Fall 2007

Center for Innovative Sintered Products

CISP

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CISP Director Named

The Engineering Science and Mechanics (ESM) Department is pleased to announce the appointment of Donald F. Heaney as Director of the Center for Innovative Sintered Products (CISP). Dr. Heaney has served as the Associate Director of CISP since 2000.

Dr. Heaney's immediate goal for CISP is to engage the Board of Directors; develop strategic initiatives that will lead to increased industrial memberships, new sponsored research projects, collaborations and student support across the University; and, create a long-term vision for CISP's future.

Dr. Heaney is an Associate Professor of ESM, has been a member of Penn State's graduate faculty since 2000 and a member of the ESM faculty since 2006. Dr. Heaney's group conducts research in the areas of microcomponent fabrication, titanium powder metallurgy, metal/ceramic brazing, and organic selection for the net shape fabrication of powdered materials. While Associate Director of CISP, Dr. Heaney was responsible for powder processing equipment acquisitions and member contract research.

Dr. Heaney has over fifty refereed technical publications in the area of powder processing and is one of the leading experts in the area of metal injection molding. He received his Professional Engineer License in Metallurgy in 2005. Dr. Heaney teaches a senior level course on PM Processing (E Sc/MATSE 475) and numerous continuing education classes in powder prossessing.

Dr. Heaney received his bachelors, masters (engineering science) and doctoral (materials science and engineering) degrees from Penn State. Before joining Penn State, Dr. Heaney was a Senior Process Development Engineer with 3M Electronic Products Division (Austin, TX) and a Principal Engineer with Bristol Myers Squibb Orthopedic Implant Division (Warsaw, IN).

Dr. Heaney can be reached via e-mail at dfh100@psu.edu or by telephone at 814-865-7346.

Members' Insider

Portions of this newsletter are distributed to members, only:

- **Nano-Engineered Encapsulated-Particles for the Creation of Self-Lubricating Coatings and Alloys**
- **Quest for a Low Temperature Sintering Pathway**
- **Contact Information**

For more information on becoming a member, visit our web site at www.cisp.psu.edu or send an email to cisp@psu.edu

Inside This Edition

Upcoming Events

February 20, 2008 (8:30am-5:00pm)
Advanced Powder Injection Molding
Short Course at Pennsylvania State University – Dubois campus
Dubois, Pennsylvania, USA
call 814-375-4715 or duboisce@psu.edu

March 10–12, 2008
PIM2008
Long Beach, California, USA

March 26, 2008 (8:30 am-12:30 pm)
Innovations in Particulate Material Applications
Short Course at Pennsylvania State University – Dubois campus
Dubois, Pennsylvania, USA
call 814-375-4715 or duboisce@psu.edu

April 14-15, 2008
Materials Day
University Park, Pennsylvania, USA

April 16-17, 2008
Industry Member Meeting
University Park, Pennsylvania, USA

April 14-17, 2008
SAE World Congress & Exposition
Detroit, Michigan, USA

June 8-12, 2008
2008 World Congress on Powder Metallurgy & Particulate Materials
Washington, District of Columbia, USA

October 5-9, 2008
Materials Science & Technology 2008 Conference and Exhibition
Pittsburgh, Pennsylvania, USA

Penn State and Industry Working Together

At the April 9, 2007 CISP IMM, a panel composed of industrial members, multiple complimentary PSU entities and a MPIF representative openly discussed how CISP could better serve its industrial sponsorship, while simultaneously complimenting other organizations offering similar programs for education to the industry. Introductory comments were given by panel members: Donald Heaney (Associate Professor, CISP, Penn State); Paul Sedor (Business Development Manager, Osram Sylvania); Bob Cornwall (Materials Research Institute, Penn State); Steve Johnson (Instructor, Dubois Campus, Penn State); Jim Dale (Director of Marketing and Technology, MPIF); and Mary Lee Carns (Departmental Strategic Planning Specialist, Sociology, Penn State).

Donald Heaney emphasized that CISP was a training ground for future engineers of the P/M industry. Students at the BS level learned project management skills through small P/M projects, including equipment usage and repair, data gathering, data analysis and report preparation. A one semester class on powder processing is offered to students at both the BS and graduate level to help them in the lab and educate other engineers who may specify P/M components in the future. Graduate level theses are performed at the laboratory. CISP also offers one day short courses at Dubois and Erie targeted for new P/M industry employees and as refresher courses, which include: Powder Metal Fundamentals, Binders and Lubricants, Fracture Behavior of P/M materials, and Advanced Powder Injection Molding.

Steve Johnson reviewed the Engineering Technology Associate degree offered at the Dubois campus. The program, based in Dubois due to a large concentration of powder metal industries in North Central PA, can be a terminal degree or a spring board for other degrees, and is geared towards P/M. A second year capstone project is required. A four-year curriculum program is being developed and will emphasize materials and mechanical engineering.

Jim Dale stated the P/M Marketplace is shrinking by 500 employees per year, with 50% of APMI members being over 50 years old. Powder shipments have remained steady or increased over the last 10 years, thus, productivity is increasing. Having said this, a demand for talented employees still exists. Since the P/M industry does not have resources devoted to education, research and development, MPIF runs short courses and mini-conferences to appeal to those interested in networking. In the end, research and development is being done by powder producers with the critical mass, size and resources to handle these activities, rather than the small companies struggling to stay profitable.

Mary Lee Carns is charged with implementing new employer relations programs, growing out of co-ops and internships. She wants to build relationships between the 700 industries and organizations looking for engineers and the students and faculty of Penn State. The goal is to combine the three customer groups (students, faculty and industry) in a significant way, such as a "Diversity Showcase" or "Learning Factory Design Showcase". A Diversity showcase invites faculty to attend and network with a group of 30 industrial companies with similar interests. A Learning Factory Design showcase invites 20 to 30 industrial organizations to review senior capstone design projects.

Bob Cornwall explained that MRI was created by the university to bring together all the materials related research performed within various departments. Since Penn State does more materials research than any other university in the US, MRI co-funds faculty positions and runs events engaging faculty from different colleges within PSU. One such event, Materials Day, was started as a way for faculty to report on research and industry representative to attend and learn about that research. Four centers run meetings in conjunction with Materials Day. MRI also runs several user facilities to perform university and industrial short-term characterization, and allows small-scale fabricators access to a clean room. The clean room facilities can be used by the industry representatives on their own, or with an MRI staff person.

Paul Sedor described Osram Sylvania as having 1,000 employees and doing recruitment at Penn State for all their departments. He explained that industry is looking for students with automation and productivity skills and statistics, presentation and communication skills. Engineers need to understand business and manufacturing issues, as well as major-specific classes. Hand-on experience is a plus for students seeking jobs, as it reduces training time and increases effectiveness.

At the conclusion of the discussions, it was agreed that a need for highly skilled engineers in powder processing still exists, though the quantity required is less. Thus, CISP should emphasize highly specialized skills related to P/M processes. Students need to be educated in the practical aspects of the technology and have a co-op experience. Industry should offer co-op experiences through CISP. A program to educate students through retired engineer speakers should be explored.

Short projects, co-ops, government funding of small company development and SBIRs can be used to engage smaller companies and help develop their technologies for the future.

For more information on how you can become involved, contact Donald Heaney at 814-865-7346 or dfh100@psu.edu

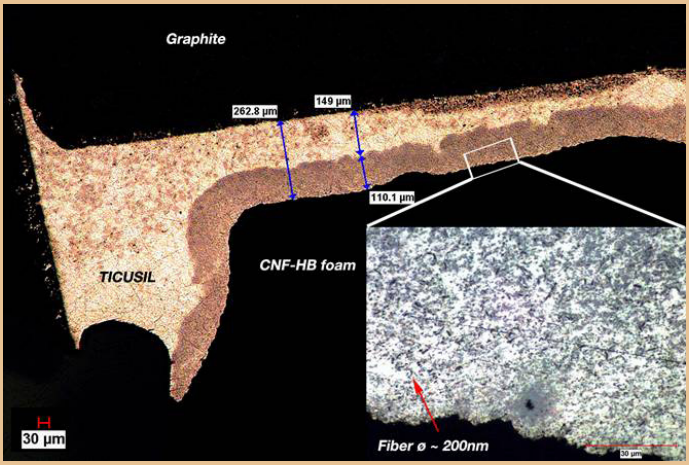
Copper-based Nano-featured Composites

Michael Kitzmantel, a graduate student from the Vienna University of Technology in Austria, came to CISP to conduct research under the supervision of Ivi Smid.

Dan Cunningham, Michael Kitzmantel, Erik Byrne, Kristina Cowan, Craig Schaffer

In electronic devices, materials with a high thermal conductivity and coefficient of thermal expansion matching Si, GeAs or alumina are used as heat sinks, heat spreaders and substrates. Besides high thermal conductivity, low coefficient of thermal expansion (CTE) is a crucial property for long-term stability and reliability of the product. Today commonly used materials, such as Mo-Cu, W-Cu, Kovar, Al/SiC, AlN or diamond, exhibit several limitations with respect to limited thermal conductivity (Kovar), high density (Mo-Cu, W-Cu), poor machinability (Al/SiC/AlN) or high price (diamond).

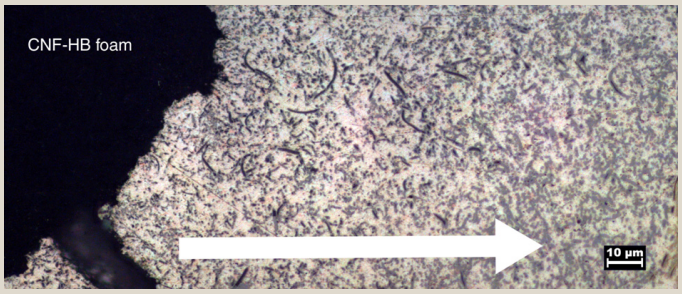
For applications with a high number of thermal cycles, standard copper material often is not sufficient. Copper has a very high thermal conductivity, but its high CTE causes severe mismatch to the substrate (i.e. Si or alumina). In some applications, the high density of pure copper is a further disadvantage.



Carbon nanofiber foam infiltrated by a Silver-Copper-Titanium alloy.

To evade these application limitations miscellaneous concepts are under development. One approach is to reinforce the copper matrix with different filler materials, such as graphite flakes, carbon fibers or carbon nano-particles. Several investigations with graphite flakes and carbon fibers have shown promising results and improve the demanded properties. Due to the lack of chemical interactions between carbon and copper, the manipulation and investigation of the interface plays an essential role. To exploit the potential for carbon nanotubes (CNT's) as filler material, the interface between the fiber and the matrix has to be studied in detail.

The wetting behavior between carbon and copper alloys containing carbide forming elements is influenced by those additives, causing the contact angle to decrease, meaning good to excellent wetting ability. Compared to the mentioned conventional carbon fibers with a diameter of about 7-10µm, nanofibers with a diameter of about 100-200 nm have a much higher surface to volume ratio, and therefore, the interface between the fiber and the metal gains is more important for the resulting properties.
Many problems, which are mainly solved by producing Metal Matrix Composites (MMC's) containing 'regular' carbon fibers, still appear when nanofibers or nanotubes are introduced as reinforcement. Besides separation, dispersion, alignment and orientation of the fibers, as well as densification problems, the reproducible quality of the raw material is very important and not always simple. Only rare data of the properties of carbon nanofibers is available.



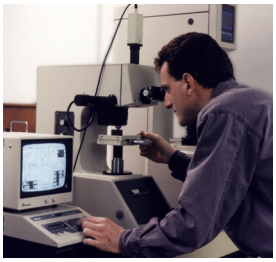
Carbon nanofibers in the infiltrated area, the arrow indicates gradient of formed carbide.

Infiltrating carbon performs, such as nanofiber and nanotube foams, gives some promising results and avoids the problem of clustered nanoparticles.

There are countless applications for heat sink and heat spreader materials. As the building elements of microelectronics get smaller and have to cope with growing power density, a much more efficient cooling system and improved heat transfer material will be a very hot topic. Suitability for cycling temperatures will also be crucial for future materials, as well as long-term stability. Furthermore, CNT-MMCs satisfy good surface quality and excellent machinability. By adjusting the nanofiber content in the matrix, the CTE can be adapted easily, making the product flexible and tailored for various applications.

For more information on how you can become involved, contact Ivi Smid at 814-863-8208 or smid@psu.edu.

Testing Services



CISP continues to offer testing to Center members and external clients. Frequently requested testing ranges from surface area and particle sizing to scanning electron microscopy and thermal diffusivity. Turnaround time is typically 2-5 business days. Center members receive a 10% discount.

Recent work included an investigation into damage caused by cavitation and corrosion.

Scanning electron microscopy (SEM) was used to inspect the surfaces after testing to see if applied coatings and/or cryogenic treatments reduced damage due to corrosion and cavitation. In all cases cryogenically treated samples performed better. The samples showed the cavitation mechanism was secondary to the corrosion mechanism, but that both worked together to erode the material.

If our lab can help your company determine or compare performance or properties of your material, please contact us. For questions about types of testing and sampling, please contact Kristina Cowan at 814-865-1393 or kcc126@psu.edu. You can also visit our testing services price list at http://www.cisp.psu.edu/testserv.

Student Update

NSF International Experience— Penn State students Jens Weyant and James Moses were selected for the International Research Experience for Students (IRESM) at the University Carlos III of Madrid (UC3M), Madrid, Spain in the summer 2007. Students worked with four different research groups within the UC3M lab on four separate projects.

The first project concentrated on preparing and characterizing nickel super alloy (Ni 635) feedstock.

The second and third project focused on optimizing press and sinter parameters, focused on titanium and admixed titanium-iron powder.

The third project focused on pre-alloyed copper-tin-lead, copper-tin, and copper-tin-bismuth powders.

The final project focused on corrosion testing metal cubes.

For more information, contact Jens Weyant jew238@psu.edu

Mesmacque Vincent visited from France for three months to conduct research, and offered this testamonial:

"This training enabled me to develop my direction of autonomy and initiative. I discovered all the things necessary to do before and after tests, including precautions when working with hydrogen gas and good analysis methods. I deepened my knowledge in the science of materials thanks to running different tests and critically analyzing results by participating in a Penn State research project.

I also learned to work in a team. This training shifted my previous focus from mechanical design, to mechanical engineering and materials science. I think, if I have another opportunity to train in the US, then why not at Penn State and for the Center for Innovative Sintered Products?"

Publications/Presentations

D. Cunningham, I. Smid, J. Keane, J. Smith, **"Material Characterization of Tough Coated Hard Particles (TCHP),"** *College of Engineering Research Symposium, University Park, PA (February 8, 2007)*

G. Aggarwal, I. Smid, A. E. Segall, **"Impact-Contact Modeling of Particle Bonding in the Cold Gas Dynamic Spray Process,"** *136th Annual Meeting & Exhibition of the Minerals, Metals & Materials Society (TMS2007), Orlando, FL (February 25-March 1, 2007)*

I. Smid, K. Cowan, E. Neubauer, P. Angerer, **"Thermal Properties of the Diamond-Copper Interface in Hot-Pressed Metal-Matrix-Composites,"** *136th Annual Meeting & Exhibition of the Minerals, Metals & Materials Society (TMS2007), Orlando, FL (February 25-March 1, 2007)*

I. Smid, **"MMCs from Particulate Composites – preparation, characterization, modeling,"** *University of Vienna, Austria, Dept. Physical Chemistry (March 16, 2007)*

M. Kitzmantel, E. Neubauer, C. Eisenmenger-Sittner, I. Smid, P. Angerer, **"Copper based Composites with carbon nanofibers,"** *International Conference on Powder Metallurgy & Particulate Materials (PowderMet2007), Denver, CO (May 13-16, 2007)*

E. Neubauer, M. Kitzmantel, C. Eisenmenger-Sittner, I. Smid, P. Angerer, **"Copper based Composites with carbon nanofibers,"** *Advances in Powder Metallurgy and Particulate Materials 2007 symposium, International Conference on Powder Metallurgy & Particulate Materials (PowderMet2007), Denver, CO, pp. 9.01–9.09 (May 2007)*

I. Smid, B. Risser, M. Huff, R. Toth, J. Keane, J. Smith, **"Evaluation of Fracture Toughness Using Palmqvist's Method Applied to TCHP Hard Metals,"** *International Conference on Powder Metallurgy & Particulate Materials (PowderMet2007), Denver, CO (May 13-16, 2007)*

I. Smid, E. Neubauer, **"Tailoring of Thermal Conductivity and CTE in Composites,"** *16th International Conference on Composite Materials (ICCM-16), Kyoto, Japan (July 8-13, 2007)*

I. Smid, E. Neubauer, **"Preparation and Interface Properties of Carbon Reinforced Copper-MMCs,"** *Proceedings of the 16th International Conference on Composite Materials (ICCM-16) Kyoto, Japan, pp. H.--H.7 (July 2007)*

D. Heaney, **"Lithographic Techniques for the Production of Micro and Meso Inorganic Components,"** *Nanotechnology: Innovative 3D Nanoparticulate Material Processing Innovative Forming Techniques, Materials Science & Technology 2007 Conference and Exhibition, sponsored by ACerS, AIST, ASM, and TMS, Detroit, MI (September 16-20, 2007)*

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