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CISP

Center for Innovative Sintered Products

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Director's Message

CISP continues to maintain a strong position in particulate processing R&D. Recent activities include the 2010 Industrial Member's Meeting on April 13 and 14 and an invited presentation to the MPIF Refractory Metal's Association Meeting in Washington, DC, on March 24. Research programs in microforming, carbide debinding and sintering, two material injection molding, SPS (FAST), and final stage sintering are under way.

The 2010 CISP Industrial Member's Meeting was a success. Our attendance records indicate that 12 different companies and 31 participants were present. Highlights of the meeting included a review of graduate students' projects on microforming, final stage sintering, precipitate hardened alloy development, cold spray, a review of the capabilities of the Dr. Fritsch Direct Hot-Pressing Technology, and an invited presentation on Benchtop Solution Routes to Nanoparticulate Solids. We at CISP hope to see you at our next meeting in April 2011. We look forward to your future involvement.

CISP continues its effort in refractory and hard materials. The Kennametal Foundation has continued their funding and we are preparing our center plan to present to industry. Our survey suggests a center of $250,000 to $500,000 with two levels of membership based on company annual sales. If you would like to review the new center plan and bylaws and did not participate in the survey, please contact us. With the addition of a new Spark Plasma Sintering unit and the already in place infrastructure focused on metal particulate processing, CISP is ideally suited to serve this industry.

CISP plans on participating in the upcoming MPIF PM short course being held here in State College on July 26 – 28. During this event, CISP will lecture on Refractory and Hardmetals – applications, properties, and processing, and testing of P/M products.

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:

- Micro Forming with the Use of Lithographic Technology
- The Effect of Vacuum on Final Stage Sintering
- Porous Nickel Electrodes for Fuel Cells
- Engineered Self-Lubricating Coatings Utilizing Cold Spray Technology
- Development of New Compositions and Processing of High Strength Cast Steels
- The Development of High Strength Cast Steels with Increased Low Temperature Toughness
- Student and Staff Contact Information

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

Inside This Edition

Upcoming Events

June 27-30, 2010
PowderMet 2010
Hollywood (Ft. Lauderdale), FL
www.mpif.org

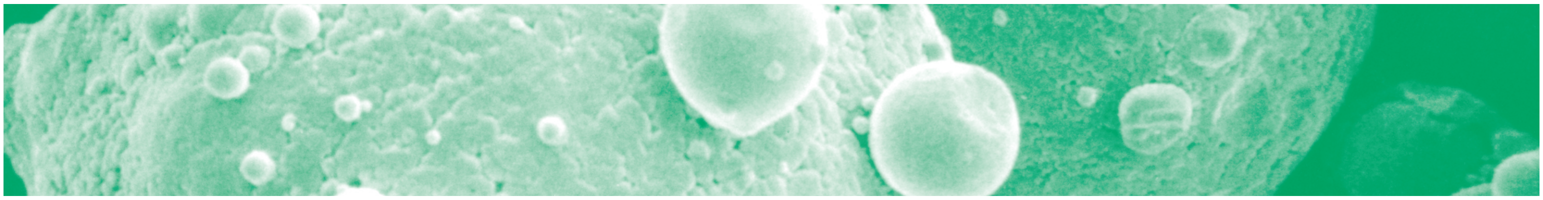
October 10-14, 2010
PM2010 Powder Metallurgy World Congress & Exhibition
Florence, Italy
www.epma.com/pm2010

October 17-21, 2010
Materials Science & Technology 2010 Conference & Exhibition (MS&T'10)
Houston, TX
http://matscitech.org

October 18-20, 2010
2nd International Powder Metallurgy & Advanced Ceramics Exhibition & Conference
Shanghai, China
www.China-PM-ACE.com/en

January 23-28, 2011
35th International Conference & Exhibition on Advanced Ceramics and Composites
Daytona Beach, FL
http://ceramics.org/icacc-11

April 2011
Industrial Members' Meeting
University Park, PA
www.cisp.psu.edu



Laser Cladding: A Technique for Repair and Manufacture via Powder Fusion

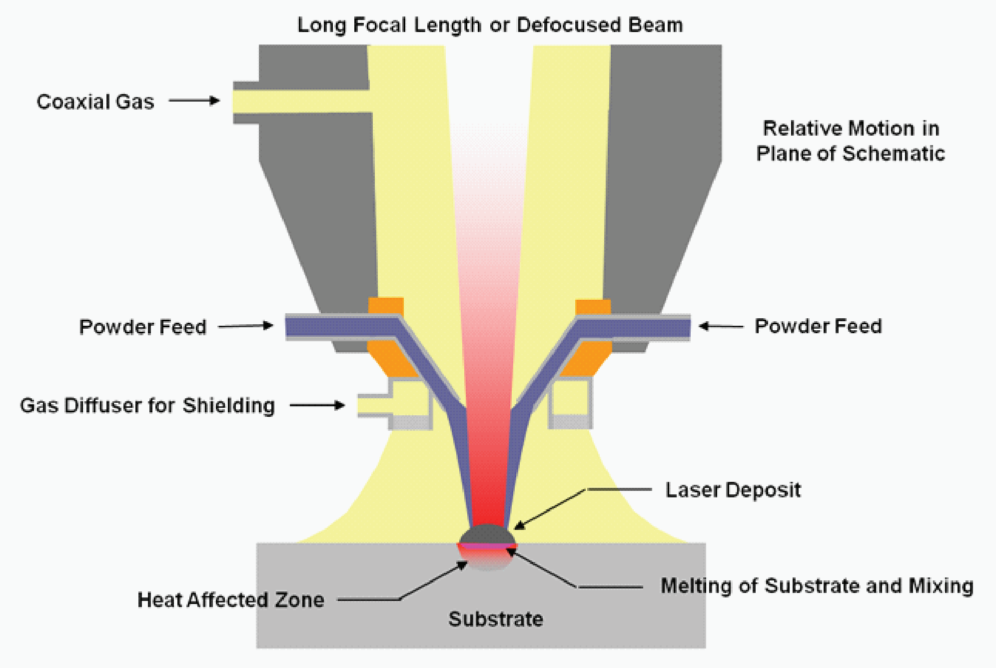


Figure 1: Schematic of laser cladding process. Courtesy: Applied Research Lab, Penn State

Figure 2: Near net shape cladding:- Tube is Inconel on the bottom and nickel-aluminum-bronze on the top. Courtesy: Applied Research Lab, Penn State

Cladding is a process of fusing material with desired properties onto a substrate via melting ofpowder or wire. Low dilution and distortion, along with a fully metallurgical bond, are primary objectives of the cladding process. Cladding carried out by conventional welding methods such as gas tungsten arc welding, oxy-acetylene flame or plasma surface welding (GTAW), produce a sound metallurgical bond but often result in significant distortion and dilution of the clad layer. This dilution requires laying down of thick and/or multiple layers to achieve the desired clad properties. Laser cladding, on the other hand, utilizes highly controllable low heat input and can provide a fully metallurgical bond with low dilution, low porosity and a limited heat affected (HAZ) zone. Additionally, the low heat of the laser clad can limit thermal distortion that often accompanies clad processes. Pre-placement of cladding material as powder on the substrate, injection of cladding-material into the laser path via powder feeder, and feeding of clad material in the form of wire are among the common methods of supplying material. Laser power, wavelength, spot size, velocity of the scan, feed rate of the cladding material, surface contamination, and process gases are all important factors that affect the quality of the clad. The blown powder laser cladding is more popular than other methods for certain applications, as it is highly controllable and thus readily adaptable to automated processing. Laser cladding can be used for a wide variety of purposes, including the application of wear-resistant or corrosion-resistant coatings, the repair of corroded, worn, or otherwise damaged workpieces, and the complete manufacture of near net shape 3-D components. While many applications are found in the automotive, aerospace, power generation, and shipbuilding industries, laser cladding has also been used in quite diverse applications, e.g. to coat hydroxyapatite onto titanium prosthesis for improving cell adhesion. *For more information, contact Ravindra Akarapu at 814-867-1571 or rxa186@psu.edu or Edward Reutzel at 814-863-0449 or ewr101@psu.edu.*

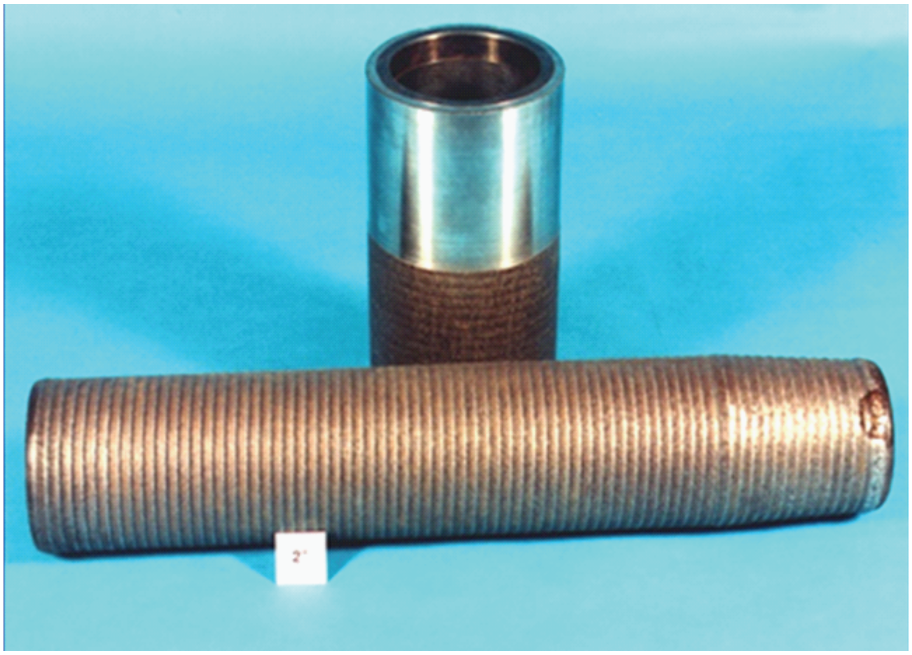
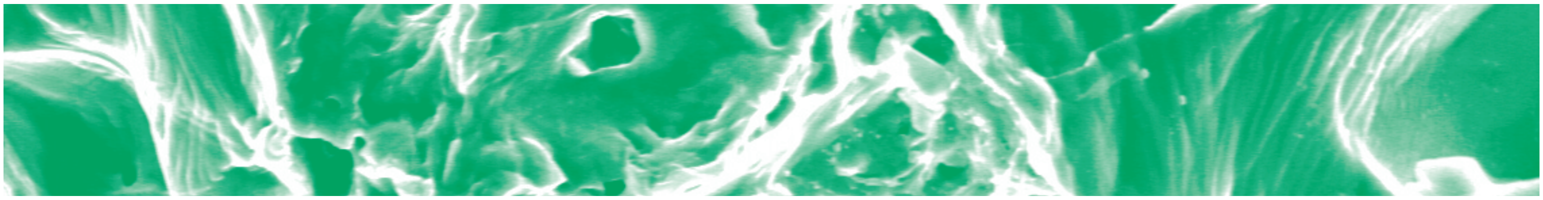


Figure 3: Laser cladding for refurbishiment and as replacement for chrome plating of large struts for Caterpillar Corporation. Courtesy: Applied Research Lab, Penn State

Ravindra Akarapu, Research Associate, Department of Engineering Science and Mechanics
Edward Reutzel, Department Head, Laser System Engineering and Integration, Applied Research Lab



Benchtop Solution Routes to Nanoparticulate Solids

Benchtop solution chemistry tools are powerful for producing nanoparticulate solids with a wide range of morphological characteristics, including controllable shapes, sizes, and size dispersities. The techniques for doing so range from simple open-air aqueous systems to rigorously air-free reaction setups, depending on the chemical system and morphological requirements. For metal and alloy nanoparticles, typical chemical methods involve the reaction of soluble metal precursors with reducing agents, or thermal decomposition of zero-valent metal complexes, to ultimately transform the soluble precursors to insoluble zero-valent metals. Chemical additives in solution help to mediate size and shape control by truncating growth and stabilizing certain crystal facets, as well as ensure dispersibility in the solvent. While rigorous size and shape control of a growing number of metal and alloy systems (as well as other materials such as oxides, phosphides, and chalcogenides) is readily achievable using chemical methods, it can be challenging to scale these reactions to bulk quantities.

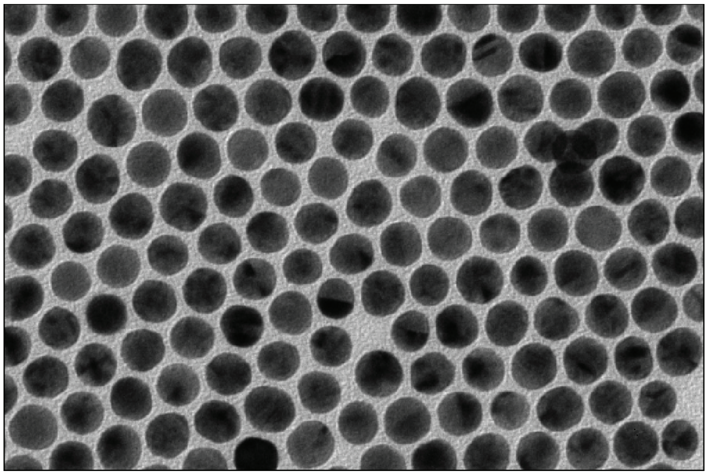


Figure 1: Chemically-synthesized AuCu alloy nanoparticles with uniform sizes of ~10 nm.

We have been developing solution routes to "exotic" nanostructured solids in a variety of chemical systems, including transition metals, alloys, and intermetallic compounds, as well as metal phosphides, oxides, sulfides, selenides, borides, and carbides. This talk provided an overview of our synthetic capabilities, focusing on solution routes to nanoparticulate transition metal solids. A brief overview of general capabilities in metal nanoparticle synthesis using solution chemistry routes was provided, along with a survey of elemental systems that have and have not been successfully synthesized using these routes. We have been focusing on the development of chemical routes to metal nanoparticle systems that have traditionally not been the focus of such studies, particularly because of challenging chemical limitations. This talk highlighted our capabilities involving room-temperature benchtop chemistry routes to colloidal nanoparticles of elemental indium and germanium, as well as more traditional high-boiling solvent routes to rhodium and gold nanoparticles. Chemical challenges and recent capabilities for more exotic early transition metal systems, including tungsten and manganese, were highlighted.

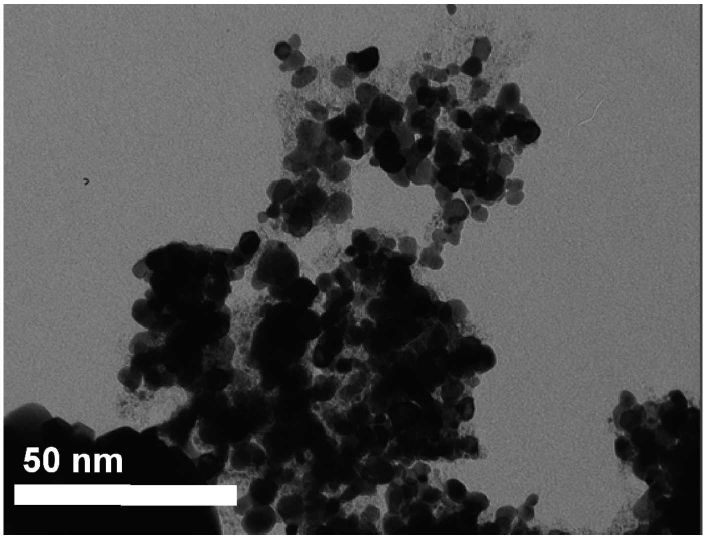


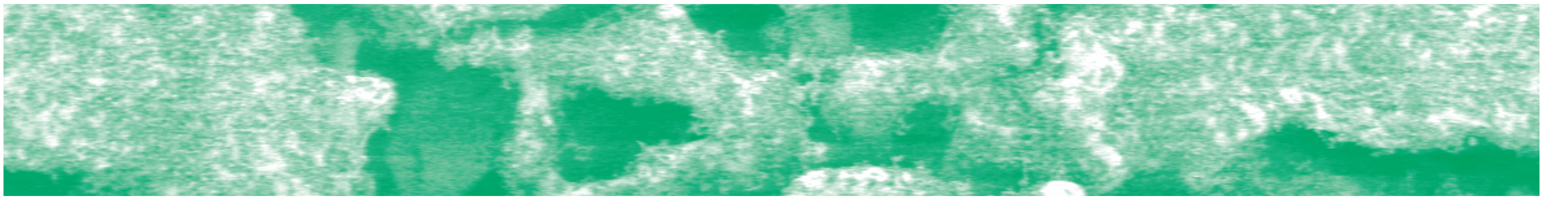
Figure 2: Chemically-synthesized tungsten nanoparticles

Historically, it has not always been straightforward to use these solution chemistry methods to synthesize multi-metal nanoparticles, particularly intermetallic alloys. Our efforts to simplify and significantly expand these synthetic capabilities for intermetallic nanoparticles were highlighted, with a focus on the "conversion chemistry" paradigm: the use of easy-to-make metal nanoparticles as templates ("reagents") for chemical transformation into traditionally difficult-to-make nanoparticle systems ("products"). Using this approach, we can engineer rigorously shape-controlled single-crystal nanoparticles of a diverse range of alloy systems using a robust and unified chemical toolbox of reactions.

One particularly exciting consequence of using low-temperature solution chemistry routes to synthesize metal, alloy, and other nanoparticles is the possibility of stabilizing non-equilibrium phases that are not accessible using traditional high-temperature methods for synthesizing solids, such as powder metallurgy or arc melting. This talk provided an overview of non-equilibrium phases that we have recently accessed as nanoparticulate solids, including the $L1_2$ intermetallics Au_3Fe, Au_3Ni, and Au_3Co, wurtzite-type MnSe and ZnSe, and Au-Rh alloys.

Finally, we discussed recent efforts to scale-up reactions to generate larger quantities of samples. As an example, we highlighted the synthesis of bulk dense pellets of ternary thermoelectric alloys, along with the electrical transport properties. We also highlighted other efforts in processing and property measurement that focus on scale-up and bulk transport measurements. In particular, modifications to these chemical methods for synthesizing metal nanoparticles can produce mm-sized single crystals of certain intermetallic compounds that include $CoSn_3$, $FeSn_2$, and Ni_3Sn_4. *For more information, contact Raymond Schaak at 814-865-8600 or res20@psu.edu.*

Raymond Schaak , Associate Professor, Chemistry



Powder Based High Deposition Rate Laser Cladding

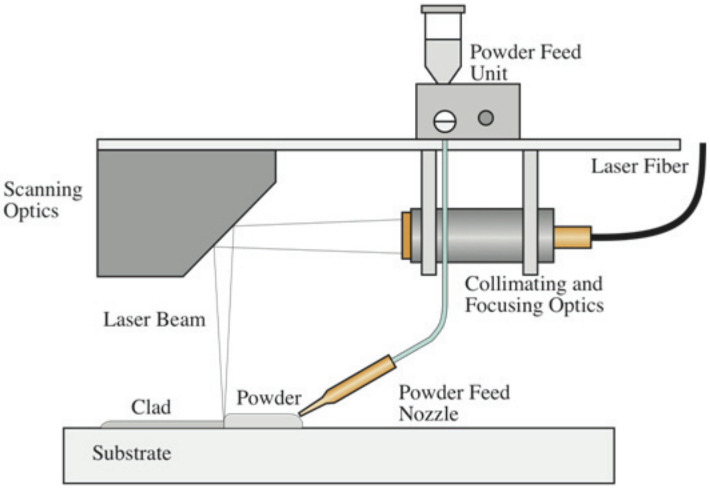


Figure 1: Schematic diagram showing the experimental set-up for high deposition rate laser cladding.

The application of corrosion and wear resistant coatings on structural materials using the laser cladding process is becoming more common with the introduction of new and more powerful laser systems. Laser cladding is characterized by lower heat input levels and lower base metal dilution than widely used arc based cladding processes. High deposition rate laser cladding (25- to 30 lbs. per hour) at moderately rapid travel speeds (20 inches per minute) has been demonstrated at the Applied Research Lab with high power fiber delivered laser systems. These deposition rates are equivalent to those obtained in SAW and electro-slag cladding, showing that laser cladding can be a viable option for new and existing applications. On the other hand, the powders currently used for these operations are optimized for plasma transferred arc (PTA) processes, which have resulted in mechanical deficiencies, particularly with Alloy 625 laser clads. Changes in material chemistry and powder size distribution must therefore be investigated to optimize the powder to the unique characteristics of laser processing. *For more information, contact Todd Palmer at 814-863-8865 or tap103@psu.edu.*

Todd Palmer, Research Associate and Assistant Professor, Materials Science

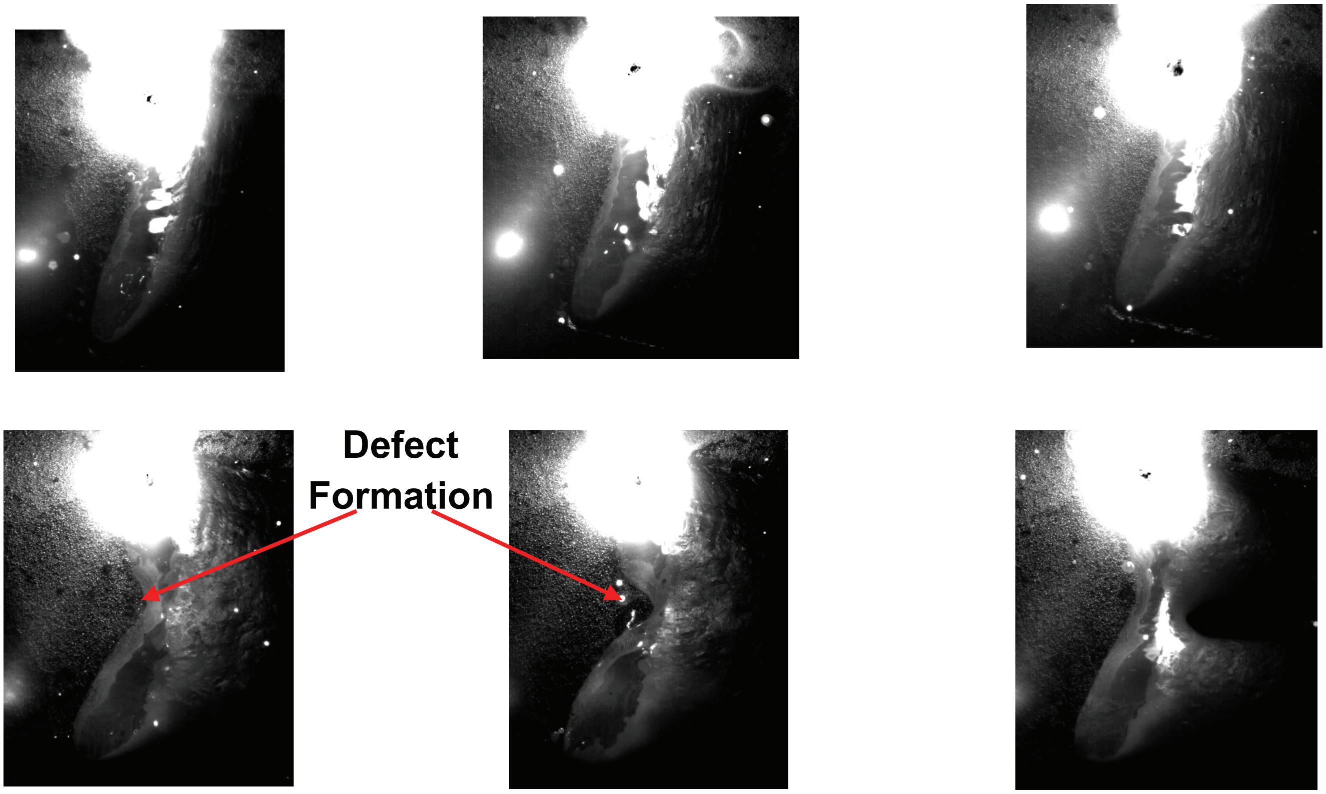


Figure 2: High speed camera images showing acceptable and unacceptable laser clads forming.

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