JTTEE5 17:167–168
DOI: 10.1007/s11666-008-9172-6
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News from Research and Technology Institutes Worldwide

This column informs *JTST* readers of activities in research and technology institutes active in the field of thermal spray technology. Technical overviews help the reader to understand the primary focus of the institution and the needs driving their thermal spray research and development. Getting to know the research interests and professional experience of our thermal spray colleagues allows us to better recognize experts in specific fields of study. Knowledge of institutional expertise is important for developing complementary partnering relationships to increase the fundamental understanding of thermally sprayed materials and increase the quality and breadth of practical applications.

This column includes articles giving an overview of current activities or a focus on a significant breakthrough. To submit an article for this column, please contact Kendall Hollis, *JTST* Associate Editor at: Los Alamos National Laboratory, P.O. Box 1663, MS G-770, Los Alamos, NM 87544; e-mail: kjhollis@lanl.gov.

Thermal Spray Research at Los Alamos National Laboratory

Thermal spray research at Los Alamos National Laboratory (LANL) is focused on meeting U.S. national needs in the areas of toxic/hazardous materials, high temperature oxidation resistant materials, high stress tolerance materials, reactive molten metal containment materials, net-shaped spray-formed parts, and the evolving coating needs of U.S. national security programs.

LANL is a multidiscipline research laboratory operated for the U.S. Dept. of Energy. The primary mission of LANL is performing research and development to meet U.S. national security needs. LANL is spread over 110 km^2 of the Pajarito Plateau in the Jemez Mountains of north central New Mexico.

Thermal spray R&D at LANL is part of the Materials Science and Technology (MST) division. Thermal spray activities are focused on meeting internal LANL needs and providing unique research facilities for use in the national interest. As part of the MST division, the emphasis of thermal spray R&D is on understanding the interaction between materials processing, properties, structure and performance as in the materials tetrahedron proposed by Merton Flemings in his 1989 National Research Council report titled Materials Science and Engineering for the 1990s.

The thermal spray activities are divided up into two categories: beryllium and non-beryllium. The high hazards inherent in handling and processing beryllium in the particulate form have necessitated a specially designed facility for the beryllium work. The beryllium thermal spray activities are carried out in the Beryllium Technology Facility (BTF), which is dedicated to beryllium processing. The BTF ventilation and particulate control enclosures are designed to keep airborne beryllium exposures well below an action level of 0.2 $\mu g/m^3$, which is an order of magnitude below the U.S. Occupational Safety and Health Administration's permissible exposure limit of 2 $\mu g/m^3$. While in the BTF, the air in the workers' breathing zone is monitored for the presence of beryllium to verify the satisfactory performance of the safety equipment and procedures.

Several specially designed features are utilized in the BTF thermal spray system to ensure worker safety. Powder hoppers are filled from special transfer canisters filled under inert gas at reduced pressure. The powder is transferred to the hoppers without exposure to atmosphere, thereby nearly eliminating personnel exposure to powder while at the same time keeping the powder clean by preventing reactions with the atmosphere. Currently, plasma spray and plasma transferred arc (PTA) deposition of beryllium and beryllium alloys are conducted in the BTF. Deposition takes place in a vacuum capable glove box. The glove box is used like a low-pressure plasma spray (LPPS) chamber for deposition at reduced pressures in controlled environments. Overspray powder is removed from the chamber by an inert gas blow down and is captured in a cyclone separator connected to a high velocity ventilation system. This material can be recycled to reduce waste and cost which is particularly important for an expensive material like beryllium. Any overspray material that passes through the cyclone separator is captured in HEPA filters. The beryllium deposition is monitored by video and infrared cameras looking through windows in the chamber.

Beryllium is traditionally processed by powder metallurgy techniques (hot pressing powder) since wrought metal processing causes cracking in the brittle material. Maintaining small grain size while maximizing the beneficial properties of beryllium such as high stiffness and low density are the goals of processing. The rapid cooling of plasma spraying is utilized to produce fine-grained deposits. Depositing thick (>10 mm) coatings of beryllium has been one area of current research with an example of such a coating shown in Fig. 1. This uniquely thick beryllium coating survived low cycle thermal fatigue testing at Forschungszentrum Juelich in Germany and Sandia National Laboratories, Albuquerque in the U.S. PTA deposition has also been investigated as a way of producing near-net shaped beryllium parts. An example of the structure of a PTA beryllium deposit is shown in Fig. 2. Even though the PTA melt processing results in much larger grains (~250 μm) than powder metallurgy material (~12 μm), the tensile yield

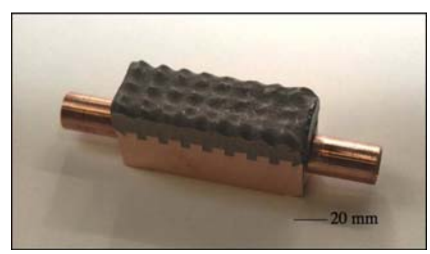

Fig. 1 Thick (10 mm) beryllium coating on a copper substrate

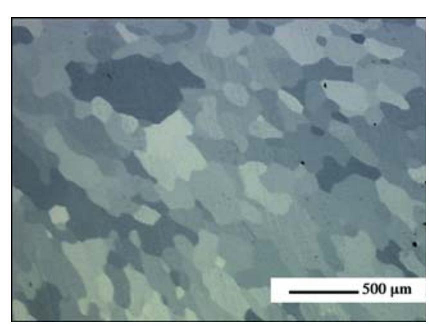

Fig. 2 Microstructure of PTA deposited beryllium

strength of the PTA deposit is 80% of that of the powder metallurgy material, as is shown in Fig. 3.

The non-beryllium thermal spray facilities consist of an LPPS chamber and an atmospheric spray cell with 6-axis robotic manipulation. Processes used in these facilities include plasma spray, high velocity oxy-fuel spray, wire arc spray, flame spray and PTA. Process diagnostics include infrared video imaging, high speed video imaging, Control Vision laser illuminated video imaging, and DPV2000 particle diagnostic. Recent research activities have been in support of high temperature corrosion resistant materials (silicides and oxides), coatings with high stress tolerance (strain reliving structures) and high thermodynamic stability materials for containment of reactive metals. An example of recent development work is the net-shape spray forming of thin-walled Y_2O_3 and Er_2O_3 ceramic crucible liners shown in Fig. 4.

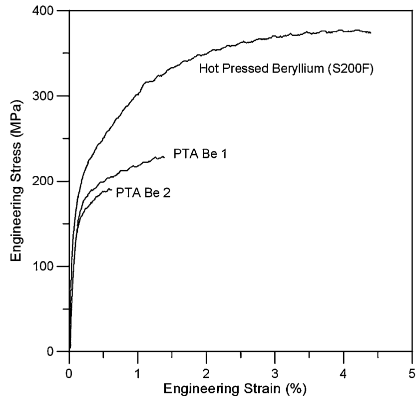

Fig. 3 Tensile test results for PTA beryllium samples compared to fine-grained hot-pressed beryllium

LANL thermal spray R&D has specialized in the deposition of highly reactive, hazardous and/or difficult to process materials. This capability and expertise have been developed for challenging problems facing U.S. national security needs. However, collaborations with outside institutions have brought mutual benefit on many past occasions and we welcome future collaborations with outside organizations. For further information, please contact Kendall Hollis at e-mail: kjhollis@lanl.gov.

Fig. 4 Net-shaped plasma-spray-formed Y_2O_3 (white) and Er_2O_3 (pink) crucible liners. The large size is 210 mm diameter and the small size is 70 mm diameter. Wall thickness can be varied between 0.5 and 4 mm.

News from ITSA and TSS

News from ITSA: ITSA Thermal Spray Pavilion a Tremendous Success

The first International Thermal Spray Association (ITSA) Thermal Spray Pavilion at the 2007 Fabtech International and American Welding Society (AWS) Welding Show was extremely successful. The show hit record-breaking attendance, with 31,354 people attending the event at the McCormick Place in Chicago. Questions were never-ending, and the 27 Thermal Spray Pavilion exhibitors had numerous opportunities to educate attendees on thermal spray processes and benefits. In 2008, the Fabtech International and AWS Welding Show will be held in Las Vegas, Nevada, from October 6–8.

Adopted with permission from *SPRAYTIME* **14**(4); Web: www.spraytime.org.

News from TSS: Electrohydrodynamic Tip Streaming Research at Purdue

A sufficiently strong electric field can destabilize a fluid interface separating a drop from the surrounding air. An unstable interface takes on a conical shape and typically either a stream of drops or a fine jet that subsequently breaks up into drops is emitted from the cone's tip. Such electrohydrodynamic tip streaming or cone-jetting phenomena, which are often referred to as electrospraying, occur widely in nature and technology. Well-known examples of cone jetting include ejection of streams of small charged drops from pointed tips of raindrops in thunderclouds and the popular technique of electrospray mass spectrometry, which is used for assaying large biomolecules. Currently, electrosprays are finding application in an ever-growing number of areas including separations, powder synthesis, coatings and encapsulation for controlled release.

Chemical engineers at Purdue University, West Lafayette, IN, are the first to mathematically describe precisely how droplets form when liquids are exposed to electric fields, an advance that could have applications in areas ranging from manufacturing to medical diagnostics. "Despite its importance, industry doesn't really understand exactly how drops form," says Osman Basaran, the Reilly professor of Fluid Mechanics in Purdue's School of Chemical Engineering.

Conventional modeling methods use diffuse interface techniques, which do not precisely predict how the strands and droplets form. The Purdue researchers used a more precise method called finite elements with elliptic mesh generation, a technique that breaks down a material into many small segments and solves the mathematical equations governing the behavior of each segment separately. Using the method enables researchers to understand the dynamic, changing shapes of each segment making up the drop-forming strands and the droplets. The technique allowed the engineers to negotiate the dramatic size differences between the strands and original liquid, a process that falls in the realm of "multi-scale modeling." The approach allows conducting this multi-scale modeling in one big calculation.

This information was adapted from the TSS publication *International Thermal Spray & Surface Engineering*, **3**(1).