to find information and carry that with them the rest of their careers.”

❖❖❖

Summer Research at ORNL

Shawn Kelly
(Grad Student, MSE)

This summer, I made a research visit to the Oak Ridge National Laboratory in Oak Ridge, Tennessee. I worked under the supervision of S. Suresh Babu and Stan A. David in the Materials Joining and Non-Destructive Evaluation Group of the Metals and Ceramics Division. The six-week stay was facilitated through the Oak Ridge Institute for Science and Education (ORISE) under the Higher Education Research Experience (HERE@ORNL) program.

The goals of my visit were to apply the thermal model developed for laser metal deposition (LMD) of Ti-6Al-4V to the Laser Surface Alloying (LSA) process and gain ideas for coupling the thermal model with a microstructural model that considers not only the thermal history and its affect on microstructure, but thermodynamics and kinetics as well.

Laser metal deposition processes are a generic group of rapid manufacturing processes that are currently in their infancy but have the potential to greatly affect manufacturing in the future. The basic premise of any LMD process is first designing a part in a CAD file, slicing the three-dimensional part into two-dimensional layers, and using a high-powered laser to melt delivered or pre-placed metal powder into a bead or track and using a motion control system to scan multiple tracks to form a single layer. The focal point of the laser is indexed to deposit the next layer.

Laser metal deposition processes have numerous applications in the metallurgical industry. They may be used to build a complex part or prototype directly without the need for significant amounts

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On the Cover (Border)

The microstructure featured on the front page is a result of the Laser Metal Deposition of the titanium alloy Ti-6Al-4V. Ongoing research involving this process is described above in “Summer Research at ORNL.” The microstructure contains needles (grains) of the alpha (HCP) in a matrix of retained beta (BCC). The width of each alpha grain is approximately 2ìm. Courtesy Shawn Kelly (B.S. ‘99, M.S. ‘02) and Steve Kampe.

A Philosophy of Education

Bill Reynolds

When the editor asked me to contribute a brief article about my philosophy of education, my first response was to realize I have yet to assemble any education ideas worth calling a "philosophy." I thought about coming up with a few pithy words about the art of education but quickly abandoned that strategy. There are plenty of clever zingers from great thinkers, such as, Socrates: "I cannot teach anybody anything, I can only make them think;" Mark Twain: "I have never let my schooling interfere with my education;" or Einstein: "It is a miracle that curiosity survives formal education," to mention a few. As a fallback, I adopted the less ambitious goal of assembling a few musings from personal experience. I can't claim they are original, but they ring true to me.

I suppose most teachers approach educational strategies by examining what works well for them when they learn something new. In my case, many of my lasting educational experiences came from one-on-one instruction. I had great classroom instructors and I heard many stimulating and entertaining lectures to be sure, but what I remember best are the personal discussions, explanations, and demonstrations from my teachers. These 'instructional moments' came from all kinds of teachers: my parents, public school teachers, music teachers, various job supervisors, professors, colleagues, and students.

The lessons learned from one-on-one instruction often arise when one attempts to do something and gets stuck in the process. Of course, "doing" (as opposed to passive listening) is central to most learning, but the personal, or one-on-one, instruction that I mean here is the role a teacher plays in leading the student through the difficulty. The instruction can be a subtle suggestion, a dialog that leads to exploration, or a blunt comment about how to do something correctly. Regardless of how it is delivered, personal instruction, when one is struggling with a problem, inevitably leaves a lasting impression. It probably is not coincidental that personal instruction is an essential component of internships and apprenticeships in the skilled trades and master classes in the art education methods that have a long and successful tradition.

There are several reasons why personal instruction works well. For one, there is nothing like being in a bind to focus your attention. In a sense, a stumbling block makes you particularly receptive to learning. The value of an idea or solution becomes self-evident in a natural way when you are trying to resolve a problem. The effect of the importance or usefulness of a concept on a person's likelihood of learning that concept is difficult to overstate. In a lecture, for instance, the teacher must first establish the value of what is to be presented with an example or compelling context in order to prepare students to absorb the material. If the teacher fails to establish the utility of a concept, the chances of students learning much from the lecture are low.

Personal, one-on-one instruction enhances the overall educational experience for our students.

A second reason personal instruction is effective arises from the sharp focus it brings to learning. A teacher helping a student through a problem can concentrate directly on the concepts that are essential to the problem without distracting the student with unnecessary details. Although it might sound like I am referring to engineering instruction, the focus principle applies to many different kinds of learning.

To illustrate with a simple example, consider a person learning to drive a car with a manual transmission who is having trouble starting out without stalling the car. Someone teaching the new driver usually recognizes that the essential concept that needs mastering involves coordinating the release of the clutch with a gentle push on the gas. If the teacher were in a classroom setting, she might cover a lot of issues related to driving a manual transmission car: how fast the gears should be shifted, engine RPMs, whether braking should be done with the clutch in or out, etc. In one-on-one instruction, a good teacher can easily avoid these confusing details and simply direct the driver to an empty parking lot for some practice and a few suggestions about how to coordinate the clutch and the gas.

In a formal school or university setting, it is unlikely we will ever return to a model of completely personalized instruction. The efficiencies gained by teaching large numbers of people in classrooms ensure mass education will remain an important part of our school system. Nevertheless, the personal learning moments that can happen even in conventional school settings are important to the quality of the educational experience and are worth encouraging.

Another nugget I have learned about education is the power of teaching as a learning tool. Joseph Joubert, the French essayist, stated this idea rather concisely: "to teach is to learn twice." The act of organizing a topic in a logical sequence and explaining it to someone else stimulates the familiarity with a topic we usually associate with understanding. If you really want to learn a subject, try teaching it to someone else. Parents encounter this phenomenon when they try explaining something to their children. Teachers run into it when they prepare a new course, or when bright students ask probing questions.

The teach-to-learn principle also applies to students teaching each other. I don't know if it has ever been demonstrated, but I suspect that students who work as tutors benefit as much from the experience as the students whom they tutor. Good students probably are not tutors just because they know a particular subject well; it could be that they learn the material well because they have tutored others.

Group homework assignments can encourage this type of learning if the problems are sufficiently challenging. Ideally, groups of students can help each other through difficulties as they work toward a solution. One student can benefit from explaining his approach to another student and from seeing alternate ways others may have used.

Education continued on page 9

Faculty Research Sabbaticals

Guo-Quan Lu at NASA

Dr. Guo-Quan Lu spent last fall semester working at NASA/Goddard Space Flight Center in Greenbelt, Maryland. His goal was to expand his research and development experience in optoelectronics, communications, nanotechnology, and micro-electro-mechanical systems (MEMS). Lu worked with scientists and researchers in the Detector Systems Branch, which houses a strong program in MEMS, as well as a state-of-the-art microelectronic fabrication facility.

Dr. Lu contributed time to two major MEMS projects underway in the Detector Systems Branch. Both projects are concerned with developing technology for the Next Generation Space Telescope (NGST). He focused on developing advanced packaging concepts for large area micro-mirror and micro-shutter arrays. Specifically, he developed a packaging concept for attaching and aligning the large-scale MEMS chips into a mosaic pattern and interconnecting it to the rest of the system. The goal is to eliminate global thermo-mechanical stresses that are caused by mismatched coefficients of thermal expansion between chip and substrate.

Dr. Lu's work with NASA has paved the way for future research opportunities between Virginia Tech and NASA. Lu has been invited to collaborate on a project addressing RF MEMS switch reliability and packaging. In addition, NASA has donated to Virginia Tech a projection mask aligner, which will strengthen processing capability for MEMS research at Virginia Tech.

MSE Students, Gustina Collins, Jeff Maciborski, and Kelly Stinson-Bagby visited Dr. Lu at NASA. Behind them is a full-sized model of the space shuttle.

Brian Love at NIST

Dr. Brian Love spent the spring semester in residence at the National Institute of Standards and Technology (NIST) in Gaithersburg, Maryland. He collaborated with researchers in the Materials Science and Engineering Laboratory (MSEL) in the Dental Materials Branch. He also worked with researchers from the American Dental Association (ADA) Paffenberger Research Center, also in residence at NIST.

Dr. Love participated in two project areas, the first dealing with processing and structural characterization of amorphous calcium phosphates. The second series of projects dealt with photopolymerization of new types of dental resin formulation. Plans are underway to present results of these collaborations at the International Association for Dental Research in Gothberg, Sweden, next year.

A direct benefit of Dr. Love's efforts at NIST is the establishment of an alliance between NIST and Virginia Tech for future projects. Two proposals have already been submitted to the National Institutes of Health, both dealing with tissue-engineered constructs for bone repair and replacement.

While in Maryland, Dr. Love gave several seminars around the DC area, including the Naval Research Laboratory, Army Research Laboratory - Aberdeen Proving Grounds, and the Patuxent River Navy Engineering Laboratory. He also traveled to Mississippi State University to give a seminar. In addition, he attended seminars and meetings at NIST and at Virginia's Center for Innovative Technology. A joint proposal has resulted from Love's vision of forming key alliances between research labs and Virginia Tech. The proposal links NSF Research for High School Teachers (RET) in the D.C. area, lead by Virginia Tech with NIST, NRL, ARL, and perhaps local companies.

Other Department News

D.P.H. Hasselman, Professor Emeritus of the MSE Department, has been named "Highly-Cited Researcher" by the American Society of Information Science and Technology. This honor is given to those whose lifetime number of citations of open-literature publications is ranked in the top 0.5 percent. Dr. Hasselman's approximately 300 publications are experimental and theoretical studies of the thermal shock resistance, mechanical behavior, and thermal diffusivity and thermal conductivity of materials for high-temperature applications. Dr. Hasselman is also a recipient of the John Jeppson Medal (American Ceramic Society), the Humboldt Prize (German Government), and the International Thermal Conductivity Award (ITC Conferences), and he is an elected member in the International Academy of Ceramics. ❖

In June, **David Clark** and **Guo-Quan Lu** traveled to China to learn more about Chinese universities, federal laboratories, and companies, and to establish formal ties with some of the top institutions in China for recruitment and future collaboration purposes. ❖

Alumni visits

This fall **John Kroehling** (CERE '48) paid a visit to Steve Kampe's Materials Selection and Design class, where he gave a presentation on refractory materials and catalysis.

Alfred E. Knobler (CERE '38) spent a day visiting the department in October. He chatted with faculty, staff, and students during a morning reception, and in the afternoon he gave a talk on the history of Pilgrim Glass. ❖

John Kroehling (right) talks with Steve Kampe (left) and David Clark.

Alfred Knobler (center) visits with MSE students and faculty.

Dr. Clark traveled to Italy and Australia this summer. In Florence, he presented an invited paper entitled "Microwave Processing of Materials," which will be published in Ceramic International. He also chaired a session on "Polymers Pyrolysis" and participated in the Ceramic International Advisory Board Meeting. In Australia, he chaired a roundtable at the 3rd W. Congress. The topic was "Are We Really Bridging Science, Technology, and Applications?" ❖

Photonics Lab

This fall, The Center for Photonics Technology (CPT) was awarded a $1.1 million grant from the U.S. Department of Energy to continue sensor development for use in coal-produced electricity. The Center, housed in the Department of Electrical and Computer Engineering, is directed by Anbo Wang and **Gary Pickrell**. Gary received a doctorate in MSE in 1994, studying under Dr. Jesse Brown. ❖

The MSE website has undergone significant renovations over the last few months. We've added some new features and updated others. Take a look: *www.mse.vt.edu.* ❖

Obituary

John F. Eckel, former head of Virginia Tech's metallurgy department (now the MSE department), died September 27 at his home in Blacksburg at the age of 99. After receiving his doctorate from the Carnegie Institute of Technology (Carnegie Mellon University), Eckel taught at Purdue University and worked for several companies, including Bell Telephone Laboratories, Western Electric, and General Electric's Knolls Atomic Power Laboratory. He joined the Virginia Tech faculty in 1956 and retired as head of metallurgy in 1968. ❖

2002-2003 MSE Scholarships

Alfred E. Knobler
Josh Beck
Nicholas Bell
Lisa Copley
Erik Herz
Elizabeth Hubbard
Elizabeth Jeffers
Michelle Kennedy
Adam Maisano
Jemmel Pursoo
Ashley White
Emma White
Michael Willeman

John B. Greiner
Elizabeth Hubbard

MSE Faculty
Eric Payton

Stuart & Mary Shumate
Christopher Kessler

John H. Kroehling
Andrew Miller
Patrick Muffo
Mark Taczak
Ryan Turner
Brendan Wells
Bryce Whited

Gilbert & Lucille Seay
Douglas Banerjee
Lisa Copley
Matthew Hubbard
Elizabeth Jeffers
Matthew Lynch
Andrew Miller
Jemmel Pursoo
Brendan Wells
Michael Willeman

Ray D. & Violet Frith
Andrew Miller

Thomas G. Stroyan
Douglas Banerjee
Matthew Hubbard
Christopher Kessler
Matthew Lynch
Robert Mitchell
Edward Parker

William C. McAllister
Erik Herz

Gordon W. Jones
Mark Taczak

Thomas L. Leivesley, Jr.
Robert Mitchell

Pulley-Loudon
Ashley White

Frank M. Fazio
Lisa Copley
Adam Maisano

Barry M. Goldwater
(U.S. Congress)
Erik Herz

Morgan L. Williams
(Washington, D.C. chapter, ASM)
Mark Taczak

Foundry Education Foundation
Julie Beth Cope

H.H. Harris Foundation
Christopher Kessler

For more information about these scholarships, visit *www.mse.vt.edu/people/AwardPages/honors-awards.html*

Student and Alumni News

Virginia Tech's Human-Powered Submarine Team

Adam Maisano
(Junior, MSE)

L to R: Justin Hlavin (OE, Subteam Pres. '01), Wenonah Sumner (OE), Andrew Hopkins (AE), John Hennage (ME, Ph.D.), Justin Stepanchick (OE), Adam Maisano (MSE, Subteam Pres. '02), Dustin Grissom (AE)

The Human-Powered Submarine (HPS) Team has seen success over the past two years, winning international competitions in 2000 and 2001, and this year proved to be no different. At HPS 2002 in Escondido, California, the team was presented with the Overall Engineering Award as well as first place awards in the Best Submarine Design and Innovation categories. These two awards, along with four second place finishes in the remaining five categories, helped the team repeat as World Champions for the third straight year.

A pilot pedaling inside the boat, similar to riding a bicycle, has typically propelled human-powered submarines. This power turns a propeller at the back of the sub to move the boat down the course. Speeds in excess of 7 knots (8 mph) have been recorded on a 100-meter course, so maintaining control for that distance is critical. To be able to compete at this level, the team saw a need for a radically new and comprehensive design as well as the integration of advanced construction techniques.

The HPS team, which has been in existence at Virginia Tech since 1989, raced their newest submarine, Phantom 4, at the California competition. The design of this new, one-person, propeller-driven submarine began soon after the 2001 races and construction was started early in the spring 2002 semester. A significant amount of research and testing went into the development of the shape of Phantom 4, including computer simulation, construction of a scale model, and wind tunnel testing. By minimizing volume and optimizing flow characteristics, the team created a CAD model of the hull shape. Fiberglass, carbon fiber, and closed-cell foam were laid up in a female mold and vacuum-bagged to form a structural composite body.

This year the team chose to incorporate a counter-rotating propeller system into the design of their boat. The advantage to this propulsion system is that the torque from acceleration is counteracted by the two propellers spinning in opposite directions on the same axis. This pedal-driven system has a 4:1 gear ratio allowing each propeller to spin at 150-200 rpm, which translates to a differential of over 300 rpm between the two propellers. The sealed gearbox was kept dry by maintaining an internal pressure slightly higher than ambient pressure at that depth. By optimizing each component of this system, from the gears to the shape of the propeller blades, total efficiency over 91% is possible.

Until last year, all of Virginia Tech's submarines have been mechanically controlled. The jump to using electronics proved to be a difficult but worthwhile endeavor. This year the pilot controlled the submarine using a computer joystick modified to work underwater and provide an intuitive system for the pilot to steer the boat. A small computer, located in the stern, processes the signals and operates pneumatic valves, allowing pressurized air to actuate pistons connected to the control surfaces.

One major concern in the design process was the workload experienced by the pilot since he or she must both pedal and steer the submarine. Therefore, an auto-leveling system was incorporated, using a pair of pressure sensors to determine the attitude of the boat and automatically operate the stern planes. This technological achievement made the boat semi-autonomous, a first in the Human-Powered Submarine racing community.

The MSE Department joined other Virginia Tech departments in sponsoring the team. Funds helped to offset travel costs for the competition. This year, the HPS Team will compete for its fourth straight championship at the International Submarine Races in June in Carderock, Maryland. To find out more about the team, visit *www.hps.vt.edu.*

Justin Hlavin demonstrates submarine operation

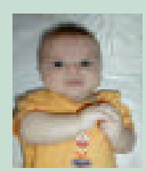
More Student & Alumni News

Dale Barnes (B.S. '93) completed a 20-year tour of duty with the U.S. Navy last September. He is now the Senior Manufacturing Engineer in charge of the Packaging Department at Tyco Healthcare's dosage pharmaceutical company in Hobart, New York. ❖

Stacey Sharp Nyakana (B.S. '02) is working as an R&D metallurgist at Titanium Metals in Hendersen, Nevada. "TIMET is the world's largest supplier of high quality titanium metal products." Stacey's work includes providing technical support for production and customers, as well as process and product development. ❖

Nick Katawczik (B.S. '01) is a Cost Analyst for the U.S. Navy in Maryland. ❖

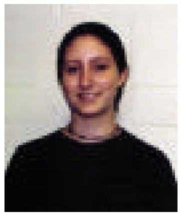
Celine Mahieux (Ph.D. '97) and **Jon Medding** (B.S. '94, M.S. '97) are the proud parents of Sarah, born September 7. Jon and Celine are currently living in Wettingen, Switzerland. ❖



Liz Myers-Vailhe (B.S. '92) is a scientist with Ethicon, a Johnson & Johnson company in Summerville, New Jersey. She works in the area of product characterization doing verification and product development testing, as well as medical device testing on such products as sutures, meshes for hernia repair, and topical skin adhesives to replace sutures. Liz is married to **Christophe Vailhe** (M.S. '92, Ph.D. '96), and they

Students Gain Valuable Work Experience Through Summer Internships

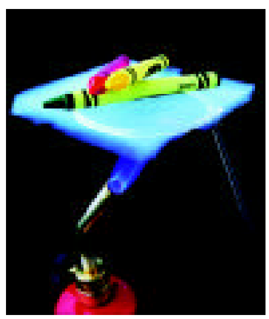
Ashley White (*Junior, MSE*)
Lawrence Berkeley Lab



I spent this past summer in Berkeley, California, participating in Lawrence Berkeley National Laboratory's Energy Research Undergraduate Laboratory Fellowships (ERULF) program. The ERULF program is funded by the Department of Energy (DOE) and offers science, engineering, and math students from the United States and Puerto Rico the opportunity to participate in a research project at one of twelve DOE national laboratories. Each student is assigned a research project and a mentor to help guide his research. My project focused on developing an aerogel-based material for use in insulating industrial furnaces.

Aerogels are unique materials with many amazing properties and applications. Silica aerogel is the lightest solid on earth, with a density as little as 0.003 g/cm^3, only three times denser than air. The aerogel typically used in applications is about 95% air and 5% silica; however, some specimens are over 99% air. Silica aerogel appears nearly transparent because most of its pores, which have an average diameter on the scale of tens of nanometers, are too small to scatter light.[1] Aerogel is useful in many electronic applications since it has the lowest dielectric constant of any known solid material.[2] While it is a brittle material, sometimes crumbling at the touch of a finger, it is extremely strong. A piece the size of a human would weigh less than one pound, but could support the weight of a small car.[3] One of the most useful commercial properties of aerogel is its ability to insulate from both heat and sound. By mass or volume, silica aerogels are the best insulators ever discovered, especially under a moderate vacuum. They are one hundred times more insulative than normal density glass.[4] These insulative properties were the focus of my research.

The large furnaces used in industrial applications require a great deal of insulation. Aerogels could provide better insulation at a smaller thickness than the types of insulation that are currently used. A problem, however, is that silica aerogel begins to disintegrate at temperatures of about 500°C, and industrial heating applications require a material that can withstand temperatures of up to 1000°C. Therefore, my project focused on developing an aerogel composite of aluminum, chromium, and silica that could withstand these high temperatures while still retaining most of its insulative properties. The group's research on this project is continuing; however, my work contributed significantly to the overall goal of the project and the results will hopefully be published in the near future.



Aerogel protects the crayons from the intense heat of the blow torch. (Courtesy Aerogel Photos, http://stardust.jpl.nasa.gov/photo/aerogel.html)

While working at Berkeley Labs, I lived at the University of California at Berkeley's International House with other students in the ERULF program and UC Berkeley students taking summer classes, many of whom were international. Additionally, San Francisco is just a short subway-ride away from Berkeley so I had the chance to explore a lot of the city.

This was the fourth summer research program in which I have participated, and I can say that these types of programs are excellent in that they give a real taste for what a research career is like and are a lot of fun. Because of these programs, I plan to continue on to graduate school to pursue a research career.

For more information on this and other DOE-sponsored research programs, visit *http://www.scied.science.doe.gov/scied/sci_ed.htm*. And remember to keep an eye out in the future for aerogel insulation!

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Internships continued next page

have 2 children, Madeline, who is 3, and Remy, 5 months (pictured above). ❖

Cindy Kornegay Waters (M.S. '85) is teaching materials classes at NCA&T State University in Greensboro. She is pursuing a doctorate there, studying nano-thin films and superconductor materials. She is also mom to two sets of twins, girls, 15, boys 13. ❖

Stephan Stücklin (B.S. '99) earned his master's in April '01 at the EPFL (Swiss Federal Institute of Technology, Lausanne), then he spent nine months interning with the Research and Engineering Center at Nippon Steel Corporation in Futtsu, Japan. He is currently working for Stratec Medical, a biomedical company in Switzerland. ❖

Andrea Kay (B.S. '93) and Nao Tsumagari are the proud parents of Erika Michelle Kay-Tsumagari, born July 18, 2002. She weighed 5 lbs., 4 oz. and was 19 inches long. Andrea is a Quality Engineer with EST in Milwaukee, WI. ❖

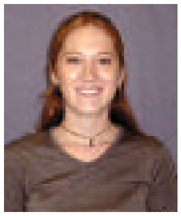
Erik Herz was awarded a Barry M. Goldwater Scholarship for the fall semester. This foundation was established by the U.S. Congress in 1986 to honor Senator Barry M. Goldwater, who served his country for 56 years, first as a solider, then as a statesman. The purpose of the foundation is to provide a continuing source of highly qualified scientists, mathematicians, and engineers by awarding scholarships to college students who intend to pursue careers in these fields. Erik, a senior, is currently working on undergraduate degrees in MSE, economics, and international studies. He plans to continue his studies at Tech, pursuing a master's in MSE. ❖

James Myers (B.S. '99) married Byerly Walker (ARCH '99) May 5, 2001. James is a Performance Engineer in the Testing Department at Brenco in Petersburg, Va. Byerly works for Balzaar & Assoc., a C.E. & Arch. firm in Richmond. ❖

Heidi (Allison) Williams (B.S. '93, M.S. '97) is an Engineer in IBM's Materials & Physical Analysis Lab in Research Triangle Park, NC. She married Robert Williams in 1997, and they have two children, Nathan, 4, and Abigail, 20 mos.❖

Internships continued from page 7

Emily Vernon *(Senior, MSE)*
Dominion Metallurgical, Inc.



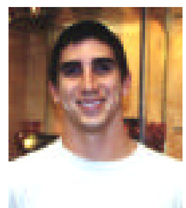
Anyone who tells you that metallurgy is all work and no play has never met Paul Huffman. I had the opportunity to work with him in several different capacities over the past year, both during my senior design project and during a summer internship, and there was never a dull moment. Mr. Huffman serves as an advisory board member to the MSE Department and is also president of Dominion Metallurgical, Inc. (Domet) in Roanoke, Virginia.

I first worked with Mr. Huffman in August 2001, as he was the industry advisor for the project completed by Robyn Herman and myself titled "Determining the cause of corrosion in a sheet metal roof." The project entailed discovering why a recently installed metal roof on the library at Hollins University in Roanoke was corroding at an unacceptably rapid rate. We worked in conjunction with Domet, Hollins, and East Coast Roofing Consultants, an independent company out of Richmond, Virginia, to solve the problem. The fact that we were able to work on a "real life" project was invaluable to the senior design experience. Aside from learning how to plan and execute a design project, we also gained knowledge about how things really work in industry, be it good or bad. Mr. Huffman was a wonderful source of information on this topic and gave us confidence in our work despite the fact that we were just "lowly college students" surrounded by people who had been doing this type of work for the better part of their adult lives.

As a result of my work on the Hollins roof project, Mr. Huffman hired me to work at Domet as an intern this past summer. Although I did continue some work on the Hollins project, I also had the opportunity to work with many of the other employees of Domet on a wide variety of projects. The main specialty of Domet is metal castings, but what makes the company special is that all of the account managers, who work as mediators between customers and the foundries, have, themselves worked extensively in foundries or machine shops. Because of this, their combined knowledge base is amazing, and there seems to be someone that specializes in just about every aspect of metal casting.

Some of the projects that I worked on included heat treatment analysis of metal liners for shaped charges, material selection for rapid prototyping in casting applications, and coordination of efforts between Domet and Virginia Tech to create a private foundry for the university. I also created a material properties database and a foundry/machine shop database for use by the account managers in the field. My favorite task, however, was setting up the mini-metallurgical laboratory, including several grinding and polishing wheels, hardness testers, and other analysis tools. Domet had acquired several very old optical microscopes at auctions, and I had the incredible task of somehow making forty-year old microscopes work without the help of any sort of handbook or parts (they don't make them anymore!). In the end, to everyone's surprise (including mine), I succeeded, and now Domet has their very own metallurgical analysis laboratory, complete with posterity.

Adam Maisano *(Junior, MSE)*
NASA - Langley



This past summer, I spent my vacation working for NASA as an intern in the highly competitive Langley Research Summer Scholars (LARSS) program. I worked in Structures and Materials Competency at NASA-Langley, located in Hampton, Virginia.

During the ten-week program, I worked closely with engineers and scientists in the Metals and Thermal Structures Branch where I learned how NASA is developing new technology to improve air and space travel. My major research project was to use an electron beam welding machine for freeform fabrication. This technology has potential use as a means to fabricate large structures in orbit or as a way to rapid prototype necessary components on extended space missions.

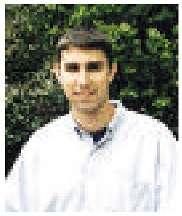
Electron beam freeform fabrication (EB F^3) is a rapid prototyping process that uses an electron beam to melt wire feedstock onto a substrate. In EB F^3, a focused electron beam is used to create a molten pool of metal. Wire is fed into this pool as the beam is translated across the surface of the substrate. This process is repeated to fabricate parts layer by layer. Aluminum alloy 2219 is an aerospace alloy often used for its good cryogenic properties. This alloy is readily weldable and has high strength and fracture toughness.

Through my work, it was shown that complex geometries can be welded and a desirable microstructure can be achieved. After welding several specimens up to 6-inches in height, I sectioned and polished each one to examine the microstructure. The result was a 100% dense material that was fully fused with the substrate. Tensile specimens were also tested and it was found that strength values were comparable to annealed and tempered aluminum.

The LARSS program accepts approximately 125 students from across the country each year. The program is open to rising juniors, seniors, and first-year graduate students from all majors.

Electron beam welder in the process of freeform fabrication.

Kelly continued from page 2



of post-deposit machining, repair damaged components that would otherwise be too expensive to replace, or to apply a surface treatment or structure to an existing part. The surface treatment could be a hard-face coating, or laser heating to induce a more desirable mechanical property at the surface. LMD processes save time and are economical in small batch production.

The microstructural evolution in these processes is inherently complex, due to the thermal variations experienced as multiple layers/tracks are deposited. Thus in order to understand and predict the microstructural evolution in an LMD process, the thermal history must be measured or, in absence, modeled. Initial work has focused on the LMD of the titanium alloy, Ti-6Al-4V, for rapidly manufactured structural aerospace components. A complex microstructural morphology was observed and, in an attempt to understand the microstructural evolution, a thermal model for LMD processes was developed. An evolution scheme has been developed based on thermal history characteristics (peak/minimum temperature, cooling rate).

In LSA, tungsten carbide particles are introduced into the laser-induced molten pool of a metal alloy to create a hard-face composite on a substrate. An industrial application of the LSA process would be to coat fossil fuel drilling shafts with a hard composite to extend the life of the part. Depending on conditions, the tungsten carbide particles may dissolve in the molten pool, adversely affecting the overall hardness of the coating. To better understand the dissolution and control the microstructure, the thermal history as multiple tracks are deposited was examined. The stay at Oak Ridge was too short to analyze the microstructural evolution in the deposit; however, future work in this area is planned.

Future plans include a return to ORNL in the spring of 2003 to continue work with laser metal deposition process modeling, with the end result being a Ph.D. degree no later than December 2004. The Ph.D. research will focus on developing a couple thermal-kinetic model for laser deposition processes that will predict microstructural evolution. It is hoped that someday this tool can be coupled with a process control model so that LMD processes can be controlled by-wire to produce multifunctional parts with one process. In the future, a one-step process such as LMD would be ideal for space-based manufacturing.

What was life like in the Secret City? Oak Ridge was founded during WWII out of a need for a secure, remote site for production of fissionable material for the Manhattan Project. Initially, Oak Ridge was a military installation, where civilians working in the labs and production facilities were housed in barracks. During my stay I lived in the boarding home of one of the original Oak Ridgers, Ms. D. Young, who worked in the K-25 plant, where U-235 was produced. "We were told to monitor the gauges and make sure that they stayed between certain levels," Ms. Young said. "We found out what we were making after the atomic bomb was dropped on Hiroshima."

The food at Ms. Young's house was good southern cooking, and as a result, I put on a few pounds. Just thinking about her meals makes my mouth water and my stomach crave for slow cooked beef and green beans.

While at Oak Ridge, I walked the same streets as some of the world's top scientists and engineers did 50 years ago, worked with nearly 300 Ph.D.s in the Metals and Ceramics Division and with about 1,500 scientists and engineers in the lab; inspiration for research was ever present.

Did anything strange happen? One day while walking through the parking lot, an announcement came over the public address system. Low doses of strontium-90 had been found in a parking lot near the lab. That's something you don't hear everyday while walking to class at Virginia Tech.

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Education continued from page 3

Along similar lines, I recall from a course I took many years ago that cognitive psychologists have used the teaching-to-learn concept to explain why the youngest child in a family has a statistically lower IQ than older siblings. The hypothesized mechanism behind this observation is that children teach their younger siblings and, in so doing, stimulate their own intellectual development. The youngest child has no younger brother or sister to teach and presumably learns less than he otherwise would. (Note: If you are a youngest child, let me add a few disclaimers here before you get too indignant. Not all youngest children have lower IQs than their siblings; the IQ differences between siblings that are attributed to this effect are very small and are only noticeable in large samples of children, and I don't really know what IQ tests measure anyway.) My purpose in mentioning the teaching-learning connection in children is to point out that one does not have to be an education professional to benefit from teaching.

My last little chestnut about education involves the need to keep learning; this topic is often discussed under the rubric of "lifelong learning" in today's education-speak. Lifelong may be too pretentious a term, or at least too ambitious, but the central idea is to encourage people to keep learning and recharging their intellectual batteries after graduation. For a researcher and educator, the need to keep learning is an imperative. Unless you happen to be a Latin instructor, you can expect your field to change constantly – sometimes very quickly – and staying abreast of the changes is essential to remain relevant. My wife reminds me of this point when she tells me, "You can't teach what you don't know." Learning new subjects and skills sometimes puts the old, familiar subjects in a different light, and this also helps keep a teacher's outlook and presentation fresh.

That's about all of my ruminating on education. If this little essay sounded too much like a dry lecture, then I hope I do a better job with the students one-on-one.

Bill Reynolds is a professor and the assistant department head in the MSE Department. He is also the director of the MSE graduate program.

People in Materials

Kyanite and Virginia Tech: Jesse J. Brown Carries on a Tradition

LeeAnn Ellis

Most of you will remember that Professor Jesse Brown retired from the MSE Department a couple of years ago. I recently paid a visit to Kyanite Mining Corporation in Dillwyn, Virginia, where Dr. Brown has been working as the Director of Research and New Product Development. During our visit, I learned about the importance of kyanite, how it's extracted and refined, and I learned about Virginia Tech's role in the history of the development of alumino-silicate materials and the history of Kyanite Mining Corporation (KMC).

What's so important about alumino-silicates?

This class of materials forms a key component in many end products. "Alumino-silicate refractories," explained Dr. Brown, "are critical for making iron and steel, making any metal you can think of, making ceramics, glass, absolutely critical for the United States and the world, for that matter." Alumino-silicates are materials with compositions of SiO_2 and Al_2O_3. The key minerals for these applications are kyanite, andalusite, sillimanite, and mullite. "The mullite is the real important phase that we all want," said Dr. Brown, but mullite is nowhere to be found. What KMC does is mine kyanite, which is 60% alumina, and calcine it to form mullite. Kyanite is one of only a handful of minerals that can be manipulated to form mullite. "Looking at the overall picture, in the United States there are only two places where you can get materials in the 50-70% alumina range. You can calcine bauxitic clay or you can calcine kyanite."

Why do we need kyanite and mullite?

Most of us are not familiar with kyanite or mullite, yet they are key ingredients in many items in use everyday. Mullite lends heat resistance properties to, for example, ceramic bakeware, where thermal shock protection is needed to prevent dishes from cracking. A pizza stone requires mullite to stand up to repeated cycles of heating and cooling. Mullite increases the mechanical strength of floor and wall tiles. As calcined kyanite decomposes into mullite, it expands irreversibly. This makes the mullite particularly valuable where shrinkage is undesirable, as in bricks and mortars. Also important are its refractory properties such as heat and corrosion resistance, which make it valuable in high-temperature furnaces and reactors. Electrical insulators are another place where mullite is used because of

Kyanite Mining Corporate Offices, built in 1957 of kyanite quartzite rock.

How Does Kyanite Become Mullite?

1.Mining

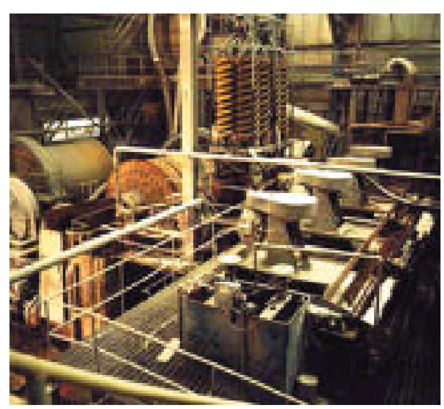
Dynamite

2.Crushing & Grinding

Various stages take the mined rocks from boulders to fine (28 Mesh) particles.

3.Flotation

The crushed particles travel through several flotation stages to separate out the kyanite from other minerals such as pyrite and sand.



its low electrical conductivity and high thermal resistance. In fact, electrical insulators sparked the beginning of interest in kyanite back in the late 1920s.

The Virginia Tech Connection

Kyanite Mining Corporation's roots date back to about 1927. The company was known as McClanahan-Watson for its two founders, who began to experiment with kyanite. During World War II, there was a growing need for spark plug insulators, which meant there was a need for materials that were 60-70% alumina.

"It has occurred to me over the years," commented Dr. Brown, "that Virginia Tech faculty, staff, and alumni have had a critical role in the development of alumino-silicate refractories." The Virginia Tech/Kyanite connection dates back to the 1940s, when John Whittemore did consulting work for the company that would become Kyanite Mining Corporation. Dr. Whittemore was a professor of ceramic engineering at Tech, appointed in 1928. From 1952-1963 he served as dean of the College of Engineering. During all of his years with Virginia Tech, Whittemore served as a consultant for KMC and, in fact, he played an important role in getting the company up and running by setting up their first laboratories. Stashed away in the KMC files are many letters and reports written by Whittemore, such as "The Development of a Refractory Aggregate from Virginia Kyanite."[1] In the process of growing the company, more land containing kyanite deposits was purchased over the years, including land previously owned by Vic Kelsey, a ceramist, and uncle to Tech graduate, Vic Kelsey (CERE '69).

Beginning in the 1960s, a Virginia Tech graduate became interested in alumino-silicate materials. George Eusner (CERE '43) started Mullite Corporation of America (MULCOA) near Andersonville, Georgia. The company eventually became C-E Minerals (Combustion Engineering Minerals), the largest producer of alumino-silicate minerals in the world. George's son, Paul, completed ceramic engineering degrees at Tech in 1968 and 1970 and went to work for his father in Andersonville, followed by Dilip Jain (CERE M.S. '73), who was Dr. Brown's first graduate student, and Mark Northrop (MATE '89). Paul Eusner recently co-founded a new company, Great Lakes Minerals, that imports minerals from China and is rapidly becoming a major player in the alumino-silicate minerals business.

Dr. Brown began consulting for KMC in 1973, picking up where Whittemore left off. He set up a new laboratory based on atomic absorption testing. That lab remained in operation until 2000, when a new facility, the Billy R. Coleman Memorial Laboratory, was completed. Dr. Brown is in charge of this new laboratory, where he oversees a variety of testing activities such as particle size analysis, X-ray diffraction, X-ray fluorescence, specific gravity, and others. He also handles training, and, according to Hank Jamerson (PhysEd '74), Director of Sales at KMC, "helped educate the company owners on the whys and wherefores of kyanite production and its uses."

"There's a tremendous Virginia Tech connection to all of these alumino-silicate materials," said Dr. Brown. "It may be one of the bigger contributions that Virginia Tech has made to science and industry."

Reference

1. Sawyer, J.P. and J.W. Whittemore, "The Development of a Refractory Aggregate from Virginia Kyanite," Bulletin of VPI, Eng. Exp. Station #49, November 1941.

The author wishes to thank Dr. Brown for his help in preparing this article and also for giving her a fascinating tour of Kyanite Mining Corporation and an excellent lunch at Teresa's Place.

4.Roasting and Reducing

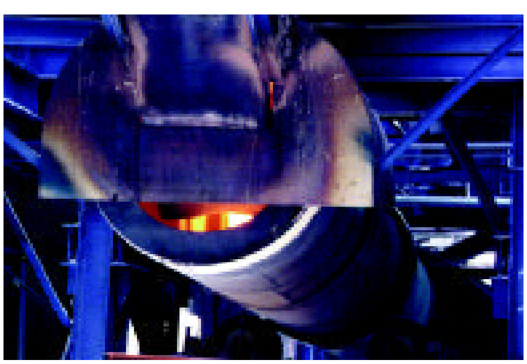
The kyanite is roasted in a reducing environment to magnetize all iron, which must be removed.

5. Magnetic Separation

Iron is pulled out.

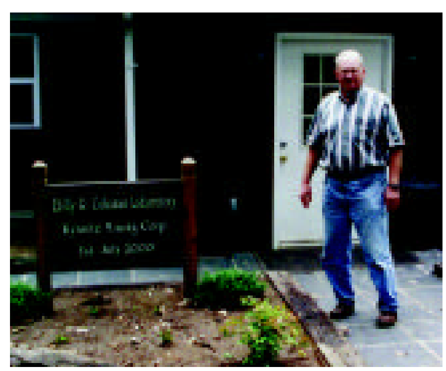
6. Calcining

The kyanite is heated to a high temperature so that it will decompose into mullite.



Testing

Throughout this process, sample materials are tested in the field and in the lab for particle size and chemical composition.



Head's Up

David Clark

MSE has achieved several major milestones in the last year. In October 2002, our undergraduate program received a Next General Review (NGR) rating from the Accreditation Board for Engineering and Technology (ABET). This rating means that our program has met all the requirements of ABET and will not be reviewed again for six years. Likewise, our graduate program was evaluated in April by a team of external experts. There is no national requirement to evaluate graduate programs, but the College of Engineering at Virginia Tech requires an evaluation be done every five years to ensure that students are receiving a high quality and competitive education. Although the review team made several recommendations for consideration by our faculty, our program received high marks overall.

The MSE Advisory Board met on April 3-5 in Blacksburg. They were given an overview of the department's academic programs, research, and facilities. The board submitted a report offering recommendations that are at various stages of implementation. This Advisory Board, chaired by Warren White, consists of 14 members representing industry, academia, and federal laboratories. A complete listing of the members, affiliations, and the board's mission can be found on our website.

MSE has been involved in recruiting activities this year. Our annual Open House was held on October 16. Over 250 freshmen visited Holden Hall and saw demonstrations in superconductivity, sensors, night vision goggles, memory metal, computation materials science, among others. A few students learned to use a ceramic golf putter and won t-shirts in a putting contest. MSE also hosted a Parents' Day visit to the department and an evening with freshman Honors students. We expect these events to have a positive impact on our undergraduate enrollment.

Two of our alumni, John Kroehling and Alf Knobler, visited the department and made presentations to the faculty and students. John lectured a senior design class on catalysis and Alf gave a seminar on Pilgrim Glass. Both individuals have made generous donations to support our undergraduate students and to purchase state-of-the-art equipment.

In June, G.Q. Lu and I visited universities and national laboratories in China to strengthen our ties. A formal memorandum of understanding (MOU) was signed between our department and the MSE department at the University of Fudan. This MOU will foster student exchange and joint research opportunities between the two departments. A similar agreement is in place with the University of São Carlos in Brazil.

Our faculty continues to be successful in securing research funding. This is especially important in times of dwindling state support. Since April, MSE's portion of the state budget has been permanently cut by about 8%. Such unprecedented cuts will certainly impact our department, but our faculty are working hard to ensure that the high quality of education provided to our students is not compromised.

MSE is supportive of the new Institute for Critical Technology and Applied Science at Virginia Tech led by the College of Engineering. The Institute will provide an infrastructure and space that will foster synergistic research between engineering and the sciences. This initiative has three phases and will require raising $85 million for buildings, equipment, and infrastructure. Fund raising activities are underway and Phase 1, which will focus on Advanced Materials and Nano-technology, Information Technology, and Biomedical Technology, is expected to be operational in three to five years. We expect the Institute to add significantly to materials research and education capabilities at Virginia Tech. More on this in the next issue.

MSE has an ambitious plan to become nationally ranked by the year 2010. The top priority is to build our graduate program with respect to quality and diversity while maintaining the strength of the undergraduate program. We have identified some of the key components required to achieve this goal and these are provided on our website.

We appreciate the strong support that we have received from the Dean's office. Interim Dean McPherson retired at the end of 2002 and Associate Dean Ed Henneke (presently Interim Dean) will provide the leadership until our new dean, Dr. Hassan Aref, arrives in April. We wish Malcolm a happy retirement and look forward to working with Hassan.

Virginia Tech

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