Summer 2008

Center for Innovative Sintered Products

CISP

The Pennsylvania State University
CISP Lab, 118 Research West
University Park, PA 16802-6809

Phone: (814) 865-2121 • Fax: (814) 863-8211 • E-mail: CISP@psu.edu • Web: http://www.cisp.psu.edu

Director's Message

The Center for Innovative Sintered Products has undergone significant transformation over the last few years. The number of memberships has decreased as a result of the loss of the Ben Franklin Grant. We currently have 17 members and are working on increasing this membership level by refocusing the research in specific topic areas. We have identified a few needs for the industry – one being graduate student education to serve the refractory and hard materials industry and the other being a lack of a fundamental understanding of the ways that polymers interact with powders. We are initially starting to market a consortium in Refractory and Hard Materials and are planning another consortium in the area of Powder Injection Molding. Please read about our concept for the Refractory and Hard Material Consortium in this issue. If you have a specific industrial need that an academic institute can help you with through precompetitive research, please contact us so that we can discuss getting the appropriate level of funding to be successful.

We have regrouped and are enhancing CISP industrial exposure. Our attendance at the 2008 World Congress on Powder Metallurgy & Particulate Materials, Gaylord National Resort & Convention Center, National Harbor, Maryland (Washington, D.C.) should help our effort. Come visit us at Booth Number 343. We have also reestablished ourselves with the Metal Powders Industry Federation (MPIF). We will participate in the MPIF Powder Metallurgy Basic Short Course, July 21-23 at the Penn Stater Conference Center Hotel, State College, PA. We are offering a tour of the CISP laboratory and are giving a presentation on PM Testing and Characterization.

CISP has also been proactive in the maintenance and acquisition of equipment. We have negotiated maintenance programs in exchange for in-kind membership in CISP with some equipment suppliers. We have also acquired a Spark Plasma Sintering (SPS) machine. Please see the write-up on our SPS device in this issue.

Industry can work with CISP in many ways – as a member, as a materials testing and services user, or in sponsoring proprietary research projects. Please contact us for more information and we look forward to serving the powder processing community. *Donald F. Heaney, dfh100@psu.edu, 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***
- ***Transformation Assisted Consolidation (TAC)***
- ***Financial Update***
- ***Contact Information***

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

Inside This Edition

Upcoming Events

July 21-23, 2008
Basic PM Short Course
University Park, PA
www.mpif.org

October 5-9, 2008
MS&T '08 - ACerS 110th
Pittsburgh, PA
www.matscitech.org

October 25-26, 2008
PM China 2008
Shanghai, China
www.China-PMexpo.com/en

November 16-20, 2008
Sintering 2008
La Jolla, CA
www.ceramics.org/sintering2008

January 18-23, 2009
33rd International Conf. & Exh. on Adv. Ceramics & Composites
Daytona Beach, FL
www.acers.org/meeting/schedule.asp

April 13-14, 2009
Materials Day
University Park, PA
www.mri.psu.edu/news.asp

April 15-16, 2009
Industrial Members Meeting
University Park, PA
www.cisp.psu.edu

Spark Plasma Sintering Machine

The Center for Innovative Sintered Products will be installing an SPS machine manufactured by FCT Systeme GmbH in its facility. The unit is expected to be installed by August of 2008. The equipment has been purchased by collaborative effort between the Applied Research Laboratory, College of Engineering, College of Earth and Mineral Sciences, The Department of Engineering Science and Mechanics, The Department of Materials Science, and the Materials Research Institute.

The unit is a Type: FCT HP D 25. The specifications are as follows:

- Mold Dimensions = Ø 200x300 mm
- Component Dimensions = Ø 80 mm
- Pressing Force = 250 kN
- Voltage = 10 V
- Current = 10000 A
- Power Consumtion = 85 kVA
- Max Temperature = 2400°C

Using the SPS technique, components are heated directly by DC current pulses, thus, cycle times of a few minutes are possible. It is believed that the DC current pulse results in enhanced sintering activity at point contact between particles, resulting in a plasma that acts to clean the particle surfaces and enhance densification. Lower temperature and pressures are expected, as compared to Hot Pressing. Possible applications for this technology are sputtering targets, functionally graded structures, structural ceramics, cemented carbide materials, and nanostructured materials

For more information on how you can have your material tested using this equipment or to discuss a research project, please contact Donald F. Heaney, CISP Director, dfh100@psu.edu, 814-865-7346 or Ivi Smid, Associate Director, smid@psu.edu, 814-863-8208.

Refractory & Hard Materials Consortium (R&HM)

A highly focused consortium within the Center for Innovative Sintered Products (CISP) at The Pennsylvania State University is proposed to meet the technology and workforce development needs of U.S. Refractory and Hard Materials Industries. Graduate recruiting specific to these technologies is difficult, since few U.S. schools emphasize such materials. Consequently international companies must turn to Europe and Asia to recruit students, sponsor research, and participate in non-U.S. consortia. A U.S.-based consortium is required to provide the educational and development resources for North America. The competitiveness of refractory and hard materials companies depends upon sustained industry and university-based research and technology development, and a continuous pipeline to industry of Masters and Ph.D. level graduates schooled in refractory and hard materials development and manufacturing technologies. This cannot be accomplished without an increase in graduate education and research related to refractory and hard materials. The Penn State Refractory and Hard Materials Consortium is well positioned to develop and deliver graduate education, provide technical workforce development, and conduct university-industry collaborative research programs that address these needs.

Penn State is uniquely capable of leading this effort. Penn State is ranked number one among American research universities for metallurgical and materials research funding, and "dominates the field internationally" according to the Institute for Scientific Information (ISI). A world-class powder processing laboratory already exists at Penn State within the Department of Engineering Science and Mechanics in the College of Engineering. This laboratory, known as the CISP laboratory, has powder processing and testing equipment that includes: powder characterization, powder shape forming (pressing, PIM), powder consolidation (sintering, HIP), and property evaluation (metallurgical, thermophysical, mechanical). Penn State has just placed an order for a 25 ton Spark Plasma Sintering (SPS) system to further enhance its sintering capabilities. Administered through the Department of Engineering Science and Mechanics and CISP, the consortium will engage in multidisciplinary activities in the Department of Materials Science and Engineering, the Materials Research Institute, the Penn State Applied Research Laboratory (ARL), a U.S. Navy University Affiliated Research Center (UARC), and other entities as project needs arise.

The goals of the Penn State Refractory and Hard Materials Consortium are to:

1) strengthen the U.S. Refractory and Hard Materials industry to ensure global competitiveness and meet national security needs;

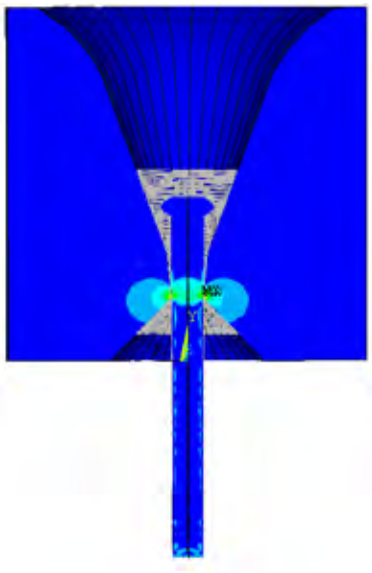
2) assure a pipeline of skilled Masters and Ph.D. level graduates to meet the technical workforce needs of the U.S. Refractory and Hard Materials industry; and

3) create high quality jobs and retrain the workforce in Refractory and Hard Materials technologies.

. . . continued on page 4

Research Snapshots

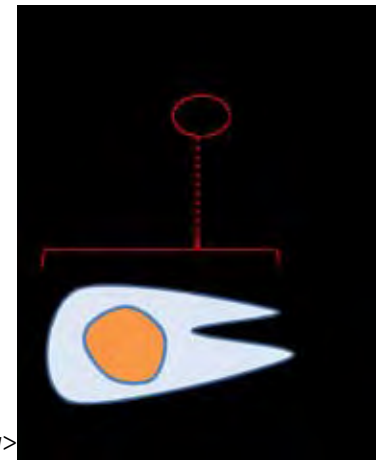
Composite Hard Metal for Wire Drawing Dies - Fabrication, Experimentation, Modeling



The process of pulling a wire through a series of conical shaped dies which incrementally reduces its cross sectional area is known as wire drawing. These wire drawing dies are subjected to extremely high stresses while at the same time expected to survive long service lifetimes. Finite element modeling was used to model the interactions of these materials throughout the wire drawing process. These models showed that during the drawing process the wire at the exit of the die reached local stresses of almost one and a half times its yielding strength. These stress concentrations were found to be small and only caused localized plastic deformation in the steel wire at regions directly near the die exit region. Significant stress oscillations were also found as the wire is pulled through the die which can cause distortion and possibly fracture in the wire. Future advances in these finite element simulations include determination of a relationship between drawing speed and these stress oscillations, wear lifetime as well as influence of temperature during drawing. *For more information on how you can become involved, contact Ivi Smid at 814-863-8208 or smid@psu.edu.*

Dan Cunningham <djc292@psu.edu>

Modeling Vickers Indentation Cracks in Hard Metals with Ceramic Inclusions

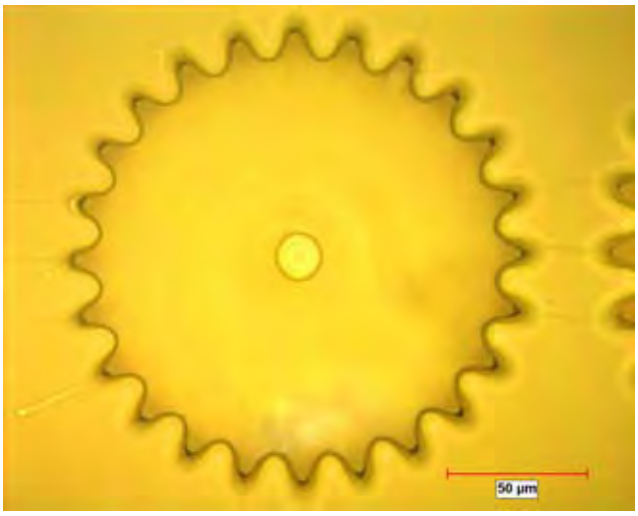


Tough coated hard particle (TCHP) based hard metals provide a combination of mechanical properties that is unmatched in conventional hard metals. Due to complex crack interactions at the microstructural level, accurately evaluating the fracture toughness of TCHP hard metals using Palmqvist's method requires great care. A finite element method (FEM) simulation detailing the stress distribution from Mode I loading conditions is presented. FEM is a useful tool for large length and time scales, but more information is needed to model the material's response at the crack tip. Future work will lie in detailing the crack/microstructure interaction at the crack tip using a molecular dynamics (MD) simulation.

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

Erik Bryne <emb229@psu.edu>

"ON-CHIP" Microcomponent Fabrication Utilizing Micron Size Powders



SU-8 Pattern on an Alumina Substrate. Pattern courtesy of Adair et al.

The current research is aimed to develop a technique for the mass manufacture of metal microcomponents utilizing micron size powders through the exploratory use of Mylar and SU-8 photoresist patterns. The trend for miniaturization creates a high demand for the mass production of microcomponents to be used for many engineering and biomedical applications. The effect of different binders, sintering times, solids loading, and shrinkage are being studied. The technique offers the ability to fabricate microcomponents with high resolution, high manufacturing rates, small features, low cost, and allows any alloy to be used for component fabrication. Non-powder based technologies are limited to certain types of metals that can be used to process components. This research will help aid in the development of a technique for the mass manufacturing of metal microcomponents utilizing micron size powders. *For more information on how you can become involved, contact Donald Heaney at 814-865-7346 or dfh100@psu.edu.*

Craig Shaffer <cvs118@psu.edu>

Testing Services

Materials Testing and Services within CISP helps give companies and academia access to specialized testing and equipment. **Thermal conductivity**, the rate of heat flow through a material is frequently requested. The flash method used at CISP determines the thermal diffusivity of a material and its heat capacity. If the density of the material is known, thermal conductivity can be derived. Major advantages of the test include using a small dime-sized sample and relatively quick testing at varying temperature points of interest. Disadvantages are that porous or non-homogenous samples require careful interpretation of results, and the testing equipment itself can be expensive. The equipment at CISP is capable of testing from room temperature to 1500°C in four atmospheres: hydrogen, nitrogen, argon, and vacuum. *For more information, 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/pricelist.htm .*

Staff and Student Updates

Tracy Potter, Lab Manager of the CISP laboratory for the last 15 years has elected to pursue a full time career in industry at his company, Advanced Powder Products, Inc., located in Philipsburg, PA (www.4.app.com). *Tracy can be reached at 814-280-2008.*

Three undergraduate students are participating in the summer research opportunities provided by CISP. **Minna Ranjeva** (Engineering Science) and **Anthony Kmetz** (Civil Engineering) are under the supervision of Ivi Smid. **Kevin Geist** (Mechanical Engineering) is under the supervision of Donald Heaney. These students are gaining valuable laboratory experience with emphasis on powder processing.

Jens Weyant graduated in May 2008 with an MS in Engineering Science. His Thesis, titled "Nano-Engineered Encapsulated-Particles for the Creation of Self Lubricating Coatings and Alloys", focused on reducing fretting within the dovetail joint of jet engines, with help from advisors Dr. Ivi Smid and Dr. Albert Segall. Jens is currently seeking employment in industry, particularly within the Central Pennsylvania area. *Jens can be reached at jens.weyant@gmail.com*

CISP is continuing its collaboration with the international community. **Michael Lefebvre** (Mechanical Engineering), an international student from the Institut Universitaire de Technologie de Bethune, France, is visiting the CISP lab this summer. Additionally, **Daniel Cunningham** will be traveling to the University Carolos III in Madrid, Spain to work with Dr. Torralba and to Acqui Terme for a week long series of powder metallurgy processing seminars. The international research experience is funded through a NSF grant given to the Mississippi State University.

Eric Gift graduated in May 2008 with a B.S. in Mechanical Engineering. He was recently hired by Polychem Systems (Reading, PA), a division of Brentwood Industries, Inc., as a project engineer. *Eric can be reached at Eric.Gift@Polychemsys.com or 484-651-1439.*

Renee Lindenberg was awarded the 2008 ESM Staff Legacy Award for Creativity and Innovation by the Engineering Science and Mechanics Department.

R&HM Consortium

. . . continued from page 2

Membership in the consortium will entitle the industrial partner to direct and have access to precompetitive graduate work in Refractory and Hard Materials. The industrial partners will decide how the research funds are spent based on the recommendations of CISP management and opportunities for federal funding. Consortium members can also sponsor private research programs on company specific topics. Newsletters will be sent twice a year highlighting research accomplishments and an annual meeting will be used to disseminate the precompetitive research findings. *For more information, please contact Donald F. Heaney, 814-865-7346, dfh100@psu.edu.*

Center for Innovative Sintered Products
The Pennsylvania State University
CISP Lab, 118 Research West
University Park, PA 16802-6809

Visit us on the web at: *www.cisp.psu.edu*

Phone: 814.865.2121 • Fax: 814.863.8211 • email: cisp@psu.edu

Donald F. Heaney, Director
Phone: 814-865-7346
Email: dfh100@psu.edu

Ivica Smid, Assoc. Director
Phone: 814-863-8208
Email: smid@psu.edu

CISP Newsletter
Published twice per year

Managing Editor
Renee L. Lindenberg

Layout and Illustrations
William E. Ames