Winter 2003

CISP

Center for Innovative Sintered Products

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There's Room for Success: Invest in Technology and Knowledge

Sharon L. Elder - Executive Director

Turning the calendar does not immediately change the state of the economy, yet everyone from the news media, politicians, to the optimist or pessimist is speculating on what this year will bring. To predict with any credibility one must know where you've been. I think back on the past year and realize there is some very forward-thinking work going on. CISP is now seeing a renewed interest in industry sponsored projects, thus giving an indication that the economic climate is recovering. Another example is in our equipment donations. This is a great use of company resources to boost exposure level and at the same time increase the expertise of students, thus increasing the size and quality of the future talent pool. During the next upturn one of the most frustrating dilemmas for a company will be the inability to find enough qualified people, so it is great to see this being addressed.

For the past 18 months, the news focus has been on finances and cutting costs with very little on technical developments. Let us not forget that technology is still the enabler and drives our desires. Although the market is still sluggish, the American consumer is still faced with overwhelming choices in products. Long ago we abandoned the Henry Ford - "You can have a Model T in any color - as long as it is black." It is staggering to consider our technological advances and think that in 1840 the US was producing 3000 goods. During this timeframe, people listed 16 needs and 72 wants - a horse, harness, hoe, wagon, roof over head, cooking pot, rifle, flint - just to name a few. By 1940 the US was producing 385,000 goods, now needs increased to 94 and wants to 484. One never thinks they have enough if they see more. Through research and development, we must focus on new processes, new materials, and new markets. Success for this industry rests in investments in technology and knowledge. These are two areas where CISP can most benefit the industry.

Mark Your Calendar

The CISP Industry Member Meeting will be held on 24-25 February 2003 at the Penn Stater Conference Center, University Park, PA. Open to all CISP members, this is an opportunity to hear technology updates on the 12 pre-competitive member and Ben Franklin Technology Development Authority sponsored projects, meet students and faculty, and network with other industry representatives. A special capabilities session will feature 25 industry representatives each giving 5 minute presentations.

PENNSTATE 1855
Center for Innovative Sintered Products

New Energy Cell

Porous substrates with high porosity of Nb, Mo-49Re, and Ir with controlled pore size are critical components for Alkali Metal Thermal to Electric Converters (AMTEC). The materials are used in a sodium regenerative cell that converts heat directly to electricity by converting sodium vapor to sodium ions in a closed loop cell. Production of these materials involves tailoring the size of powders to attain the correct green pore size for a given packing density through various combinations of presintering, milling, and sieving. Given the particle size D and fractional packing density f, the mean pore size d can be estimated by the following equation:

$$d = \frac{2}{3} \cdot \frac{D \cdot (1 \cdot f)}{f}$$

Reference: Particle Packing Characteristics, R. M. German, p 298

Although powder injection molding would be an ideal forming

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Upcoming Events

February 24-25, 2003
Industry Member Meeting
University Park, PA

March 17-19, 2003
PIM 2003
State College, PA

March TBA 2003
Understanding Particle Characteristics in P/M and Ceramic Processing
University Park, PA

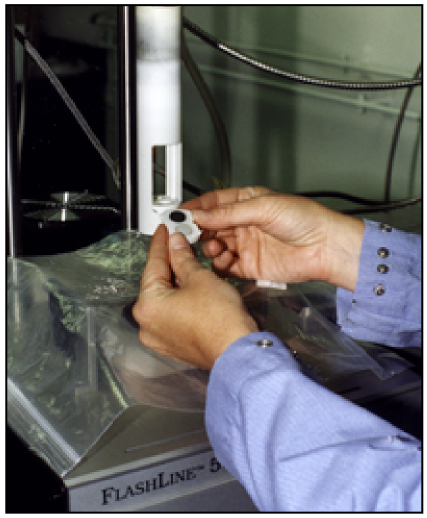
September 15-17, 2003
Sintering 2003
State College, PA

New Energy Cell *continued*

route, slurry casting was used to produce the required shapes, since the powder is expensive, and quantities are low. In this process, metal powder is mixed with melted wax and poured into a rubber mold, avoiding the need for hard tooling. After the parts are cooled and removed from the mold, the wax is removed by packing the parts in alumina powder for thermal wicking in high purity argon. The structures are then sintered in vacuum. Porosity and pore size distribution are measured by mercury porosimetry. The equation accurately predicted the sintered pore size,when sintering shrinkage is taken into account. A 7 µm Nb powder, packed to 55% density as-cast, produced a 2 µm pore size after sintering. The equation predicts a 3.8 µm green pore size for this condition. Contact: Neal Myers (nsm104@psu.edu)

Laser Flash Analysis Comes to CISP

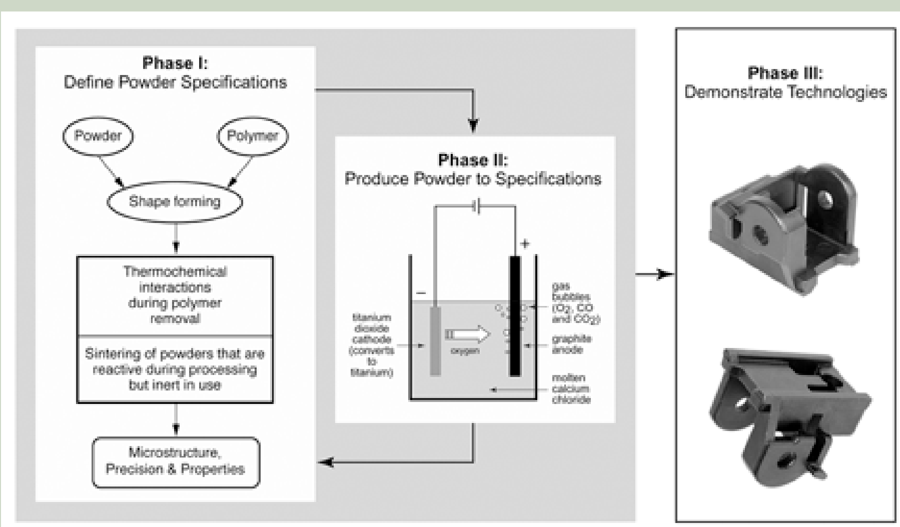
A new capability for thermal diffusivity and thermal conductivity analysis now exists in the CISP laboratory—the Anter Flashline 5000 thermal diffusivity laser flash analysis system. This system measures the dynamic thermal property, thermal diffusivity, by measuring the temperature transient when the sample material has been "flashed" with a burst of thermal energy. If the density and specific heat of the material are known, thermal conductivity may also be extracted from this measurement. The system can make measurements *in situ*, from room temperature to 1650 °C, in inert, hydrogen, and low vacuum environments. Sample configuration, shown at left, is a 12.7 mm diameter disk, 2-4 mm thick, and two samples may be tested concurrently. Our current work on this equipment includes the study of the evolution of thermal diffusivity and conductivity in the early stages of sintering, and the corresponding onset of handling strength, particularly with injection molded materials. Contact: Connie Schlaefer (ces947@psu.edu)



Two samples ready for loading--once placed on the sample holder platform, the tube will be lowered into the sintering furnace for testing.

Cost-Effective, Net-Shaped, Titanium Components: Powders and Processes

Titanium and its alloys have a useful combination of mechanical and corrosion properties for numerous advanced technologies, especially in the context of lightweight applications. Despite its relatively high natural abundance, difficulties in extraction and processing have been the major factors adversely affecting the cost and usage of titanium. To remove these barriers, the Center for Innovative Sintered Products and British Titanium, UK, have submitted a $2.75 million proposal to DARPA. The proposed work will combine a revolutionary process for producing titanium with new and emerging net-shaping methods based on powders and sintering. Titanium will be obtained by electrochemical extraction of titania using the Fray-Farthing-Chen (FFC) Cambridge Process, patented by British Titanium. The resulting powders will be tailored for the fabrication of high performance components from two net shaping routes, powder injection molding and direct laser sintering. The project will culminate with demonstrations of the new titanium technologies for producing net-shaped components. It is anticipated that the outcome of the research will significantly aid the development of low-cost advanced materials and processing methods for military, transportation, medical, chemical, and consumer applications. For further information, please contact: Sundar V. Atre (sva101@psu.edu)



Right: Three phases of DARPA proposal

Modeling of Thermal Debinding Project

Debinding and delubrication play a key role in the economics and successful application of all processes where a binder is used for shape retention of a ceramic or metallic body in the green state, as in powder injection molding (PIM), clay burning or pelleting. Long debinding times not only decrease the profitability of the process but also significantly increase the energy consumption.

To date, there are no robust and practical models for predicting the debinding behavior that could be used to save time and energy. Our goal is therefore to develop a model for simulating and optimizing the debinding process in a furnace. A simple model has been developed as a joint effort between CISP and Austrian Research Centers, which predicts the pressure build-up in the gas phase during burnout of the binder components.

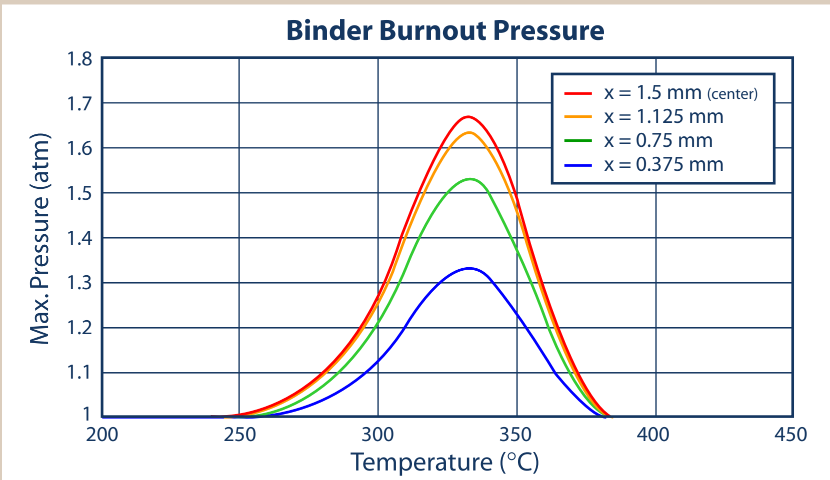
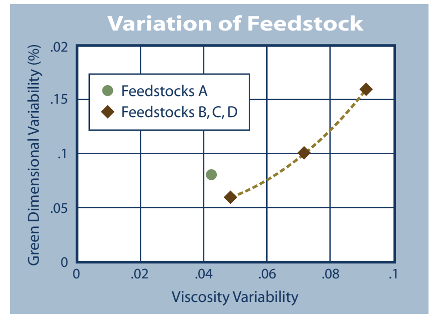


Figure above plots the pressure build-up at different locations of a 3 mm thick solvent-debound PIM component using a heating rate of 5°C/minute. An extension of the model will account for liquid binder motion and component deformation during debinding.

Contact: Rudolf Zauner (rcz1@psu.edu) or Donald Heaney (dfh100@psu.edu)

Six Sigma

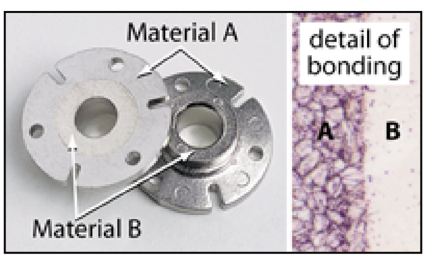
A correlation of an increase in green part dimensional variation as feedstock viscosity variation increases has been found in the CISP Six Sigma Project.



The effect of feedstock viscosity variability on the dimensional variability of green parts.

This relationship was found to be independent of powder type and mixing technique. The variation of feedstock viscosity was found to be lowest over the greatest temperature range for high-shear continuous compounding with a broad distribution irregularly shaped powder. Thus, this material would have the greatest process window for injection molding with the least variation. Contact: Rudolf Zauner (rcz1@psu.edu) or Donald Heaney (dfh100@psu.edu)

From Ideas to Reality



Traditionally, the combination of two materials into an integral component is done by welding, blazing or press fitting, which are extra operations that slow production and add to the overall expense.

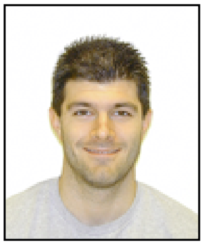
Advanced Materials Technologies (AMT) has successfully developed a "method to form multi-material components" using Powder Injection Molding (PIM). This innovation, which capitalized on AMT's core strength in PIM, was granted a patent by the US Patent and Trademark Office on 8 October 2002. CISP did initial studies to determine the success of bi-material injection molding using dilatometry as a main tool.

The injection molding of such bimetallic components is a single step manufacturing operation that eliminates mechanical assembly and the associated fixturing and handling of parts that must be properly oriented, thereby reducing manufacturing cost. The sintering process inherent to PIM allows the two different materials to achieve metallurgical bonding, the strength of which cannot be matched by any mechanical bonding process.

This invention offers engineers and designers another manufacturing solution, and opens a new horizon of applications. Already, AMT has adopted this invention into current production, initially for an automotive component. Further formulations of material combinations are emerging from ongoing development efforts such as given in these examples:

	1st Material	2nd Material
Characteristics	Magnetic	Non-Magnetic
	Hard	Soft
	High Thermal Conductivity	Low Thermal Expansion

Student"s Corner



Ethan Westcot

Ethan Westcot joined CISP as a graduate research assistant in August 2001, after receiving his B.S. in Physics from the University of Wisconsin-Whitewater. In November, he defended his master's thesis titled, "*In Situ* Observation and Evaluation of Solvent Debinding Mechanisms and the Effects on Powder Injection Molding Processing." He graduated in December with an M.S. in Engineering Mechanics and will begin his career at Smith Metal Products, MN in January. Best of luck, Ethan.

Alumni Association Dissertation Award

Debby Blaine

Congratulations to Ms. Deborah Blaine for being selected for the $5,000 Alumni Association Dissertation Award for her outstanding accomplishments in the area of sintered materials. Debby is a Ph.D. student in the Engineering Science and Mechanics Department with her thesis research in the Center for Innovative Sintered Products. Her area of research is on modeling sintering behavior, and investigating the micro- and macroscopic influences on sintering of various materials, such as 17-4PH stainless steel, nickel and W-Ni-Fe, so that these can be combined in sinter models. Her thesis is titled, "The Micromechanical Influences on the Constitutive Equations of Sintering using a Continuum Model". During the past year, Debby has worked on the ATP/NIST program "Powder Metal Injection Molding", focusing on developing a sintering densification and shrinkage model for PIM 17-4PH stainless steel injection molded with a Honeywell agar binder.

Outreach & Education

Manufacturing Materials, Process & Laboratory Course

CISP continues the partnership with the PennState DuBois campus. As part of the continuing education and instruction, Don Heaney, Research Associate at CISP and Director of the Development Center, will be teaching a 15 week course in St Marys, PA on Manufacturing Materials, Processes and Laboratory beginning 15 January 2003. For additional information please contact: Diana Ricotta at Penn State DuBois, phone: 814-375-4716 or email: dricotta@psu.edu

Faculty Profile

Albert E. Segall

Albert E. Segall received his Ph.D. in Engineering Science and Mechanics from the Pennsylvania State University in 1992. After completing his degree, Dr. Segall remained at Penn State and served as the Associate Director of the Center for Advanced Materials and a Senior Research Associate at the Applied Research Laboratory until 1999. In 1999, he joined the Washington State University Vancouver faculty as an Associate Professor of Mechanical and Manufacturing Engineering where he eventually became the Director of Engineering Programs. In 2002, Dr. Segall returned to Penn State as an Associate Professor in Engineering Science and Mechanics.

His research interests focuses on the thermo-structural behaviors and reliability of materials. This research includes the study of creep and fatigue behaviors of stainless steel PM alloys. Additional research interests include the development of probabilistic fracture and brittle-design methodologies and their application to the understanding of thermal shock behaviors of ceramics. Dr. Segall is also interested in the study of wear, friction, coatings, and the development of realistic tribo-test methods to assess wear-couples under industrially relevant conditions. An avid science fiction fan, he is working on innovative ways to integrate this genre as seen in movies and books with engineering education. (aesegall@psu.edu)

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