



Center for Innovative Sintered Products



Spring 2005

CISP

The Pennsylvania State University
CISP Lab, 147 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>



Highlights of PIM 2005

Sharon Elder –Executive Director

The fifteenth International Conference on the Powder Injection Molding of Metals, Ceramics, and Carbides organized by Innovative Material Solutions and supported by CISP was held at the Doubletree

Mission Valley Hotel in San Diego, California on 21-23 March. This was the sixth time I attended and noticed some of the regulars from previous conferences were not in attendance. Attendance was somewhat lower than previous years but there were many new faces. From Europe, Germany and Austria were well represented as well as Asia, but US participation was lighter than I expected. Some of this was due to the popularity of San Diego at this time. The hotel was completely booked, several other conferences were taking place, spring break, airline flights were full so last minute planners could not be accommodated. The program co-chairs were Rand German (CISP), Kuen-Shyang Hwang, National Taiwan University, and Marko Maetzig, Arburg GmbH + Co KG. A half-day tutorial program lead the conference on 20 March. This popular program provides a quick introduction for both practicing engineers and those contemplating PIM. The meeting was rounded out by a nice tabletop exhibit on Tuesday evening. This session was well attended and afforded an additional venue for discussions. As is the case with most meetings, several good discussions took place outside the conference room.

Some of the statistics and highlights from the meeting:

- Papers and participants at the meeting were from around the world—USA, Canada, United Kingdom, Austria, France, Germany, China, Slovenia, Russia, Japan, Korea, Malaysia, Taiwan, Thailand, and a few others.
- Over 45 oral and 15 tabletop presentations rounded out the program.
- A large percentage of the talks were from research organizations: CISP and Sandia National Lab from the US, Karlsruhe and Fraunhofer from Germany, and the micromolding group from Japan.
- CISP was well represented by both researchers from Penn State and member companies.
- There were many talks on micromolding, but little discussion of end-users.
- The overall MIM market was reported as flat the last couple of years. Potential industry consolidation similar to what GKN did with P/M was discussed. Some consolidation has taken place in Japan, which along with Taiwan, is becoming placed under increasing pressure by China, which now has 13-15 MIM companies.
- It is clear that the trend is towards microminiature PIM rather than large parts.

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For Members-Only

Special insert pages...

• **Liquid Phase Sintering of W-Cu**

Recent studies have investigated densification mechanisms during liquid phase sintering of W-Cu. W-Cu is a ...

• **Liquid Phase Sintering of Al Alloys**

Al alloys have been consolidated by uniaxial pressing and liquid phase sintering, and subsequently...

• **Critical & Optimal Solids Loading Determination for Feedstocks**

Solids loading is defined as the volumetric ratio of solid powder to the total volume of powder and binder...

• **Process Models for Fine Grained Molybdenum**

Research in the "Press and Sinter Processing Realities with Nanoscale Powders" identified unique ...

Portions of this newsletter are distributed to members-only. For more information on becoming a member visit our web site at www.cisp.psu.edu or contact Sharon Elder: cisp@psu.edu

Upcoming Events

April 20-21, 2005

Industry Member Meeting
University Park, PA

May 30-June 3, 2005

16th Int. Plansee Seminar 2005
Reutte, Austria

June 19-23, 2005

PM² TEC '05
Montreal, Canada

July 11-13, 2005

Basic PM Short Course
State College, PA

Aug 29-Sept. 1, 2005

Sintering'05
Grenoble, France

PENNSYLVANIA STATE UNIVERSITY



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- Despite substantial efforts to move in the direction of large components, this effort appears to be falling by the wayside due to difficulties with powder, cycle time, etc.
- Rand German presented an interesting talk on dimensional tolerances of 17-4 PH in the MIM industry. He came up with an average 3 sigma dimensional capability of ± 0.17 mm for the industry based on a review of 99 publications, internal reports, etc.
- Christian Kukla presented Battenfeld's approach to novel heat sink designs. Their concept is to hollow out round pins to increase the surface area for airflow from top to bottom. This produces a thin-walled structure with a high aspect ratio. The thinnest walls that could be filled were 0.26 mm. Battenfeld's Varitherm process was used for heating during fill and cooling the mold for ejection. Other thin-walled structures that required thermally cycling the mold included microchannels and sacrificial substrates for microparts.
- Two talks were given on MIM Ti. This continues to be an area of active research. One was a Korean group and showed typical densities and chemistries associated with hydride-dehydride powders. Another talk from Malaysia presented some of the problems associated with carbon contamination.
- John Johnson of CISP gave an interesting and well-received talk on bimaterial molding.
- Some of the problems that have been on-going are still perpetual. There is the same quality and dimensional issues which could be overcome with a good literature search.

The conference ran the gamut from the nano, micro-MIM to large parts. Overall, there is great potential especially at the microminiature level. Keeping the technology moving will require industry to hire quality people and continue to push the envelope. On a personal note, I would have liked to see more input from end users, economics, and marketing efforts. The next offering has yet to be determined, but will most likely be in the southeast US. Sharon Elder: cisp@psu.edu

Sintering 2005 Conference

The fourth International Conference on Science, Technology and Applications on Sintering will take place in Grenoble, France from 29 August to 1 September 2005.

The scope of the conference will be broad, covering all processes, materials and applications, there will be four topics explored particularly:



- Nano-structured materials
- Novel processes (microwave, spark plasma, etc.)
- Composite components (multilayers, graded materials, coatings, etc.)
- Multi-scale modelling and simulation.

The technical programme will include invited lectures, contributed papers, poster presentations and several roundtables on hot topics. Oral papers and poster presentations will be published in conference proceedings. An exhibition of local companies involved in powder processing, part production and equipment fabrication will be held during the conference. <http://www.emse.fr/sintering05>

Projects Proposed

CISP Industry Members are voting on the suite of research projects to begin 1 July 2005. The center offers members the opportunity to pool research dollars in support of precompetitive research projects, thus encouraging greater technical challenges they could not or would not do alone. All companies have the opportunity to vote on which projects they wish to go forward in the upcoming year. It is then the duty of the Industry Council to consider the votes, balance the portfolio, and make the final decision on which projects should go forward. The Industry Council will meet on 21 April following the culmination of the Industry Member Meeting.

Proposed Research Projects

- 1 - *Press and Sinter Processing Realities with Nanoscale Powders (nano-P/M)* – Randall M. German
- 2 - *Crack Detection in Green and Sintered Parts using EMATs* – Joseph Rose
- 3 - *Microfabrication of P/M Material by Hot Embossing* – Seong Jin Park, John Johnson and Randall M. German
- 4 - *Technical and Economical Comparison of Micro Powder Injection Molding* – Seong Jin Park and Randall M. German
- 5 - *Powder Injection Molding of Microminiature Devices: Dimensional and Property Characterization* – John L. Johnson
- 6 - *Economics of Powder Processing* – John L. Johnson
- 7 - *Oxyon Furnace Evaluation* – Donald Heaney and Tracy Potter
- 8 - *Heat and Mass Transfer in Rapidly Heated Powder Compacts* – Randall German and Ryan Koseski
- 9 - *Thermodynamic Modeling of Sintering* – Zi-Kui Liu and Raymundo Arroyave
- 10 - *Microstructural Evolution in Liquid Phase Sintering* – Jianfeng Guo and Randall German
- 11 - *Binder Removal in Nitrogen/Hydrogen Atmospheric Mixtures* – Lou Campbell

All member companies are encouraged to become familiar with, and take advantage of, or mentor any research project. Sharon Elder (cisp@psu.edu)

Dilatometer Determines Good Sintering Cycles

Troubleshooting or determining good sintering cycles for new or unknown materials is a common problem in research labs. A very useful tool for solving this problem is a high temperature dilatometer.

Traditionally, the dilatometer is used to determine the coefficient of thermal expansion (CTE) of materials. The CTE is the change in length per unit length of material for a one degree Centigrade change in temperature. Expansion versus temperature is recorded, and the CTE calculated for linear ranges.

In dilatometry for sintered materials, we look at shrinkage not expansion. In a typical test, the material will expand then shrink once densification begins. After recording the dimensional changes throughout the thermal cycle, the rate of maximum shrinkage can be calculated; the temperature at this rate is then used as the sintering temperature for powder metallurgy materials.

In both cases, the original height of a sample is recorded and the sample is placed between a flat plate and a movable pushrod. The pushrod maintains contact with the sample while recording changes in linear dimension. The model located at CISP is capable of running at a top temperature of 1500°C in hydrogen, nitrogen, argon or a mixture of these atmospheres.

Computer modeling softwares developed at CISP use shrinkage measurements to characterize sinter-models for particular material systems. Once the model is perfected, it can be used to predict density evolution for any temperature and time combination, and to design sinter cycles for optimal productivity and energy efficiency. Once density evolution is predicted, it can be used in furnace control software to obtain tailored densities.

The dilatometer in the CISP lab is available to members & non-members on a fee basis; members receive a discount off the cost. For the current price list visit: <http://www.cisp.psu.edu> (click on Testing & Services). Kristina Cowan (814) 865-2121, kcc126@psu.edu

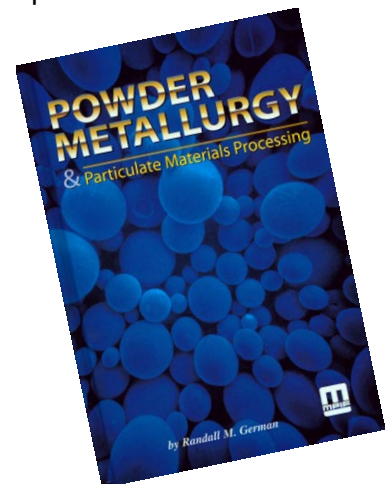


New Release

Powder Metallurgy and Particulate Materials Processing

As an outgrowth from the best-selling Powder Metallurgy Science, published in 1984, with a second edition in 1994, this book is written from a perspective based on the laws of physics, chemistry, mechanics and dynamics, thermodynamics, kinetics, and chemical engineering as applied to powder metallurgy and particulate materials. 536 pages. Available through MPIF: www.mpif.org

This is the 14th book written by CISP Director, Dr. Randall M. German. He is also the author of 737 articles, 19 edited books and 22 patents.



Keeping a balanced portfolio

One of CISP's missions is to foster industrial growth via the dissemination of technology so the whole industry can move forward. This entails the proper balance in federal and industrial sponsored funds. As we are planning for which precompetitive projects shall move forward for next year, we also have to make sure our portfolio is in proper balance. To achieve this goal we need a mix/balance of long- and short-term funding, industrial-government balance, and a strong global network with non-USA sponsors. (Currently our funding is about 1/3 industry, 1/3 pure government, and 1/3 hybrid). Over the past quarter we submitted several federal proposals. The funding awards at the federal level tend to be for more basic research where the commercialization aspect is 10 or more years away. This will assure our pre-capitalization goals are on target and that we are on a solid base in sintered materials research. Sharon Elder: cisp@psu.edu

Submitted Federal Proposals

- Nanoscience and Engineering Research Center: NanoParticulate Assembly and Processing
- Processing Science for the Production of Net-Shape Bulk Nanoscale Microstructures
- Shape Retention during Liquid Phase Sintering under an Electric Field
- Functionalization and Simulation of Carbon Nanotubes in Metallic (Al, Cu, Ni or Re) Matrices
- Metal and Ceramic Injection Molding of Biocompatible Materials for Surgical Implants
- Determination of the Grain/Pore Size Distribution of Sintered Metals from Viscoelastic Data
- Detailed Linkages from Powder Characteristics to Properties in Press-Sinter Processing of Metallic Transmission Gears
- International Planning Visit to the Tsinghua University, Beijing, China
- International Research Experience for Students in Innovative Sintered Materials

Visiting Researcher



José
Manuel
Martín

José Manuel Martín joined CISP as a visiting researcher from CEIT (Centro de Estudios e Investigaciones Técnicas) and the Engineering School of San Sebastián, University of Navarra, San Sebastián, Spain on 1 January 2005. He will be working at CISP for the next eighteen

months. His doctoral thesis was on liquid phase sintering of aluminium alloys: microstructural development, dimensional changes and final properties. José is now assisting on the NASA effort that involves identifying factors that control densification and distortion of tungsten heavy alloys during liquid phase sintering on earth and in microgravity.

CISP Forges Additional International Connections

The Center for Innovative Sintered Products (CISP) and the Northeast Asia Industry Technology Cooperation division (NATC) of Paichai University, Korea recently entered into a general agreement to foster international cooperation in education and research.

This agreement will encourage the exchange of activities involving several activities, such as:

- Construction of a database of technology
- Organization of joint international conferences and workshops
- Exchange of scholars and students
- Organizing of joint research information and materials

Opening of the International Interdisciplinary Material Research Center in Daejeon City, NATC is a cooperation between research institutions in China, Japan, Siberia and Korea. NATC is currently working with 3 colleges and will join the R&D district operation at Daejeon City in July 2005.

This center is targeted towards commercialization rather than research itself. It serves as the gateway to introduce fundamental technology that has been developed in Siberia and process technology from Japan to the local area.

This effort was made possible by Dr. Dae-Young Lim, Director, Northeast Asia Industry Technology Cooperation Division (NATC) and Professor, Division of Advanced Materials Engineering at Paichai and Dr. Randall German, Director of CISP. Dr. Lim recently completed a one year sabbatical at Penn State with Dr. Jim Adair, Material Science and Engineering.



Pictured L to R: Dr. Dae-Young Lim, Dr. Randall German, Sharon Elder and Dr. Seong-Jin Park.

Industry Member Meeting 20-21 April 2005

**Focusing on ...
Details**



Randall German Chair Established

The Randall German Chair in Powder Metallurgy will soon be established at the University Carlos III of Madrid, thanks to the efforts of Dr. José Torralba, Vice Rector of Research and Innovation. The chair will be sponsored by Banco de Santander Central-Hispano, a Spanish Bank (BSCH). The bank sponsors different research/teaching activities at the university with the primary goal to diffuse technology. The aim of this chair is to promote and spread P/M knowledge both within and outside the university through organizing seminars, inviting special speakers to contribute to the PM curriculum, exchanges, and lectures. Dr. Torralba will be in charge of the Chair and is now awaiting the final agreement. This chair is one more step in the CISP and UC3M history of working together. For the past three years PhD candidates from UC3M have completed a research rotation at the CISP laboratory. This scholarly exchange will continue this summer with three additional candidates arriving in May.



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visit us on the web at: www.cisp.psu.edu

Phone: (814) 865-2121 • Fax: (814) 863-8211 • E-mail: cisp@psu.edu

Randall M. German, Director

Phone: (814) 863-8025
E-mail: rmg4@psu.edu

Sharon L. Elder, Exec. Director

Phone: (814) 865-1914
E-mail: cisp@psu.edu

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Managing Editor

Sharon L. Elder

Graphic Designer

Rick Sharbaugh