# In The News

## New Literature

### *Plasma-Spray Coating—Principles and Applications*

Robert B. Heimann, 1996. Approx. 225 pages with 170 figures, hardcover, Approx. DM 198.00/sFr 192.00. ISBN 3-527-29430-9

Over the past two decades, thermal spraying of metallic, ceramic and composite coatings has emerged as a powerful tool for surface engineering, with many new applications and markets continually being developed. This book will help materials scientists and engineers to choose the most appropriate combination of materials, equipment, and operation parameters for the design of high-performance coatings with new functional properties and improved service life. The book includes: a treatment of the fundamental physical processes governing plasma spray technology, an assessment of advantages and disadvantages of the method compared with other surface coating techniques, a discussion of basic equipment requirements and limitations, and case studies and typical applications to solve industrial problems. *Plasma-Spray Coating* offers a combination of basic concepts and practical applications. Materials scientists and engineers, as well as graduate students will find this book of value.

**Contact:** VCH Publishing, P.O. Box 10 11 61, D 69451 Weinheim, Germany.

## Web Site News

### Powder Metallurgy Site—www.epma.com

The European Powder Metallurgy Association (EPMA) has launched a new Internet site dedicated to powder metallurgy (P/M)—www.epma.com. The site provides educational and commercial information on all aspects of P/M technology, publications guides, conference diaries, and details on EPMA member organizations.

The site is the most comprehensive Internet source to date on P/M—a manufacturing process for a wide range of engineering components used in cars, household appliances, power tools, cutting tools, magnets in electric motors, to name just a few applications. In-depth information is available covering all P/M materials and manufacturing techniques, plus component design tips, and technical data on properties and tolerances etc. The site will be an invaluable information source for materials and engineering students, researchers, and all those involved in the P/M industry worldwide.

Other services available on www.epma.com include frequently updated industry news, conference diaries and information, a directory of products and services provided by EPMA members, and a full catalog of P/M publications available through the EPMA. Details of the 1998 Powder Metallurgy World Congress & Exhibition, Granada, 18-22 Oct 1998, are also available on this site.

Contact: EPMA Secretariat, European Powder Metallurgy Association, Old Bank Buildings, Bellstone, Shrewsbury, SY1 1HU, UK; tel: +44 (0)1743 248899; fax: +44 (0)1743 362968; e-mail: info@epma.com.

### Sermatech Launches Web Site

Sermatech International has launched an Internet site at www.sermatech.com to provide information about protective coating and component repair capabilities for turbomachinery used in aerospace, utility and industrial power generation, and industrial processing applications.

The main sections of the Sermatech web site include:

- *Spotlight:* Features the latest news and lists the company's scheduled participation in industry trade shows and conferences
- *About Sermatech:* Presents a general description of the company and its principle products and services, as well as a listing of facilities, a description of two customer newsletters published quarterly, and information on career opportunities
- *Products and Services:* Details the company's capabilities for the aerospace market and ground turbomachinery, including gas turbines, steam turbines, and centrifugal compressors
- *Resource Center:* Contains summaries of technical and magazine articles written by company personnel and a glossary of industry terms

The Sermatech site allows visitors to subscribe to customer newsletters, order the complete text version of company-authored articles, request additional information, and submit information about specific equipment that may benefit from Sermatech's products and services.

Contact: Mike Stock, Sermatech International Inc., 155 South Limerick Road, Limerick, PA 19468, USA; tel: 610/948-5100; fax: 610/948-0811.

## News from the International Thermal Spray Association

The second half of 1996 established some important new records for the ITSA and established new milestones. The ITSA exhibit at NTSC '96, with the new photo display produced by Charles Kay of ASB, created a great deal of interest in the ITSA and generated more than 50 new membership leads. The next planned ITSA booth exhibit is at the AWS Conference in June and, following that, UTSC '97 in September in Indianapolis, IN.

### New Members

Two new regular members have been elected to the ITSA: Romatas Electric Sprayers of South Africa, founded in 1973, provides a wide range of thermal spray services, as well as PTA welding and semiautomatic shot blasting services. Director Leon Terlecki will represent Romatas to the ITSA. AB&C Thermal Spray LP of Neville Island, PA, was founded in 1996 under the umbrella of American Boiler & Chimney of Pittsburgh, PA, a fabrication and welding facility. AB&C Thermal Spray LP employs the use of the thermal arc spray process in boilers, water tanks, and bridges. President Jerry Kaelin is the ITSA representative.

### Joint Newsletter with the TSS

The first joint ITSA-TSS Spraytime issue (Winter Quarter 1997) is now completed and being distributed to our new, expanded readership—this includes approximately 1000 TSS members, ITSA members (each of whom receives 25 copies) and trade show distribution. Under the editorial direction of Daniel Parker for ITSA and Robert Tucker for TSS, the first issue of the new Spraytime showcases some important new technologies and highlights programs now in progress by the two associations. Advertisers include Sulzer Metco, Hardface Alloys, General Magnaplate, ASB Industries, ASM International, Northwest Mettech, and Praxair Specialty Products.

### ITSA Member Changes to Note

With the recent acquisition of Miller Thermal by Praxair, several changes in company representation to the ITSA will take place: Douglas Dickerson will represent Praxair Specialty Products and Daniel Foster will represent the newly formed Praxair Thermal Spray Systems (PTSS). PTSS will remain based in Appleton, WI. Plasmatec of Quebec, Canada, has moved its operation from Boucherville to an expanded warehouse, distribution, and product demonstration facility in Montreal. New contact information for Plasmatec: 1251 De Conde, Montreal, Quebec, Canada, H3K 2E4; tel: 514/941-1301; fax: 514/931-2009.

### Noted with Sorrow

Gilbert Jurak, the highly respected co-owner of Plasma Coating Corporation, passed away on 10 November 1996. Mr. Jurak served as secretary-treasurer and quality control manager. He had been a valued member of the ITSA since 1977. Donations in his name may be made to: The Gilbert Jurak Memorial Fund, Long Beach Youth Boosters, P.O. Box 92741, Long Beach, CA 90809.

### ITSA Mission Statement

To provide its membership with prestige, business opportunities, technical support, and a social network that contributes to the growth and education of the thermal spray industry as a whole.

## Industry News

### MRi Awarded $1.2M by NASA

MRi (Lansdale, PA) has been awarded two NASA Phase II SBIRs to commercialize its WideGap and SuperBraze brazing technology for the joining of composite (carbon:carbon and carbon:silicon carbide) and ceramics to metals. During the two-year development project MRi will be developing temperature brazes for electronic components, WideGap preforms, and processing techniques for applications in satellite and rocket engine components. During the contract, MRi will deliver electronic substrate/assemblies of aluminum/carbon:carbon for satellite electronics and high-temperature ceramic/metal joints for use in space furnace applications. The major use for WideGap and SuperBraze technologies is in the joining of dissimilar materials including ceramics to metals ($Al_2O_3$, AlN, $ZrO_2$, carbides, and many others) metals/ceramics composites (e.g., aluminum:silicon carbide) to metals (i.e., Al/Ti/Ni alloys) and dissimilar metals (aluminum, copper, stainless steels, magnesium).

MRi and NASA envision commercial applications in: heat exchangers, food-processing equipment, sporting equipment, pumps, aircraft components, electronic components, automobile components, and sputtering targets.

Contact: Ronald W. Smith, President MRi, 1162 Horseshoe Drive, Blue Bell, PA 19422; tel: 215/393-5703; fax: 215/393-5704; e-mail: solution @mri-bluebell.com.

# The "Job Shop" Forum

*By Elliott R. Sampson, TAFA, Concord, NH*

This will be the first of a regular feature in JTST. It will feature applications, trends, and news in the job shops of thermal spray industry. If you have an application for consideration for this forum please contact us.

## Trends

There has been an increasing focus on the use of arc spray and HVOF for commercial and aircraft applications. This first article discusses electric arc spraying trends and applications.

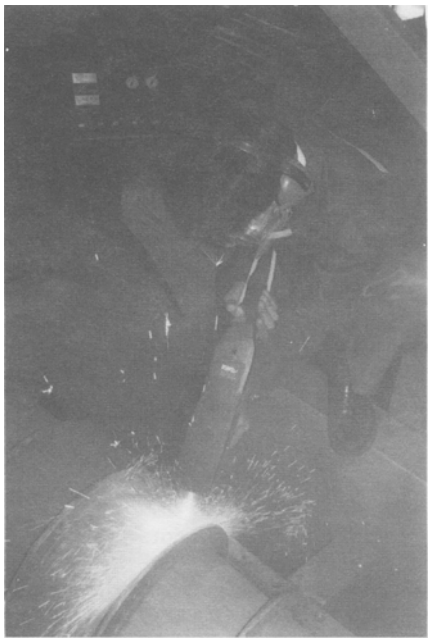

**Fig. 1** 95MXC on a Krima screw press

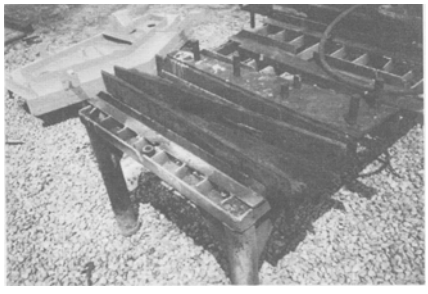

**Fig. 2** Chromium carbide wire on steel forming dies

A recent discussion of trends in a paper presented at the Western Regional NACE conference in Canada stated "Materials Development continues with the use of high chromium, high hardness amorphous materials and the use of pseudo alloys." It goes on to state, "Amorphous materials with relatively high boron content are providing good abrasion wear resistance and corrosion resistance for industry applications." The production of cored wires with tailored chemistries continues to introduce new wires for arc spray. The paper gives an example of one wire of nickel aluminum and one of nickel chromium to give both bond strength and corrosion resistance. Traditionally plasma sprayed materials are now in use for arc spray—refer to a recent article by Harper and Sampson titled "An Overview of Thermal Spray Applications in the Oil and Gas Industry." Tungsten carbide and chromium carbide in cored wire are new wires being used in applications, such as those shown in Fig. 1 to 4.

## Application Examples

Job shops use arc spray technology for pump repair. Larry Grimenstein, President of Nation Coatings in Ohio has been a leader in the application of arc coatings—especially pseudoalloys and cored wires for pump repair (a monthly publication entitled *Pumps and Systems* is featuring his article on "Pump Repair"). Figure 3 shows an uncoated pump flange that lasted five months before needing repair, and the lower half shows a pump flange that showed no wear after fifteen months. Figure 4 shows a pump housing repaired with an amorphous material.

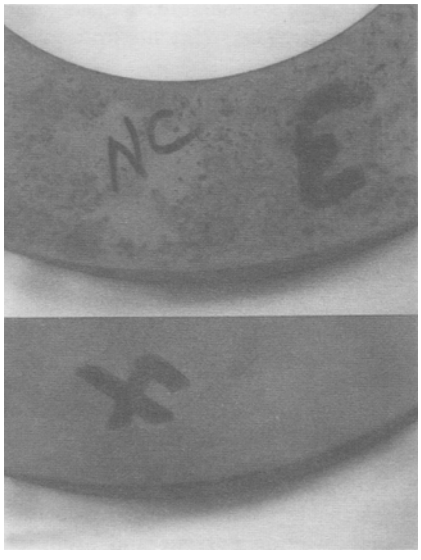

**Fig. 3** Slurry pump flanges arc sprayed with tungsten carbide

## Trends In Corrosion

Corrosion costs U.S. industry over $300 billion per year. One-third of this is avoidable. This is driving the development of equipment and materials for corrosion as well as increased use of standard materials such as zinc, aluminum, and zinc aluminum. Figure 5 shows the outside of a turbocharger sprayed with aluminum for corrosion resistance. The corrosion resistance of coatings on components will be a prime consideration for new applications in the near future. Future articles will discuss more applications on corrosion.

The next "Job Shop" Forum will include HVOF applications and an interview with a job shop.

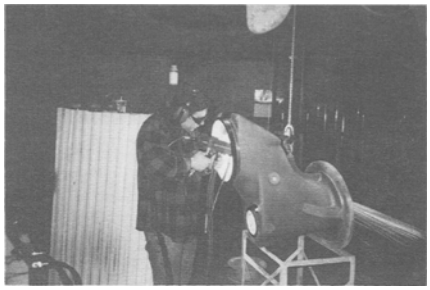

**Fig. 4** 95MXC repair of pump housing

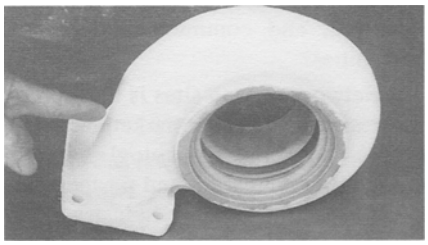

**Fig. 5** Turbocharger housing sprayed with aluminum

## New Products

### Grinding/Polishing Machines from Struers

Struers RotoSystem is based on interchangeable equipment components (modules) that can be combined to meet specific sample preparation needs of users, with easy upgradability to meet future applications. Two new units are being introduced.

- RotoPol-11 is a single-disc, tabletop grinding and polishing machine designed for the economic preparation of all materials. For wet grinding, 9 in. discs are used; polishing uses 8 in. discs. Two speeds: 150 and 300 rpm. RotoPol is equipped with a microprocessor and operated by touchpad.
- RotoForce-1 Specimen Mover is designed for fine grinding and polishing of one to three specimens. A soft-start feature protects the specimen and consumables from excessive load at startup. Force reduction at the end of the prep process can be selected from the touchpad to achieve a better finish or shorter follow-on preparation process.

**Contact:** Chris Sopko, Marketing Manager, Struers - A Division of Radiometer America Inc., 810 Sharon Dr., Westlake, OH 44145-1598. tel: 216/871-0071, 800/321-5834; fax: 216/871-8188; http://www.struers.com.

## News from NASA

### NASA On-Line: The Commercial Technology Network

One of the most successful examples of technology transfer originated about 20 years ago, when the U.S. Department of Defense began developing a high-speed computer network to connect military installations with key university researchers and set the foundation for the Internet. Today, the Internet is fueling an explosive growth in on-line services and web sites and is changing the way industry and government do business.

Recognizing the Internet's potential, NASA established the use of Internet technologies in 1994 as a core strategy of NASA's Agenda for Change—a blueprint for facilitating the transfer and commercialization of its technology. Today, the on-line NASA Commercial Technology Network (NCTN) serves as an integrated information resource for research and technology, patents, technical advice, and research and development facilities, as well as for partnering, licensing, and commercialization opportunities.

The network of web sites is developing into an electronic marketplace for NASA-sponsored technologies, facilitating communication and partnerships between NASA and industry. The NASA team also has sought to add value to the network by partnering with organizations such as NASA Tech Briefs and COSMIC (the Georgia-based center that distributes NASA-developed software to industry).

*Site-Seeing*

The NCTN core web site (http://nctn.hq.nasa.gov) is operated by the NASA Headquarters' Commercial Development and Technology Transfer Division. The site provides links to key databases and serves as a gateway to more than 25 sites operated by and affiliated with the NASA Commercial Technology Program's national network of organizations and services. Included in the network are the ten NASA field centers, the six Regional Technology Transfer Centers commercialization opportunities, the National Technology Transfer Center, NASA Tech Briefs, and other organizations dedicated to fostering dual-use partnerships and technology transfer. The following options are available:

- *Orientation:* Provides a short description of the site
- *Spotlight News:* Highlights current NASA technology opportunities and featured web sites
- *Search Tools:* Provides search options to explore the core site, all NCTN sites, and the NASA domain
- *Directory:* Links to the member sites of the network and to personnel directories
- *Technology Resources:* Includes searchable publications and databases that provide current and archived information on NASA research, technology, and capabilities
- *Small Business/SBM:* Describes how NASA's Small Business Innovation Research (SBIR) program provides funding to U.S. small businesses to develop dual-use innovations that address NASA R&D objectives and have commercial applications

Bookmark these NASA Tech Transfer Sites:

- Main Site http://nctn.hq.nasa.gov
- Field Centers
- Ames Research Center: http://www.arc.nasa.gov
- Dryden Flight Research Center: http://www.dfrc.nasa.gov
- Goddard Space Flight Center: http://afc.gsfc.nasa.gov
- Jet Propulsion Laboratory: http://www.jpl.nasa.gov
- Johnson Space Center: http://www.jsc.nasa.gov
- Kennedy Space Center: http://www.ksc.nasa.gov
- Langley Research Center: http://www.larc.nasa.gov
- Lewis Research Center: http://www.lerc.nasa.gov
- Marshal Space Flight Center: http://www.msfc.nasa.gov
- Stennis Space Center: http://www.ssc.nasa.gov
- NASA Tech Briefs: http://www.nasatech.com

Regional Technology Transfer Centers (RTTCs)

- Far West RTTC: http://cwis.usc.edu:80/dept/NASA/
- Mid-Continent RTTC: http://www.tamu.edu/mcttc/
- Southeast RTTC: http://vrww.state.fl.us/stac
- Mid-West RTTC: http://www.battelle.org/glitec/
- Mid-Atlantic RTTC: http://oracle.mtac.pitt.edu/www/MTAC.html
- Northeast RTTC: http://www.ctc.org/
- National Technology Transfer Center (NTTC) http://www.nttc.edu/
- COSMIC http://www.cosmic.uga.edu

## Thin-Film Thermocouples on Ceramics

Thin-film thermocouples on ceramic substrates have been developed to withstand temperatures up to 1500 °C for times of 50 h or more. These are prototypes of thermocouples that would be used to measure the temperatures of ceramic parts in advanced, high-temperature engines.

The thermocouple metals are platinum and an alloy of 87% Pt with 13% Rh (thermocouples made of this combination of metals are called "type R" in the industry). A thermocouple is made by sputtering films of these metals directly onto an electrically insulating ceramic substrate (e.g., silicon dioxide, silicon nitride, aluminum oxide, or mullite).

Alternatively, a thermocouple can be made by sputtering films of these metals onto a thin, electrically insulating ceramic film on an electrically conductive ceramic substrate (e.g., silicon carbide). Typically, the thin, electrically insulating ceramic film is a two-layer film made of an aluminum oxide film that has been sputter-deposited to a thickness of about 2 μm on an adherent silicon dioxide layer that has been thermally grown to a thickness of 2 μm on the surface of a silicon carbide substrate.

The metal thermocouple films are typically about 12.5 cm long, about 3 cm wide, and 5 to 7 μm thick. Lead wires made of the same materials as those of the thermocouple films are attached to the films by parallel-gap welding. The lead wires, which have a diameter of 75 μm, are routed through ceramic tubes to electrical connectors.

Experimental thin-film thermocouples were tested in ceramic-tube furnaces in both steady-state and thermal-cycling modes at temperatures up to 1500 °C. In calibration tests, the output of a thin-film thermocouple matched that of a standard wire thermocouple within 3%. Small amounts of drift were observed, ranging from negligible values to 2 °C/h, depending on the substrate material and the temperature (see Fig. 6). A main cause of drift was oxidation of rhodium at temperatures below about 1000 °C; above this temperature, the rhodium oxide dissociates. Above about 1250 °C, however, drift again became noticeable, apparently because of chemical reactions at film/substrate interfaces.

Oxidation of silicon nitride substrates was visible in tests at temperatures above about 1000 °C. At temperatures above about 1250 °C, both silicon nitride and silicon carbide substrate deteriorated noticeably, with resultant bubbling and other deformations leading to eventual delamination of the thermocouple films. No changes in the appearances of the aluminum oxide and mullite substrates were seen; thin-film sensors on these materials exhibited very little deterioration in the tests.

This work was done by Raymond Holanda of Lewis Research Center. Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Lewis Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7-3, 21000 Brookpark Rd., Cleveland, OH 44135. Refer to LEW-16072. Reprinted from *NASA Tech Briefs*, Vol 21 (No. 3), 1997, p 62.

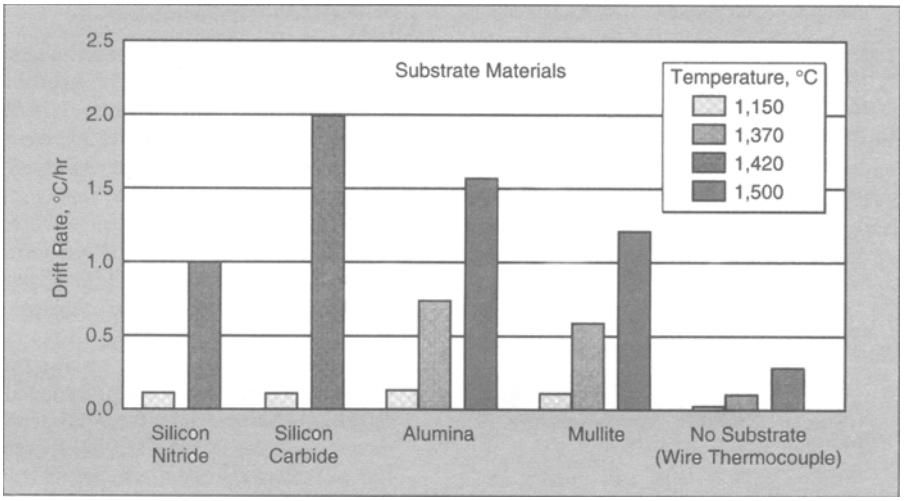


**Fig. 6** Temperature indications of experimental thin-film thermocouples drifted with time to various extents, depending on substrate materials and temperatures. The drift of a conventional wire thermocouple is shown for comparison.

# News from ASM

## NTSC '96 brings Thermal Spray to Materials Week

Nearly 1200 people attended NTSC '96, the 9th National Thermal Spray Conference & Exposition held concurrently with Materials Week, 7-11 October 1996, at the Cincinnati Convention Center. Sponsored by the ASM Thermal Spray Society, this event provided a forum for materials and design engineers, research scientists, manufacturers, suppliers, and users of thermal spray to communicate and exchange information on the latest developments in thermal spray.

The NTSC technical program drew more than 400 conference delegates and covered the latest in thermal spray research and practical applications through more than 200 presentations. Also held during the event was the Thermal Spray Exposition, encompassing more than 11,000 square feet where 55 exhibitors displayed the newest technologies, products, and services in thermal spray processes and equipment.

Thermal Spray Exposition exhibits included opportunities for hands-on operations, interfacing with key problem solvers, and side-by-side evaluation of equipment and processes with the convenience of one location.

Three thermal spray education seminars were sponsored by ASM's Materials Engineering Institute. These included "Thermal Spray Technology," "Introduction to Thermal Spray -Processes, Coatings, and Applications," and "Workshop on the Metallography of Thermal Spray Coatings."

## Awards at NTSC'96

At the NTSC'96 Banquet, the following awards were presented:

*Best Paper Awards*

- "Computational Fluid Dynamics Analysis of a Wire-Feed High Velocity Oxygen Fuel (HVOF) Thermal Spray Torch," by A.R. Lopez, B. Hassan, W.L. Oberkampf, R.A. Neiser, and T.J. Roemer, Sandia National Laboratories, Albuquerque, NM

- "Correlation between Particle Temperature and Velocity and the Structure of Plasma Sprayed Zirconia Coatings," by M. Prystay, P. Gougeon, and C. Moreau, National Research Council Canada, Boucherville, Quebec, Canada

*Certificates of Merit*

- "Particle Velocity and Temperature Influences on the Microstructure of Plasma Sprayed Nickel," by R.N. Wright, W.D. Swank, J.R. Fincke, and D.C. Haggard, Idaho National Engineering Laboratory, Idaho Falls, Idaho

- "Influence of Shroud Gas Flow and Swirl Magnitude on Arc Jet Stability and Coating Quality in Plasma Spraying," by H. Chen, Z. Duane, J. Heberlein, and E. Pfender, University of Minnesota, Minneapolis, MN

- "Parametric Study of Suspension Plasma Sprayed Hydroxyapatite," by E. Bouyer, F. Gitzhofer, and M.I. Boulos, Plasma Technology Research Center, Sherbrooke, Quebec, Canada

*Journal of Thermal Spray Technology 1995 Best Paper Award*

- "Microstructure Evolution During Reactive Plasma Spraying of $MoSi_2$ with Methane," by X. Liang, E.J. Lavernia, J. Wolfenstine, University of California-Irvine, and A. Sickinger, Sulzer Metco (Irvine), Irvine, CA

**Fig. 7** Ronald Smith (right) presents the JTST Best Paper Award to E.J. Lavernia for coauthors J. Wolfenstine, X. Liang, and A. Sickinger

## Thermal Spray Hall of Fame Awards

Four new members were inducted into the Thermal Spray Hall of Fame, which was established in 1993 by the Thermal Spray Division of ASM International. They include:

- The late Rea A. Axline, President, Metco, Inc., "Founder of the Metallizing Engineering Company, Inc. (Metco). Pioneered the thermal spray industry worldwide. Provided a nurturing corporate environment that developed engineers/specialists who labored throughout the Americas, Asia, and Europe." Andrew Nicoll, Sulzer Metco Holding AG, accepted the Thermal Spray Hall of Fame induction plaque on behalf of Mr. Axline.

- The late George H. Smith, Manager—R&D, Union Carbide Corporation. "Champion of advanced thermal spray devices, inventions, coating applications, and industrial research. Co-inventor of high-velocity oxygen fuel deposition. Mentor to research engineers, scientists, and managers for over 40 years." Dr. Robert C. Tucker accepted the Thermal Spray Hall of Fame induction plaque for the late Mr. Smith.

- James A. Browning, President, DRACO, Inc., "Inventor and implementor of numerous and unique thermal spray application devices that are mainstays of the thermal spray industry."

- The late Reginald McPherson, Professor, Monash University, Australia, "Provided outstanding contributions in thermal spray research and graduate education. Elucidated the influence of voids and porosity relative to the deposit microstructure and properties."

**Fig. 8** James A. Browning, president, DRACO Inc., inducted into the Thermal Spray Hall of Fame

## Thermal Spray Society Recognizes Leaders

Recognized for Board Service "for leadership and inspiration in the formation of the Thermal Spray Society" were Merle Thorpe and Mark Smith. Both were members of the founding board of the ASM Thermal Spray Society, serving from 1994 to 1996.

The officers and board of the Thermal Spray Society for 1996 to 1998 are Vice President Paul A. Kammer, President Robert C. Tucker, Jr., Immediate Past President Ronald W. Smith, Robert C. McCune, Andrew R. Nicoll, Herbert Herman, Secretary Walter A. (Val) Zanchuk, Douglas H. Harris, Mario H. Kyd, Christopher C. Berndt, Daryl E. Crawmer, Treasurer Albert Kay, and William J. Brindley.

The Thermal Spray Society President, Ronald W. Smith, presented the first ever Presidential Award to Prof. Christopher C. Berndt. His citation reads "For exemplary and unselfish service and outstanding contributions to the success of the Journal of Thermal Spray Technology, The NTSC Proceedings, and the TSS Hall of Fame."

**Fig. 9** Recognized for Board Service were Merle Thorpe (left) and Mark Smith (center)

Dr. William Brindley received the Committee Leadership Award for dedication to the development of the Information and Information Development Committee." Also receiving a Committee Leadership award was Dr. Robert McCune "for contributions to the formation of the Industry and Technology Development Committee."

**Fig. 10** The officers and board of the Thermal Spray Society for 1996 to 1998 are (seated, from left) Vice President Paul A. Kammer, President Robert C. Tucker, Jr., Immediate Past President Ronald W. Smith, (second row, from left) Robert C. McCune, Andrew R. Nicoll, Herbert Herman, Secretary Walter A. (Val) Zanchuk, Douglas H. Harris, (back row, from left ) Mario H. Kyd, Christopher C. Berndt, Daryl E. Crawmer, Treasurer Albert Kay, and William J. Brindley.

## People in the News

### John Iademarco Joins MRi

Dr. Ronald Smith, President of MRi (Lansdale) announced today the appointment of John Iademarco as Vice President and CFO. He will be headquartered at the company's central offices near Philadelphia. He has held a variety of management positions at Teleflex Incorporate in their aerospace, medical, marine, and fluoroplastics businesses. His last position was past President of Teleflex Aerospace and VP of TFX Equities the capital acquisition company of Teleflex Incorporate.

Mr. Iademarco, a CPA and graduate of Philadelphia College of Textiles, brings strong operating, production, and management experience to MRi.


**Fig. 11** Dr. Ronald W. Smith (right), 1994-1996 Thermal Spray Society President, discussed benefits of the society with visitors to the TSS booth at the Thermal Spray Exposition

### Sermatech Names Robert Schubert as VP of Marketing

Robert Schubert has joined Sermatech International as Vice President of Marketing. In his new position, Mr. Schubert will be responsible for the global marketing of Sermatech's protective coatings and repairs used in aerospace, utility, and industrial turbomachinery.

Prior to joining Sermatech, Mr. Schubert was Director of Marketing for ABB Power Generation, where he was responsible for strategic planning and marketing relating to the company's gas and steam turbine product lines. He held a series of sales and marketing positions of increasing responsibility with ABB as well as General Electric.

Mr. Schubert has published several technical papers for the American Society of Mechanical Engineers (ASME), Society of Naval Architects and Marine Engineers (SNAME), and New Jersey Institute of Technology (NJIT). He holds a Bachelor of Science degree in mechanical engineering from Columbia University and earned a Masters of Business Administration in international business from Xavier University. Mr. Schubert is a member of ASME, the Society of Automotive Engineers, and the Association of Energy Engineers.