PENNSTATE 1855

CISP

Center for Innovative Sintered Products

WINTER 2011 NEWSLETTER / 814-865-2121 / CISP@PSU.EDU / WWW.CISP.PSU.EDU

Director's Message

CISP has been busy performing contract research during the last six months. Our National Science Foundation microforming program has just completed. We successfully graduated two master's students – Kevin Geist and Li Li while working on this program. Kevin Geist's thesis was an evaluation of the dimensional capabilities that a powder-based lithographic processing technique could produce. Li Li's thesis was focused on final stage sintering. We addressed final stage sintering because the final stage is when the feature resolution can be maintained or lost – depending on your sintering process conditions. Our other areas of research have been in:

1. SPS, or FAST, of refractory metals – Industrial
2. Bonding of metals and ceramics – Industrial
3. Refractory-based ordinance components – Federal
4. Lubricant evaluation for conventional P/M applications – Industrial

CISP participated in the Metal Powder Industries Federation (MPIF) Powder Metallurgy (P/M) Short Course in State College, PA, during July 2011. During this event, I lectured on refractory and hardmetals – applications, properties, and processing, and P/M testing and characterization. This MPIF short course was well attended by more than 70 participants. This large attendance suggests our industry is on an upswing and there exists a growing need for trained employees. I have also noticed the industry is in need of qualified die setters. I have dialoged with Penn State Dubois to put together a proposal to address this need.

Consistent with the well-attended MPIF short course and the need for well-trained employees, our CISP students are quickly hired into industry. Kevin Geist has gone to work at PMG as a process engineer/tool designer and Derek Neupauer was hired as a mechanical engineer. To continue our training for the P/M industry, we have recently added four undergraduates to work in the laboratory. Daniel Smith and Joseph Yoder are working on their undergraduate theses under the guidance of Professor Ivi Smid. Two other students, Dylan Nelson and Clayton Burkhardt, will be working under my guidance. If you are looking for students trained in P/M please contact me.

Along with multiple publications on debinding and microforming, I am completing the editing of a book titled "Handbook of *Metal Injection Molding*." I have provided three self-written chapters and three chapters written with former colleagues. The rest of the chapters are written from experts around the world. Further information on this book is enclosed in this newsletter.

For more information on how you can be more involved with participating in CISP and maintaining this academic focused effort at Penn State, please contact us at cisp@psu.edu.

Member's Insider

Portions of this newsletter are distributed to members, only:

- Particle Size Determination Proposal
- Pore Mobility Controlled by Evaporation/Condensation

For more information on becoming a member, visit our website at www.cisp.psu.edu or send an e-mail to cisp@psu.edu.

CISP's website has been redesigned and updated. Let us know what you think: www.cisp.psu.edu

Inside This Edition

Upcoming Events

January 22-27, 2012
36th Intl. Conf. and Expo on Adv. Ceramics and Composites (ICACC'12)
Daytona Beach, FL
http://ceramics.org/tag/icacc12

February 2-4, 2012
PM-12 Intl. Congress and Exh. - New Vistas in Particulate Materials Technology
Mumbai, India
www.pmai.in

March 19-21, 2012
Intl. Conf. on Injection Molding of Metals, Ceramics and Carbides (MIM2012)
San Diego, CA
www.mpif.org

April 10-11, 2012
Industrial Members' Meeting
University Park, PA
www.cisp.psu.edu

April 23-24, 2012
Materials Day 2012
University Park, PA
www.mri.psu.edu/events/materials_day/

June 10-13, 2012
MPIF/APMI Intl. Conf. on Powder Metallurgy & Particulate Materials (PowderMet2012)
Nashville, TN
www.mpif.org

Visiting Professor from China

Figure 2.1: Dr. Haiqing Yin visiting Washington D.C. on her sabbatical leave to the United States.

Dr. Haiqing Yin took her sabbatical leave from the University of Science and Technology Beijing, China from April to September 2011 with the Center for Innovative Sintered Products in collaboration with Ivi Smid, associate professor of engineering science and mechanics. Dr. Yin worked with facilities covering both the production process of powder metal and metal injection molding parts, and the evaluation of characteristics of powders and compacts. Dr. Yin had comprehensive discussions with numerous researchers in the College of Engineering and the College of Earth and Mineral Sciences, assessing future collaboration in experimental powder metal and FE modeling. Currently a detailed plan is being drafted for the selection of simulation software for verification of experimental data.

Dr. Yin's research focuses on advanced powder metal technologies for high velocity compaction (HVC) and micro powder injection molding (μPIM). The HVC compacts of iron-based alloys, with the powders made in China, have been obtained with green densities of 7.49-7.51g/cm^3. Micro-sized metal and ceramic gears with an addendum circle diameter ranging from 200-900 μm have been achieved with good dimensional precision. At the same time, molds of WC-Co for μPIM have been obtained with a complicated cavity shape, capable of substituting for the current silicon wafer molds. With the ever increasing needs and potential for industrial application, she has recently been focusing her research on the creation of a national materials database.

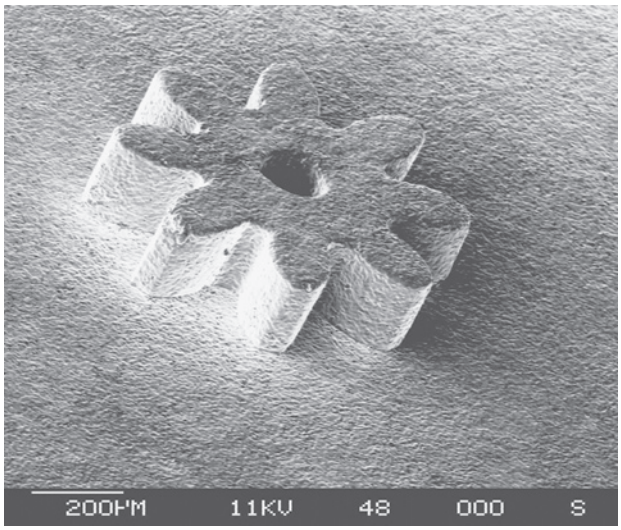

Figure 2.2: SEM image of micro-sized metal gear obtained through micro injection molding.

Dr. Yin gave a presentation on her work in high velocity and micro powder injection molding at Penn State. She also attended three conferences while in the United States: the International Conference on Tungsten, Refractory and Hardmaterials VIII on May 18-22 in San Francisco, CA; the 1st World Congress on Integrated Computational Materials Engineering (ICME) on July 10-14 in Seven Springs, PA; and the International workshop on Field Assisted Sintering Technology on August 24-25 at Penn State.

Dr. Yin has returned to China and is preparing for long-term collaboration efforts between Penn State and the University of Science and Technology Beijing. *For more information, contact Ivi Smid at 814-863-8208 or smid@psu.edu.*

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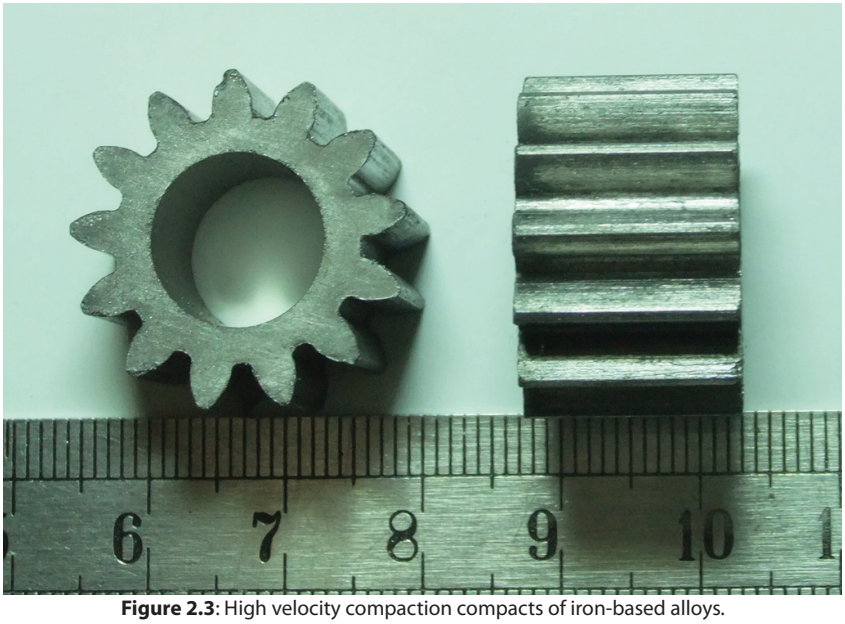
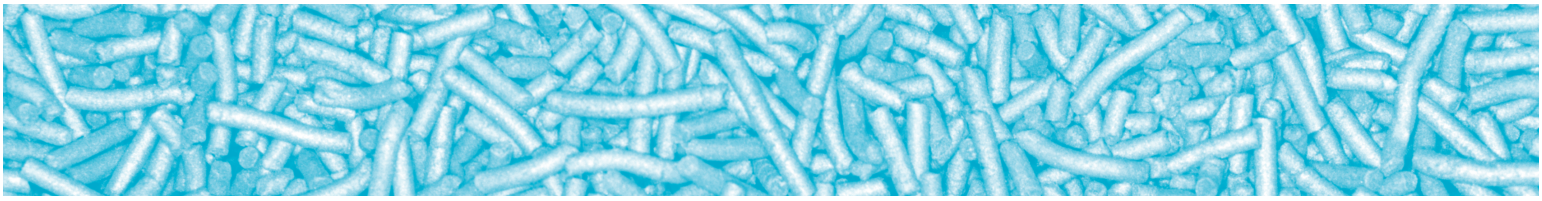


Figure 2.3: High velocity compaction compacts of iron-based alloys.



Handbook of Metal Injection Molding

Metal injection molding (MIM) is a well-developed technology for the manufacture of precision components. With component properties comparable or superior to wrought steel, the MIM process is perfect for producing small and complex parts with outstanding mechanical properties. Edited by a leading expert in the field, this authoritative handbook provides the ideal guide to the process and its wide range of applications. After an introductory overview, Part I discusses processing issues from design, powders and binders to tooling, molding, debinding, and sintering. Part II reviews quality issues such as characterisation of feedstock, modelling, common defects, qualification, and control of carbon content. The third part of the book considers specialized MIM processes such as micro MIM, 2C-PIM, and porous MIM. The final section reviews MIM processing of particular materials such as stainless steels, titanium alloys, refractory metals, and soft magnetic materials. The book will be a standard reference both for those new to MIM as well as those looking to use the process to produce high-quality components.

1. Metal powder injection molding (MIM): key trends and markets, *R. M. German*

Part I Processing

2. Designing for MIM, *D. F. Heaney*
3. Powders for metal injection molding, *D. F. Heaney*
4. Powder binder formulation and compound manufacture in metal injection molding, *S. Atre and R. Enneti*
5. Tooling for metal injection molding, *G. Schlieper*
6. Molding components in metal injection molding, *D. F. Heaney and C. D. Greene*
7. Sintering of metal injection molding components, *S. Banerjee and C. Joens*

Part II Quality issues

8. Characterization of feedstock in metal injection molding, *H. Lobo*
9. Modeling and simulation of metal injection molding, *T. Kang, S. Ahn, S. Chung, S-T Chung, Y-S Kwon, S. Park, and R. M. German*
10. Common defects in metal injection molding, *K. Hwang*
11. Qualification of metal injection molding, *D. F. Heaney*
12. Control of carbon content in metal injection molding, *G. Herranz*

Part III Special metal injection molding processes

13. Micro metal injection molding, *V. Piotter*
14. Two material/two colour powder metal injection molding (2C-PIM), *P. Suri*
15. Powder space holder metal injection molding (PSH-MIM) of micro-porous metals, *K. Nishiyabu*

Part IV Metal injection molding of particular materials

16. Metal injection molding of stainless steels, *J. Torralba*
17. Metal injection molding of titanium and titanium alloys, *T. Ebel*
18. Metal injection molding of thermal management materials in microelectronics, *J. Johnson*
19. Metal injection molding of soft magnetic materials, *H. Miura*
20. Metal injection molding of tool steels and carbides, *N. Myers and D. F. Heaney*
21. Metal injection molding of heavy alloys and refractory metals, *D. F. Heaney and J. Johnson*

540 pages; 234 x 156mm hardback; Publication: June 2012; ISBN : 978 0 85709 066 9; approx. £155/US$265/€185

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Copper-Diamond Composites for Heat-Sink Applications

Diamond metal-matrix-composites (MMC) are of high interest for advanced thermal management as they can combine high thermal conductivity with a tailorable coefficient of thermal expansion. New powder coating and consolidation techniques like thermal diffusion coating and rapid hot pressing were developed to improve the thermal cycling stability of these attractive heat sink materials. The interface is the key to exploiting the potential of diamond-MMC and has to be designed properly. The interface has to be modified by alloying additions to minimize the Thermal Contact Resistance (TCR) and to maximize the adhesion strength between Cu and C. Thermal conductivities up to 600 W/mK and a coefficient of thermal expansion below 10 ppm/K have been achieved. This development has been completed in collaboration with the Austrian Research Center Seibersdorf. *For more information, contact Ivi Smid at 814-863-8208 or smid@psu.edu.*

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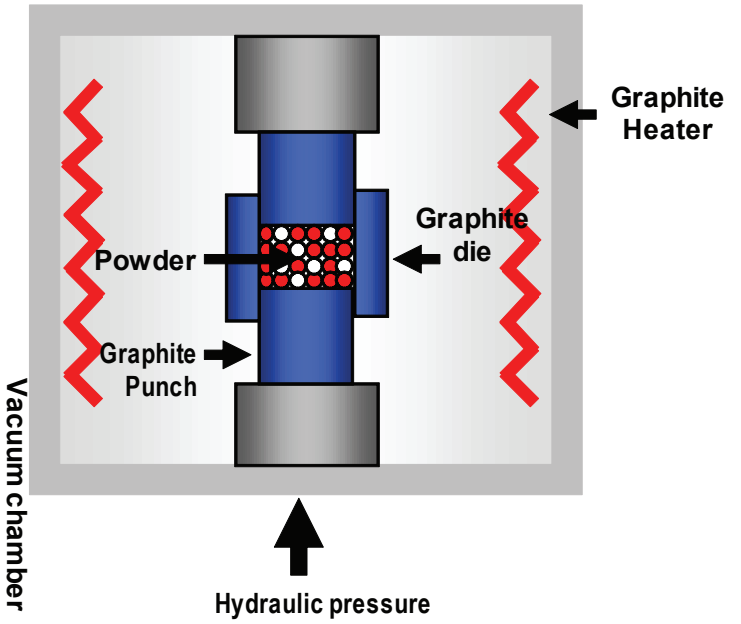

Figure 4.1: Hot-press and/or SPS-consolidation of Cu-Diamond powders

Materials Day 2012 Converging on Materials

An opportunity for industry and government agencies to connect with Penn State scientists. The convergence of engineering, physical science, and life sciences, augmented by high-speed computation and data integration, is opening new frontiers in medicine, energy, communications, manufacturing, and consumer products. Join us for an exciting Materials Day program on **April 23 - 24, 2012**, focusing on the important roles materials play in these technologies. Nationally recognized speakers, breakout sessions on topics relating to convergence, "Tools and Tutorials" workshops, and tours of the Millennium Science Complex - a new research building for 21st century science - are scheduled. The events will take place on central campus.

TA Instruments Acquires Anter Corporation

TA Instruments announced the acquisition of Anter Corporation and Anter Laboratories of Pittsburgh, PA, a privately held manufacturer of high performance systems that measure thermal expansion, thermal conductivity, thermal diffusivity, and heat capacity of a wide range of materials in July.

Commenting on the acquisition, Terry Kelly, president of TA Instruments said, "This acquisition adds powerful technologies which complement TA Instruments' market leading thermal analysis product line. The combination of TA and Anter technologies and the integration into TA's worldwide sales and technical support organizations will greatly benefit scientists who need to characterize the thermophysical properties of high temperature materials."

Key products developed by Anter include Laser and Xenon flash systems designed to measure thermal diffusivity and heat capacity of materials up to 2800°C, Dilatometer systems to measure thermal expansion and Guarded Heat Flow meters that measure thermal conductivity of materials in accordance with ASTM standards. Anter systems provide critical information to scientists that develop and characterize ceramics, metals, and glasses for use in a wide range of industries including electronics, energy, and aerospace.

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