This column is a forum to inform the thermal spray community on current activities in institutes and research centers active in the field of the thermal spray. Research efforts carried out in these organizations are oftentimes the starting point of significant developments of the technology that will have an impact on the way coatings are produced and used in industry. New materials, more efficient spray processes, better diagnostic tools, and clearer understanding of the chemical and physical processes involved during spraying are examples of such developments making possible the production of highly consistent performance coatings for use in more and more demanding applications encountered in the industry.

This column includes articles giving an overview of current activities or a focus on a significant breakthrough resulting from research efforts carried out in institutes and research centers around the world. If you want to submit an article for this column, please contact: Dr. Christian Moreau, National Research Council Canada, Industrial Materials Institute, 75 de Mortagne, Boucherville (Québec), Canada J4B 6Y4; tel: 450/641-5228; fax: 450/641-5105; e-mail: christian.moreau@cnrc-nrc.gc.ca.

Thermal Spray Research at the Advanced Materials Research Centre (AMRC), Nanyang Technological University (NTU), Singapore

The Thermal Spray Group in Nanyang Technological University (NTU), Singapore, that is located within the premises of the Advanced Materials Research Centre (AMRC) was founded in 1991 through university research grants for development of advanced materials for microelectronics and metal-matrix composites. Since its founding, the group has been actively involved in a wide variety of thermal spray projects funded by government research agencies and industries. The research in the group covers processing of thermal spray powders and composites, coating deposition of advanced ceramics, ceramics-matrix composites and metal-matrix composite materials, nanomaterials synthesis, and deposition of functionally graded coatings (thermal barrier coatings and bioceramics) using thermal spray, characterization of coatings, and study of thermal spray splats.

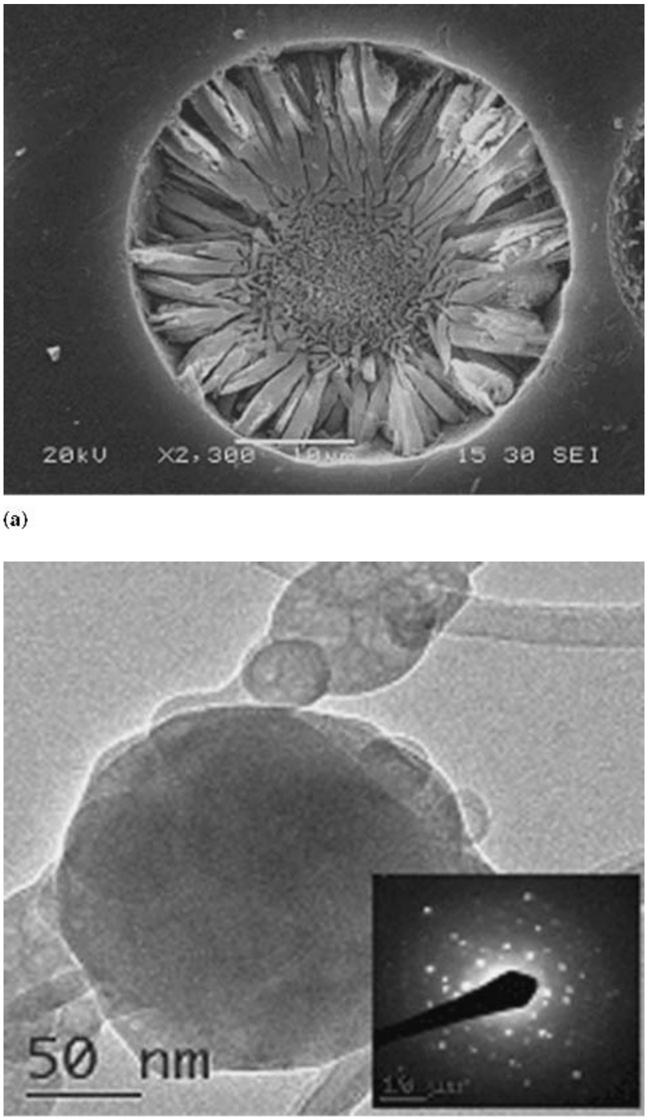
Currently, the group is focusing on several research areas:

- Biomedical coatings for hard tissue replacement,
- Nanomaterials synthesis via thermal spray,
- Postspray treatment using spark plasma sintering (SPS) technology,
- Solid-oxide fuel cell (SOFC),
- Wear-resistant coatings, and
- Fundamental studies.

Research Activities

Biomedical Coatings. The group conducted systematic study on thermal sprayed hydroxyapatite (HA) and HA-based bioceramic coatings using d.c. plasma spray and high-velocity oxyfuel (HVOF) techniques over the past decade. The HA powder is synthesized in-house through reaction between calcium hydroxide and orthophosphoric acid in a temperature-controlled bath. Influence of all the related variables, starting powder characteristics (melt fraction within individual particle and phase composition), spray parameters, coating state, etc., on microstructure and mechanical and biological (in vitro and in vivo) performances of the resultant biomedical coatings were investigated. The melt state of HA powders on phase composition of resultant coatings and competitive mechanical properties of the HA coatings were found to exert a dominant influence over the resultant HA coating microstructure and phase composition. Plasma spheroidized HA powder was employed as feedstock for deposition of HA coatings. The plasma spheroidized HA was found to have a unique structure, brought about through partial melting of the HA in its passage through the plasma flame (Fig. 1a). This resulted in HA coating with superior mechanical properties. Furthermore, addition of bioinert ceramics, titania, zirconia, etc., showed promising effect on improving the mechanical properties of both plasma (APS and controlled APS) sprayed and HVOF sprayed HA-based coatings. Different processing steps during powder production, in particular the spheroidization process, were found to exert critical influences on the properties of the coatings. The processing-microstructure-property relationship in the biomedical coatings was revealed following extensive study on the relationship among process parameter and coatings microstructures with mechanical and physical properties, suggesting that specific coatings properties can indeed be customized through variations in the fundamental process settings. Controlled atmosphere plasma sprayed (CAPS) HA coatings were studied over the past couple of years through collaborative efforts with C2P (Centre de Compétence en Projection Plasma), Ecole des mines de Paris, France and Universitate de Barcelona, Spain. Effects of high-pressure plasma spray (HPPS) on HA coating is clearly revealed. Furthermore, nanosized calcium phosphate powders were successfully fabricated in the group via RF plasma spraying of a HA-based suspension, and nanostructured calcium phosphate coatings are found to be deposited directly through suspension RF plasma spraying of a suspension (Fig. 1b). The bioactive coatings are evaluated both in vitro and in vivo. Furthermore, thermal sprayed bioceramic coatings were being used as targets for bioactive thin film fabrication via rf magnetron sputtering. The results have shown a promising effect. The resultant films appear to have a better bioactivity than that obtained using other traditional targets.

Materials Synthesis through Thermal Plasma Spray Process. Besides the powder processing—for example, spheroidization, atomization, and so forth—synthesis of materials was also conducted using the thermal spray technique in the group in NTU. Mullite-zirconia composites were produced through plasma spheroidization of alumina-zircon mixture. Plasma dissociation of zircon caused the formation of fine ZrO_2 crystallites in an amorphous silica matrix, which subsequently react with alumina to form zircon at a relatively low temperature of ~1300 °C. Also, Al_2O_3/AlN composite powders were successfully synthesized using a novel developed method in the group, direct nitration of Al_2O_3 with various additives via plasma spraying with two types of gas, Ar/N_2 and N_2. Furthermore, nanosized powders (10-100 nm), intermetallic powders, silicon nitride and carbide, superconductor powders of ($YBa_2Cu_3O_{7-x}$) and bioceramic powders of HA, dental-glass and HA-ZrO_2 nanocomposite powders, were successfully synthesized in the group using a RF plasma spray process. The inherent characteristics of the RF



(a)

(b)

Fig. 1 (a) Polished and etched cross-section of plasma spheroidized hydroxyapatite powder. (b) TEM view of nanosize hydroxyapatite synthesized in a rf plasma

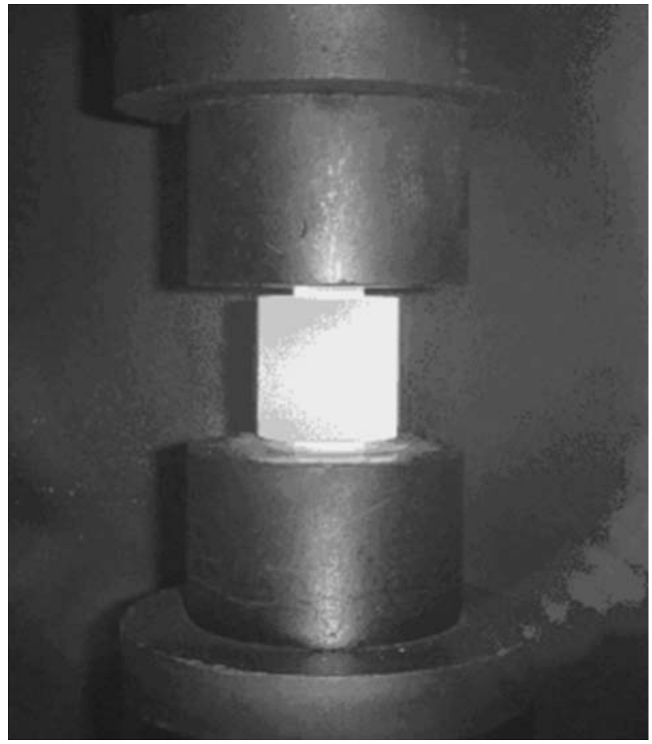


Fig. 2 Spark plasma sintering in operation as demonstrated by the glowing graphite die and punch set. The plasma sprayed sample is packed within the die using ceramic powders.

plasma allow sufficient dwell time for droplet drying and consolidation. It can also operate under a wide range of pressures with inert, reducing or oxidizing environments. This work is currently being extended to produce Al_2O_3/HA, Al_2O_3/ZrO_2/HA, SiO_2/HA, bioglass/HA nanocomposite powders in an attempt to de velop the next generation of bioceramic powders. These powders are to be used for the production of spark plasma sintered compacts intended for spinal implants.

Postspray Treatment. Spark plasma sintering (SPS) is a new sintering process that is capable of sintering ceramic powders quickly to their full density at a relatively lower temperature compared to conventional sintering methods (Fig. 2). Pulsed current is passed through the sample in the initial stages of the treatment, and temperature is normally raised at the rate 100 to 200 K/min. Material modifications are brought about through electric field effect and Joule heating. In AMRC, NTU, SPS was successfully utilized as postspray processing equipment for a large variety of thermal sprayed coatings. Besides its beneficial effect on the coating microstructure, the SPS treatment is capable of activating the plasma sprayed biomedical coatings, improving the bioactivity of the coatings, while conventional heat treatment makes the plasma sprayed HA coatings more inert during the in vitro incubation. Furthermore, it was revealed that the plasma sprayed HA coatings can be activated so that the growth of the bonelike apatite layer on their surface can be accelerated effectively. β-tricalcium phosphate was found to crystallize preferentially in the coating following the SPS treatment. SPS treatment on the plasma sprayed yttria stabilized zirconia (YSZ) electrolyte was also conducted. In the as-sprayed sample, the a.c. impedance spectrometry pattern shows only one depressed semicircle (Fig. 3). However, with the increase of the SPS heat treatment temperature, the one depressed semicircle splits into two distinctive semicircles with the concomitant reduction of the resistivity, which is consistent with the microstructure changes of the YSZ electrolyte from lamellar structure to granular structure at different heat treatment temperatures, in particular at 1400 °C. Generally, the existence of intergranular defects in plasma sprayed YSZ electrolyte is a key factor that hinders the energy efficiency of solid-oxide fuel cells (SOFC). Following postspray SPS treatment, the porosity of the electrolyte was greatly reduced, and the ionic conductivity of the electrolytes was greatly improved. Furthermore, for the wear-resistant cermet coatings, for example, WC-Co, CrC-Ni, and so forth, decarburization is very common during the coating deposition. The research work

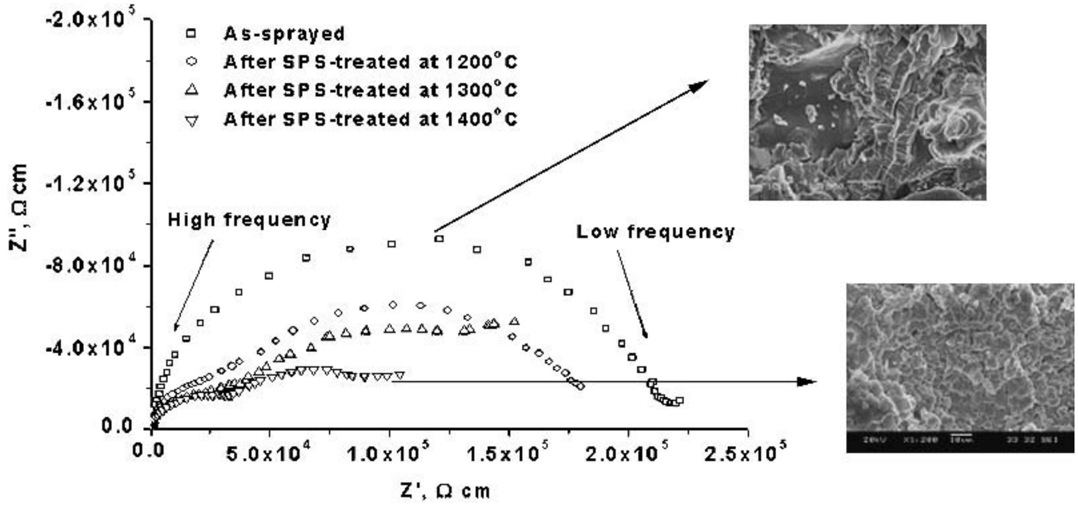


Fig. 3 Impedance spectra of as-sprayed and heat treated YSZ electrolytes measured at 350 °C

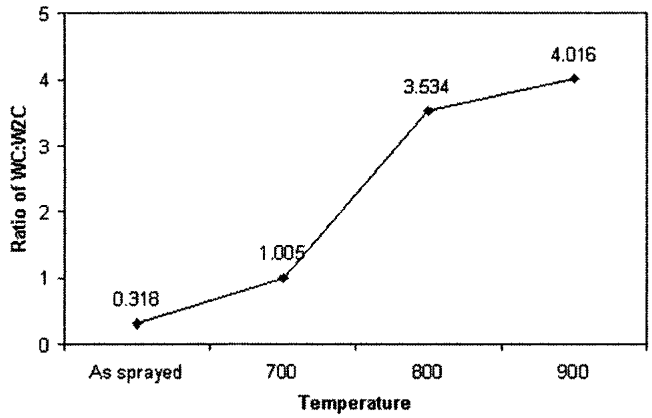


Fig. 4 Increase in the WC-to-W_2C ratio in plasma sprayed WC-Co coating as a function of SPS temperature. Duration of the postspray treatment is typically 3 min.

conducted in the group showed that the postspray SPS treatment effectively restored the WC and CrC phase (e.g., with up to 90 wt.% conversion of W_2C to WC) in the APS WC/Co and CrC-Ni coatings, respectively. Figure 4 illustrates the increase in WC phase in plasma sprayed WC-Co coating as a function of SPS temperature. The mechanical property is also improved by the SPS treatment.

Solid-Oxide Fuel Cell (SOFC). The research on application of thermal spray technology in SOFC was started several years ago in the group. Plasma spraying together with SPS postspray treatment was employed for YSZ electrolyte fabrication, which shows microstructure transformation from lamellar to granular grains, and grain growth of granular grains. The SOFC test station has been successfully established and improvement on the power output is on the way. It has been found that the microstructure of the SOFC components significantly influences the performance of the SOFC. Changes in microstructure of thermal sprayed electrolyte were being made through optimization of starting powders (size, morphology, etc.) and spray variables.

Wear-Resistant Coatings. Cermet coatings ((Ti,Mo)C-NiCo, CrC-NiCr, WC-Co, etc.) were studied by the research group in NTU for some time. Results revealed that both plasma spray and HVOF spraying brought about negligible changes in phase composition of the (Ti,Mo)C-NiCo coatings. However, plasma sprayed coatings have higher microhardness and denser structure than those deposited by HVOF. Phase changes, typically decarburization, were revealed in plasma spraying tungsten carbide and chromium carbide cermets. The phenomena and mechanisms of wear, and decarburization mechanisms, as well as influence of spray parameters on coating performances were revealed. The SPS postspray treatment on these cermet coatings has promising effect on achieving recovering of the carbides within the coatings, e.g., reversing W_2C or even W to original WC. Currently a study on clarifying the reversible phase transformation mechanisms is being carried out.

Fundamental Research. In recent years, basic research work was carried out in the group in NTU, which focused on a wide range of areas:

- Forming mechanism of individual splats,
- Microstructure characterization of individual splats (e.g., pore formation mechanisms, etc.),
- Dissolution/precipitation behavior of individual calcium phosphate splats,
- Clarification of the behaviors of sprayed particles (velocity and temperature) using SprayWatch/HiWatch systems,
- Relationship among particle variables (temperature, velocity) and morphology of splats and properties of coatings, and
- Phase transformation mechanisms of sprayed materials during coating deposition.

NTU Facilities

The thermal spray laboratory is equipped with miscellaneous thermal spray facilities that include: one set of flame spray system, a 100kW fully computerized d.c. plasma spray system (4500, Praxair Thermal Spray, IN), a six-axis, programmable robotic manipulator arm, two sets of HVOF spray systems (HV2000, Praxair, fully computerized), and a 35 kW radio frequency (rf) plasma system. A CCD-camera optics based spray diagnostic system (Oseir, Finland) aids the study of thermal sprayed particle profiles. Auxiliary instruments for coatings characterization and testing include transmission electron microscope (TEM), low-vacuum scanning electron microscope, 3 kW powder x-ray diffraction system (with attachment for in situ high-temperature diffraction study that operates up to 1600 °C [in vacuum] and 1200 °C in air), microRaman spectroscopy system, nanoindentation system, Fourier transform infrared (FTIR) spectrometry, thermal analysis systems (differential scanning calorimetry and differential thermal analyzer), high-temperature dilatometer, and universal testing machines (5-25 ton). Also, the group has been studying post-spray treatment through SPS technology.

International and National Collaborations

The Thermal Spray Group in NTU has wide and productive collaboration with many established thermal spray research centers (groups) around the world. Among these are: Mechanical Testing Lab. (SUNY, Stony Brook); C2P (Centre de Compétence en Projection Plasma), Ecole des Mines de Paris, France, Universitate de Barcelona, Spain, Industrial Material Institute (IMI), NRC, Canada, Fraunhofer Institute IFAM, Germany, International Advanced Research Centre for Powder Metallurgy & New Materials, India, Xi'an Jiaotong University, PR China, and AIST, Japan.

Moreover, there are a number of research projects conducted with industrial partners within Singapore. Among these are: Singapore General Hospital, Institute of Environmental Science and Engineering, Singapore Institute of Manufacturing Technology, National Cancer Center, and National University Hospital.

Contact: Associate Prof. K.A. Khor, School of Mechanical & Production Engineering, Nanyang Technological University, 50 Nanyang Ave., Singapore 639798, Singapore; tel: +65-6790 5526; fax: +65-6791 1859, +65-6795 7124 (direct); e-mail: mkakhor@ntu.edu.sg.

Industrial News

Wall Colmonoy Completes ISO 9001:2000 Registration at Four Facilities

Wall Colmonoy Corporation announced the registration of four of its locations as certified to conform to the ISO 9001:2000 quality-management system standards. The company has met the standards of quality assurance and management as audited and certified by EAGLE Registrations, Inc., of Dayton, OH.

Wall Colmonoy's corporate office and laboratory in Madison Heights, MI, and its Los Lunas, NM, processing plant have been registered with the ISO 9001:2000 with AS9100:2001 Rev A standard for design, manufacturing, and distribution of high-quality nickel- and cobalt-base hard-surfacing and brazing alloys for targeted industrial markets. AS9100:2001 Rev A is the quality system standard for the aerospace industry.

Wall Colmonoy Oklahoma City manufacturing plant has been registered with the ISO 9001:2000 standard for manufacture of precision sheet metal and tubular components and assemblies for the aerospace, defense, and power-generation industries.

Wall Colmonoy Dayton processing facility is registered with ISO 9001:2000 with AS9100:2001 Rev A standard for aerospace heat treating, brazing, coating, and hard surfacing.

Contact: Shirley Clemens, Marketing Coordinator, 30261 Stephenson Hwy, Madison Heights, MI 48071-1650; tel: 248/585-6400, ext. 244; fax: 248/585-7960; e-mail: sclemens@wallcolmonoy.com.

News from NASA

Lower-Conductivity Thermal Barrier Coatings

Thermal barrier coatings (TBCs) that have both initial and post-exposure thermal conductivities lower than those of yttria-stabilized zirconia TBCs have been developed. TBCs are thin ceramic layers, generally applied by plasma spraying or physical vapor deposition that are used to insulate air-cooled metallic components from hot gases in gas turbine and other heat engines. Heretofore, yttria-stabilized zirconia (nominally comprising 95.4 at.% ZrO_2 + 4.6 at.% Y_2O_3) has been the TBC material of choice. The lower-thermal-conductivity TBCs are modified versions of yttria-stabilized zirconia, the modifications consisting primarily of the addition of other oxides that impart microstructural and defect properties that favor lower thermal conductivity.

TBCs are characterized by porosity, typically between 5 and 20%. Porosity reduces the thermal conductivity of a TBC below the intrinsic conductivity of a fully dense (that is, nonporous) layer of the TBC material. The thermal conductivity of a TBC increases as its porosity is reduced by the sintering that occurs during use at high temperature. For future engines that will operate at higher gas temperatures, TBCs with greater degrees of both initial insulating capability and retention of insulating capability will be needed.

The present lower-thermal-conductivity TBCs are made of ZrO_2 and Y_2O_3 doped with additional oxides that are chosen to perform three functions:

- Create thermodynamically stable, highly defective lattice structures with tailored ranges of defect-cluster sizes to exploit the effectiveness of such structures as means of attenuating and scattering phonons, thus reducing thermal conductivity;
- Produce highly distorted lattice structures with essentially immobile defect clusters and/or nanoscale ordered

- phases, which effectively reduce concentrations of mobile defects and movements of atoms, thus increasing sintering-creep resistance; and
- Exploit the formation of complex nanoscale clusters of defects to increase the measures of such desired mechanical properties such as fracture toughness.

The additional oxides in a TBC according to this concept are typically selected as a pair—one from each of two groups of oxides denoted for this purpose as groups A and B. Group A includes scandia (Sc_2O_3) and ytterbia (Yb_2O_3). These oxides are highly stable, and the radii of their trivalent cations are smaller than those of the primary dopant yttria. Group B includes neodymia (Nd_2O_3), samaria (Sm_2O_3), and gadolinia (Gd_2O_3), which are also highly stable, and their trivalent cations are larger than those of yttria.

Like yttria, the A and B oxides are regarded as stabilizers. Preferably, the total stabilizer content (yttria + A oxide + B oxide) should lie between 4 and 50 at.%. The concentration of yttria should exceed that of each of other stabilizers, and the concentrations of the A and B oxides should be approximately equal. Formulations other than the foregoing preferred one are also possible: Variations include the use of alternative group A oxides (e.g., MgO_2, NiO, Cr_2O_3), the use of two or more group A and/or group B oxides, substitution of hafnia for zirconia, and substitution of other primary stabilizers (e.g., dysprosia or erbia) for yttria.

This work was done by Robert A. Miller of Glenn Research Center and Dongming Zhu of Ohio Aerospace Institute. For further information, access the Technical Support Package (TSP) free on-line at www.nasatech.com/tsp under the Materials category.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Steve Fedor, Mail Stop 4-8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-17039. Excerpted from *NASA Tech Briefs,* June 2003.

Noncircular Cross Sections Could Enhance Mixing in Sprays

A computational study has shown that by injecting drops in jets of gas having square, elliptical, triangular, or other noncircular injection cross sections, it should be possible to increase (relative to comparable situations having circular cross section) the entrainment and dispersion of liquid drops. This finding has practical significance for a variety of applications in which it is desirable to increase dispersion of drops. For example, in chemical-process sprays, increased dispersion leads to increases in chemical-reaction rates; in diesel engines, increasing the dispersion of drops of sprayed fuel reduces the production of soot; and in household and paint sprays, increasing the dispersion of drops makes it possible to cover larger surfaces.

It has been known for some years that single-phase fluid jets that enter flow fields through noncircular inlets entrain more fluid than do comparable jets entering through circular inlets. The computational study reported here was directed in part toward determining whether and how this superior mixing characteristic of noncircular single-phase jets translates to a similar benefit in cases of two-phase jets (that is, sprays).

The study involved direct numerical simulations of single- and two-phase free jets with circular, elliptical, rectangular, square, and triangular inlet cross sections. The two-phase jets consisted of gas laden with liquid drops randomly injected at the inlets. To address the more interesting case of evaporating drops, the carrier gas in the jets was specified to be initially initiated by the vapor of the liquid chemical species and the initial temperature of the drops was chosen to be smaller than that of the gas. The mathematical model used in the study was constructed from the conservation equations for the two-phase flow and included complete couplings of mass, momentum, and energy based on thermodynamically self-consistent specification of the enthalpy, internal energy, and latent heat of vaporization of the vapor.

The results of the numerical simulations yielded information on (1) the different spreading behaviors occurring for different inlet cross sections and (2) the differences between flow fields in the presence and absence of liquid drops. The most important consequence of interaction of drops with the flows was found to be the production of enhanced streamwise vorticity that alters entrainment and the mixing of species according to the inlet geometry. At the time station corresponding to steady-state entrainment, the potential cores of two-phase jets were found to be shorter than their single-phase counterparts by an order of magnitude (see Fig. 1). Whereas the two-phase circular jets were found to exhibit symmetric entrainment patterns at a location well past the streamwise locations of the potential cores, the noncircular jets were found, at the same location, to depart strongly from symmetry. The phenomenon of upstream versus downstream exchange of major and minor axes of elliptical cross sections ("axis switching" for short) of single-phase jets was not observed in the two-phase jets.

Considerations of the distributions of the number density of drops, liquid mass, and evaporated species distributions lead to recommending elliptical cross sections as optimal ones in that they result in optimal combinations of dispersion and mixing. All of the computations were performed for pretransitional jets (that is, jets on the laminar side of the transition between laminar and turbulent flow). Further investigations would be necessary to elucidate the effects of turbulence.

This work was done by Josette Bellan and Hesham Abdel-Hameed of Caltech for NASA's Jet Propulsion Laboratory. For further information, access the Technical Support Package (TSP) free on-line at www.nasatech.com/tsp under the Mechanics category. NPO-30400. Excerpted from *NASA Tech Briefs,* June 2003.

Hot Films on Ceramic Substrates for Measuring Skin Friction

Hot-film sensors, consisting of a metallic film on an electrically nonconductive substrate, have been used to measure skin friction as far back as 1931. A hot film is maintained at an elevated temperature relative to the local flow by passing an electrical current through it. The power required to maintain the specified temperature depends on the rate at which heat is transferred to the flow. The heat-transfer rate correlates to the velocity gradient at the surface, and hence, with skin friction. The hot-film skin friction measurement method is most thoroughly developed for steady-state conditions, but additional issues arise under transient conditions.

Fabricating hot-film substrates using low-thermal-conductivity ceramics can offer advantages over traditional quartz or polyester-film substrates. First, a low conductivity substrate increases the frac-

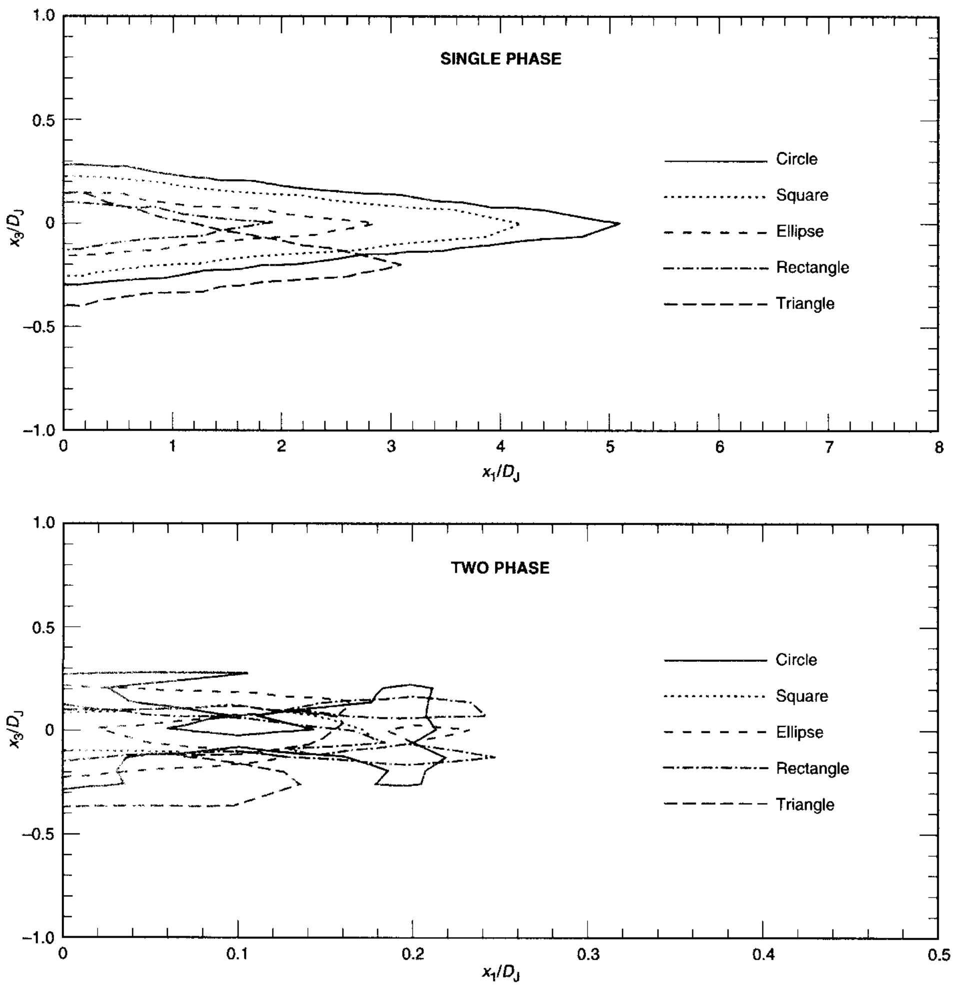


Fig. 1 The potential core of a jet is defined as the region beyond which the velocity is no longer equal to that at the inlet. These plots are outlines of computationally simulated potential cores of single- and two-phase jets issuing from inlets with the noted cross sections. D_J denotes the equivalent jet diameter, which, for a noncircular inlet, is defined as the diameter of a circular inlet of equal cross-sectional area. The symbols x_1 and x_3 denote Cartesian coordinates parallel and perpendicular, respectively, to the initial jet axis.

tion of heat convected away by the fluid, thus increasing sensitivity to changes in flow conditions. Furthermore, the two-part, composite nature of the substrate allows the installation of thermocouple junctions just below the hot film, which can provide an estimate of the conduction heat loss.

Figure 1 depicts a hot-film sensor of this type. The substrate is primarily composed of high-temperature reusable shuttle insulation (HRSI), a lightweight (density = 352 kg/m^3), porous, ceramic material originally developed to protect the space shuttle from aerodynamic heating. A hard, nonporous coat of reaction-cured glass (RCG) extends over the face of the cylinder and about one-third of the way down the side providing a surface on which the metallic hot film and its leads can be deposited. Small-diameter (0.005 in., or 0.127 mm) thermocouple wires are routed through the HRSI. Small grooves in the end of the HRSI cylinder form the lands of the thermocouples and are deep enough for the wires to lie flush with the HRSI surface prior to being coated with the RCG. The three thermocouple junctions are placed in a line. The substrates are placed in a machinable-ceramic sleeve that provides electrical isolation for the hot-film leads. Type R thermocouples must be used because the high firing temperature of the RCG coating precludes the use of the more-sensitive thermocouples of type Ks.

The hot film itself is approximately 0.004 in. (~0.102 mm) wide and 1/4 in. (6.35 mm) long. Fabrication of the hot film and its leads begins with hand painting the desired pattern using organometallic inks. The painted substrate is then heated in an oven, which removes the solvents from the ink leaving only a gold-alloy film (see photo in Fig. 1). The sensor thermocouples provide feedback control to the oven. These techniques could be used for the fabrication of other temperature and heat-flux gauges on high-temperature ceramics.

Conjugate heat-transfer analyses were performed on different substrate materials in air at moderate velocity gradients (7500 s^{-1}). For the composite ceramic substrate, the ratio of heat leaving the sensor via convection to total heat produced is about four times higher than for a quartz substrate. Figure 2 depicts steady-state temperature contours for quartz and a composite ceramic substrate. Preliminary bench tests comparing hot films on composite ceramic and machinable-ceramic substrates indicate that, at over-

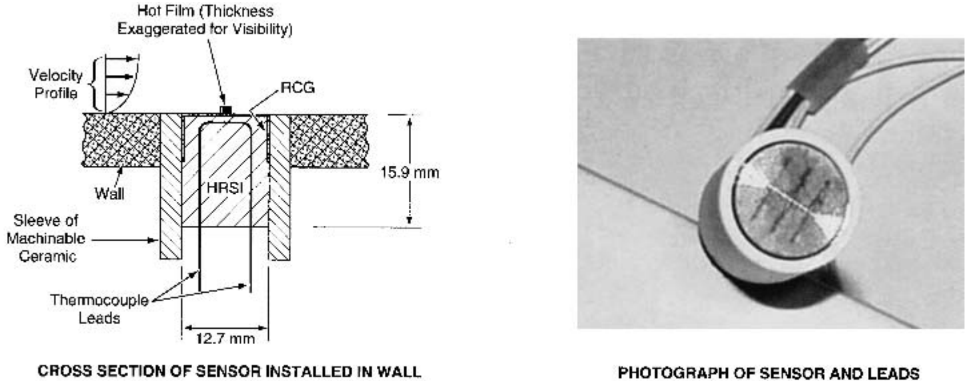


Fig. 1 The composite ceramic substrate of this hot-film sensor reduces conduction losses and increases sensitivity.

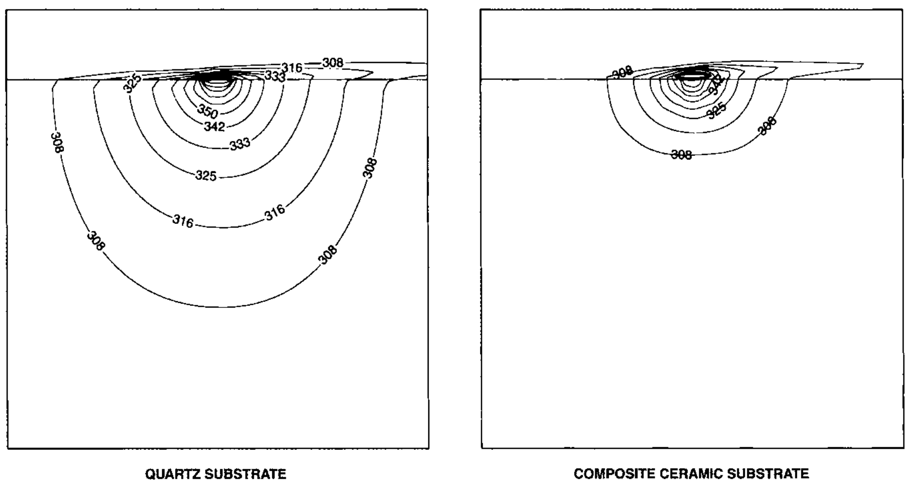


Fig. 2 Steady-state temperature contours, determined from conjugate heat-transfer analyses, illustrate the effect of the lower thermal conductivity of the composite ceramic substrate relative to a quartz substrate. Temperatures are indicated in °C.

heat ratios of 1.2 and in horizontal orientations, the higher-conductivity machinable-ceramic substrates require more than 2.5 times the power.

This work was done by Greg Noffz of Dryden Flight Research Center, Daniel Leiser of Ames Research Center, Jim Bartlett of Langley Research Center, and Adrienne Lavine of UCLA. For further information, contact the Dryden Commercial Technology Office at 661/276-3689. DRC-01-48. Excerpted from *NASA Tech Briefs,* June 2003.

Paint-Overspray Catcher

An apparatus to catch paint overspray has been proposed. Overspray is an unavoidable parasitic component of spray that occurs because the flow of air or other gas in the spray must turn at the sprayed surface. Very small droplets are carried away in this turning flow, and some land on adjacent surfaces not meant to be painted.

The basic principle of the paint-spray catcher is to divert the overspray into a suction system at the boundary of the area to be painted. The paint-spray catcher (Fig. 1) would include a toroidal plenum connected through narrow throat to a nozzle that would face toward the center of the torus, which would be positioned over the center of the area to be spray painted. The plenum would be supported by four tubes that would also serve as suction exhaust ducts. The downstream ends of the tubes (not shown in Fig. 1) would be connected to a filter on a suction pump.

The pump would be rated to provide a suction mass flow somewhat greater than that of the directed spray gas stream, so that the nozzle would take in a small excess of surrounding gas and catch nearly all of the overspray. A small raised lip at the bottom edge of the nozzle would catch paint that landed inside the nozzle. Even if the paint is directly piston pumped, the droplets entrain an air flow by the time they approach the wall, so there is always a gas stream to carry the excess droplets to the side. For long-duration spraying operations, it could be desirable to include a suction-drain apparatus to prevent overflowing and dripping of paint from inside the lip. A version without an external contraction and with the throat angled downward would be a more compact version of catcher, although it might be slightly less efficient.

This work was done by Leonard M. Weinstein of Langley Research Center. For more information, contact the Langley Commercial Technology Office at 757/864-6005. LAR-15613. Excerpted from *NASA Tech Briefs,* June 2003.

Controlling Nanotech

Learning how to transform the disordered motion of very tiny particles into ordered, directed motion is a major focus in nanotechnology research. An international

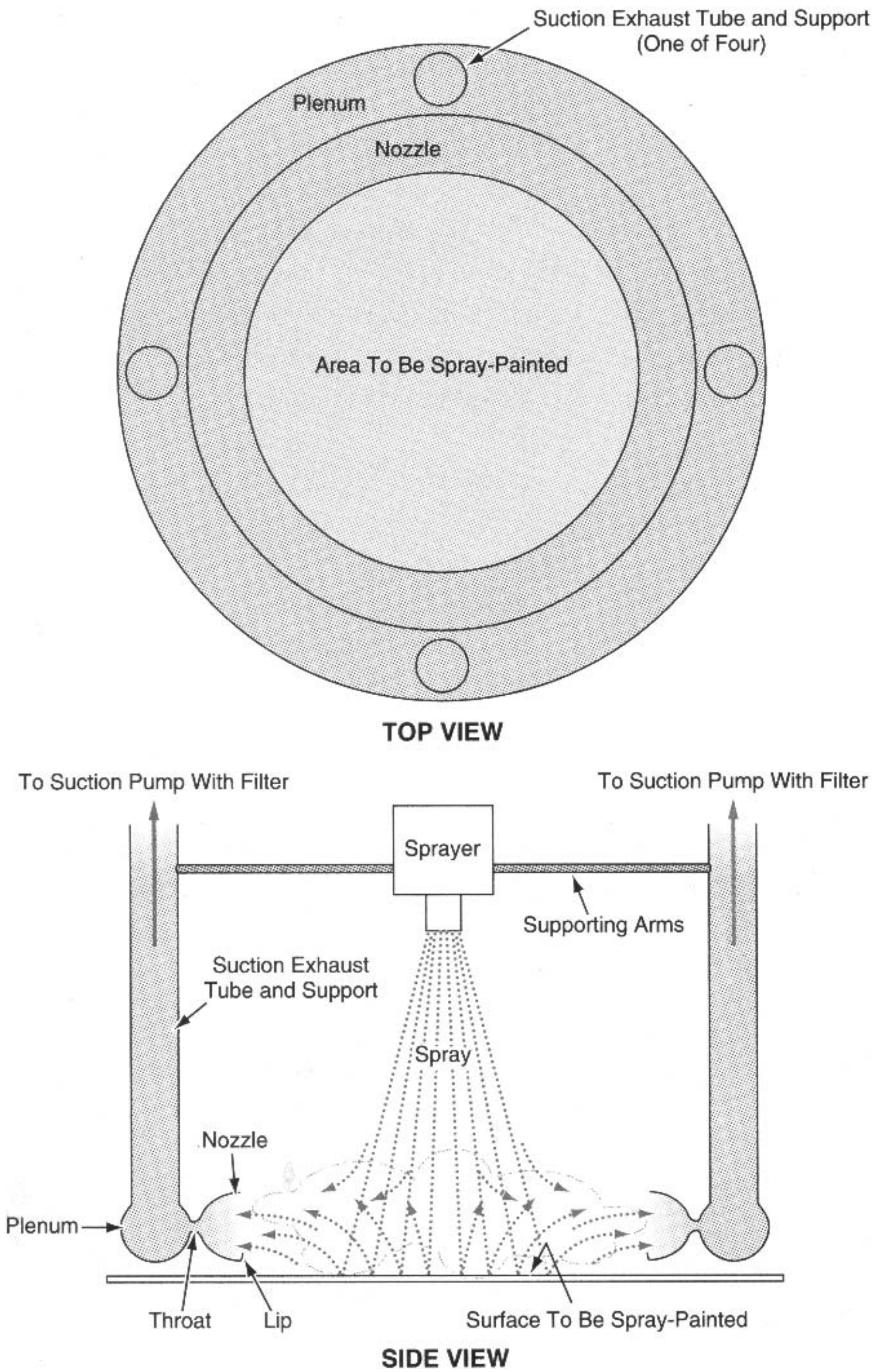


Fig. 1 The paint-overspray catcher would suck the turning flow of gas and entrained paint droplets, preventing the droplets from landing on non-target surfaces. The planform of the catcher plenum and nozzle need not be round as shown here: It could have any other convenient shape, depending on the boundary of the area to be painted.

team has recently devised a method that shows how adding “auxiliary” particles that interact with the primary “target” particles can both control and enhance the flow for both.

Very tiny particles exhibit disordered motion (also called Brownian motion) because they are subject to thermal noise. Ratchets (asymmetrically shaped sawtooth substrates) can be used to make particles flow in one direction instead of wandering at random.

This goal can be difficult to achieve when the mobile particles (ions or molecules) are weakly coupled to the underlying asymmetric substrate, which is not easily tunable. Adding a second type of active particle that couples better to the substrate allows for better control of particles that are weakly coupled to a substrate (passive particles).

These new types of tiny shuttles or microscopic conveyor belts could be used to deliver medications to specific cells or to replace wires in molecular-sized electronic devices.

Visit http://link.abpi.net/l.php?20030624A2 for the complete story. Excerpted from *NASA Tech Briefs INSIDER,* 24 June 2003.

Thermal Shock Tests

This thermal shock and thermal fatigue test method—based on controlled irradiation heating of ceramics—delivers material-specific parameters that can be immediately used by engineers to design parts.

The method is fully developed and applied for silicon nitride and silicon carbide materials, and prototype test parts. The test parameters can be easily varied for specific test conditions using a variety of materials, components, and parts geometry.

Fully quantifiable results can be utilized to compile statistical strength distributions and strength-probability-time plots. An advancement of the setup can be used to proof test ceramic components under overload conditions in order to reduce the failure probability and assure the designed lifetime.

Get the complete report at: http://link.abpi.net/l.php?20030415A4. Excerpted from *NASA Tech Briefs INSIDER,* 15 April 2003.

Indigo Systems and Infrared Thermography

Indigo Systems Omega is a tiny, high-performance infrared camera designed for high-sensitivity thermal detection with 14-bit digital capability. It is extraordinarily small (1.35 by 1.45 by 1.90 in.) and light (<120 g) and uses <1.5 W of power, with no compromise in performance.

It features SmartScene video (RS-170A) output to maximize picture quality in every frame and has instant turn on. Omega can be easily transformed into ThermoCorder, a complete handheld thermal imaging and video data recording system. Omega will be available for off-the-shelf delivery in June.

Call 805-964-9797 or visit http://www.indigosystems.com/. Excerpted from *NASA Tech Briefs INSIDER,* 8 May 2003.

Brazing Filler Metal for Heat Exchanger and High-Temperature Automotive Applications

Wall Colmonoy has introduced a new brazing filler metal for plate-and-fin heat exchangers and automotive components such as exhaust gas recirculating systems (EGRs), radiators, and catalytic convectors.

The material, called Nicrobraz 31, is a nickel-base high-chromium, oxidation-resistant braze filler metal. It has been demonstrated to have excellent capillary flow characteristics, a relatively low braze temperature, excellent joint strength/ductility and a low susceptibility to oxidation.

In the manufacture of plate-and-fin type of heat exchangers, Nicrobraz 31 has exceeded the strength of common brazing filler metals including those which meet AWS BNi-2 (AMS 4777), and AWS BNi-5 (AMS 4782) specifications. Burst strengths in excess of 2000 psi are consistently obtained using Nicrobraz 31 braze filler metal.

Nicrobraz 31 has a brazing range of 1095 to 1205 °C (2000 to 2200 °F). It is available as a powder or premixed as a paste suspension for application with the Nicrobraz "S" dispensing system. Upon request, it can also be provided as transfer tape, sheet, and flux powder paste.

Contact: Rick Hedden, Corporate Director, Marketing and Planning, 30261 Stephenson Hwy., Madison Heights, MI 48071-1650; tel: 248/585-6400, ext. 233; fax: 248/585-7960; e-mail: rhedden@wallcolomonoy.com.

Nicrobraz 31

Thermal Spray Produces Long-Life Nonstick Coat

A new-generation thermal spray technology creates a range of tough, flexible coatings with excellent wear, nonstick, and release properties.

Apticote Plasmadize 850—which uses an infused matrix of metals, ceramics, proprietary polymers, and/or dry lubricants—creates structural integrity and nonporous moistureproof surfaces that offer superior release properties against adhesives, glues, tapes, and other sticky substances when applied to metallic and nonmetallic tooling. It outperforms conventional thermal spray systems to provide a unique combination of excellent corrosion, wear and chemical resistance, high levels of lubricity, and USDA/FDA approvals.

A spokesman for Poeton says: "Apticote Plasmadize 850 can solve all the 'sticky substance' problems encountered in areas such as adhesive formulation, label printing, tape manufacture, or converting." "This advanced coating range is custom designed to act as a release system for all types of metal parts that come into contact with adhesives, where it can eliminate downtime and cleaning delays and help meet critical production schedules." Typical applications include packaging and printing, food, cosmetics, and pharmaceutical production. The technology is currently being used to protect sealing equipment such as bars, jaws, and dies against abrasive wear and corrosion.

This permanent, nonstick coating dramatically extends service life by eliminating the need to constantly apply and reapply nonstick tapes that rapidly wear out. The coating also prevents plastic and other materials from sticking or bonding to the parts. In the pharmaceutical industry it has solved one company's problem with glue adhering to sealing bars during the heat sealing of polythene bags.

The application of the FDA compliant nonstick coating eliminated sticking and dramatically improved operating speeds. Release coatings can also be customized for the different types of sticky residue that can come into contact with the surface of molds and rollers during the manufacture of food products such as biscuits and sweets.

The coatings, which are FDA compliant and USDA approved, are suitable for applications such as biscuit molds and dies, vibratory feeder bowls, hoppers, pill molds, filling machines, potato chip paddles, flow guides, cooking pans, and griddles.

A current example includes a bakery that is saving money on a Pillo-pak machine that is fitted with parts coated with Plasmadize. When the ear section of one component regularly broke off, it had to be thrown away. Now when it fails it is stripped, the ear is repaired, the profile is reformed and Plasmadize is reapplied. The refurbished part performs like a new one, at a fraction of the cost of a replacement.

Specifications for the new coating include: a 10 to 15% increase in wear resistance compared with thermal sprayed plasma tungsten carbide coatings and up to 30% compared to thermal sprayed plasma ceramic coatings, an operating temperature range from −129 to +704 °C when used as a release or gripping surface, salt-spray resistance in excess of 6 kh (ASTM B 117 and dependent on the coating type used), a coefficient of friction is as low as 0.06 compared with 0.22 for thermal sprayed tungsten carbide, and resistance to most acids, alkalis, and organic solvents.

Refer to http://www.engineeringtalk.com/news/poe/poe118.html.

Contact: Poeton Industries, Eastern Ave., Gloucester, GL4 3DN, United Kingdom; tel: +44 1452 300500; fax: +44 1452 300050; Web: http://www.poeton.co.uk/.

Test for High-Temperature Ceramics

A novel thermal shock and thermal fatigue test method based on controlled irradiation heating of ceramics is available that can be used to assess different high-tech ceramics intended to withstand severe thermal loads. This unique method enables collection of expressive data in contrast to the conventional water-quenching test. The fully quantifiable results are utilizable to compile statistical strength distributions and strength-probability-time plots. An advancement of the setup can be used to proof test ceramic components under overload conditions to reduce the failure probability and assure the designed lifetime.

The developed methodology is universally applicable and delivers material specific parameters under thermal shock loading conditions that can be immediately used by engineers to design parts.

The performance of different materials can be evaluated directly, based on the applied and measured temperature profiles; no further material properties are needed. Thermal fatigue tests with high cycle numbers give profound input data for improved lifetime prediction.

The method is fully developed and applied for silicon nitride and silicon carbide materials and prototype test parts. The test parameters can easily be varied, so that specific test conditions, depending on the material, components, and parts geometry can be used.

Contact: (U.S.) tel: 617/557-3800; fax: 617/523-8232; (U.K.) tel: + 44 2088 48 9779; fax + 44 2088 48 6469; (Japan) tel: + 81-3-5157-5440; fax: + 81-3-5157-5441; Web: yet2.com.

Awards Information

ITSC 2003 Awards

The following awards were presented at the International Thermal Spray Conference (5-8 May 2003, Orlando, FL). There were 1500 attendees from 30 countries, and more than 300 contributed papers.

Best Paper Awards (presented by ASM TSS President, Prof. Christopher C. Berndt) recipients were:

- **"Insights to Spraying Conditions, Microstructure and Properties and Their Statistical Correlation for Different Thermal Spraying Processes Using Complementary Characterization Methods,"** by **N. Margadant,** S. Siegmann, EMPA-Swiss Federal Laboratories for Materials Testing and Research, Switzerland; T. Keller, W. Wagner, Paul Scherrer Institute, Switzerland; A. Kulkarni, SUNY at Stony Brook, New York.

Berndt and Margadant

- **"A Systematic Approach to Material Eligibility for the Cold Spray Process," J. Vlcek,** L. Gimeno, H. Huber, EADS Deutschland GmbH, Germany; E. Lugscheider, Aachen University, Germany.

Inducted into the Thermal Spray Hall of Fame were:

- **Professor Maher I. Boulos,** Professor, Department of Chemical Engineering, University of Sherbrooke.

Berndt and Vlcek

Prof. Maher I. Boulos

Accepting the award in memory of their father are Joy Huber and D. Harland Harris

- **Douglas H. Harris,** Former President, APS Materials, Inc.

The **ASM TSS 2003 President's Award** was presented to **Kendall J. Hollis,** Los Alamos National Laboratory, New Mexico.

Kendall J. Hollis

Professor **Dr. Erich F. Lugscheider,** FASM, HOF, Head of Materials Science Institute, RWTH, Aachen University of Technology, Aachen, Germany received the **ASM International 2002 Albert Sauveur Achievement Award.** He is cited "for pioneering scientific and engineering contributions in materials joining, physical vapor deposition and thermal spraying area."

ASM International President Don Muzyka (left) and Prof. Dr. Erich F. Lugscheider

Certificates of Merit were awarded to:

Pershin

- **"Modeling and Design of an Attachment to the HVOF Gun," L. Pershin,** A. Dolatabadi, J. Mostaghimi, University of Toronto, Ontario, Canada.

Hussary

- **"Primary Breakup of Metal in the Wire Arc Spray Process," N. Hussary,** J. Heberlein, University of Minnesota, Minnesota.

Chráska

- **"Young's Modulus and Fatigue Behavior of Plasma Sprayed Alumina Coatings," P. Chráska,** J. Nohava, Institute of Plasma Physics, Czech Republic; O. Kovárik, J. Siegl, Czech Technical University, Czech Republic.

Knight

- **"Microstructure and Properties of Thermally Sprayed Functionally Graded Coatings for Polymeric Substrates," R. Knight,** M. Ivosevic, S. Kalindindi, G.R. Palmese, Drexel University, Pennsylvania; J.K. Sutter, NASA Glenn Research Center, Ohio.

Heberlein

- **"Fluid Dynamic Effects on Plasma Torch Anode Erosion," J. Heberlein,** X. Sun, University of Minnesota, Minnesota.

Marple

- **"Process Temperature-Hardness-Wear Relationships for HVOF-Sprayed Nanostructured and Conventional Cermet Coatings," B.R. Marple,** R.S. Lima, National Research Council Canada, Québec, Canada.

Fauchais

- **"In-Flight Oxidation of Metallic Particles in Plasma Spraying," P. Fauchais,** A. Denoirjean, A.A. Syed, P. Deniorjean, J.C. Labbe, Université de Limoges, France.

Ma

- **"Property Evaluation of HVOF-Sprayed Magnetic Thick Films," X. Ma,** S. Ge, T. Zhang, Y. Zhang, Inframat Corp., Connecticut.

Best Poster Awards were presented to:

Fauchais

- **"In-Flight Oxidation of Metallic Particles in Plasma Spraying,"** A.A. Syed, P. Denoirjean, A. Denoirjean, J.C. Labbe, **P. Fauchais,** Université de Limoges, France.

Ivosevic

- **"Development of Thermal Spray Functionally Graded Polymer/Ceramic Coatings," M. Ivosevic,** R. Knight, S.R. Kalindindi, G.R. Palmese, Drexel University, Pennsylvania; J.K. Sutter, NASA Glenn Research Center, Ohio.

Tsipas

- **"The Effects of a High Thermal Gradient on Sintering and Stiffening in the Top Coat of a Thermal Barrier Coating System," S. Tsipas,** I.O. Golosnoy, T.W. Clyne, University of Cambridge, United Kingdom.

Wilden

- "**Formation of Intermetallic Phases by Laser Alloying of Thermally Sprayed Ti and Al Coatings for Enhanced Wear Resistance of Lightweight Materials," J. Wilden,** H. Frank, Ilmenau Technical University, Germany.

The sponsoring organizations were ASM Thermal Spray Society (ASM TSS), the German Welding Society (DVS), and the International Institute of Welding (IIW).

The Yellow Brick Road and Cold Gas Dynamic Spray

The yellow brick road in manufacturing technology at the moment seems to be leading to the ability to design a machine that can put down fully dense metals in a commercially viable manner. The global race is on. University researchers in the United States, Europe, and Asia, thermal spray manufacturers, and major consortiums with some of the biggest players in

American aerospace, defense, and automotive industries have been working feverishly for the last several years to break the code in an area of revolutionary emerging technology.

What's all the rush about? In the early 1980s inside the former Soviet Union, a group of scientists discovered a phenomenon so simple—yet so significant—that their discovery will bring to the traditional thermal spray industry what cell phone technology brought to the telephone industry. The scientists discovered, quite by accident, that metal particles at or near room temperature moving at supersonic velocities would adhere to a surface upon impact. Translation: at *really high speed* there is enough kinetic energy to bond almost any surface imaginable.

So what's the big deal? Traditional methods of depositing metals—either in manufacturing production or aftermarket repair—have required the use of heat. High-temperature heat (normally at or above the melting point of the metal being deposited) has been the only viable method of getting metal to bond with metal. Think electric arc, explosive welding, plasma, or even high-velocity oxygen fuel (HVOF). Think of any traditional method of bonding metals, and there is one common denominator: HEAT. Heat makes for an explosive and dangerous operating environment as well as many other unpleasant side effects.

Adding to the dangerous environment, when there is high heat required to bond metal, the process of heating metal, by definition, creates structural changes during the bonding process that produces immediate oxidation (rust). Think about it, the minute your car begins its journey in the manufacturing process it begins to rust. To make matters worse, the heat required produces changes in the microstructure of the metals themselves (through expansion and contraction), producing inherent defects inside the actual bond. So, why use these traditional spray methods? The answer is simple. These were the only methods available to bond metal to metal . . . *until now*.

So, how long do I have to wait to buy this technology? You don't have to wait. Amazingly enough, this technology is for sale now. And, it works. While the R&D guys are debating how this technology works and are attempting to commercialize this so called "emerging" technology, there is a U.S. company primed and ready to roll out their product line.

Why has this company been such a secret? It has been waiting for the U.S. patents (granted February 2003) protecting both method and apparatus. Rus Sonic Technology, Inc. is a U.S. company, headquartered in Southern California, that was founded in 2000 with one mission in mind: to import proven, commercialized, cold gas dynamic spray technology and equipment to the U.S. market. The company's founder was approached in the late 1990s by members of the scientific team in Russia responsible for the original discovery in the former Soviet Union. These scientists have been working with this technology since their discovery in the 1980s. They were able to design, develop, produce, and ultimately successfully sell this technology in Russia, where it is currently in use in automotive, aerospace, marine, and petrochemical industries. Its current applications include corrosion protection, heat resistance and thermal barrier, electric conductivity, joining chemically dissimilar materials, anti-seize coating, and metal surface repair.

Contact: Rus Sonic Technology, Inc., 8211 San Angelo Dr., Suite H9, Huntington Beach, CA 92647; tel: 714/847-1064; fax: 714/847-1084; e-mail: LThompsonrusonic@aol.com.

News from Air Force Research Laboratory

Advanced Nondestructive Evaluation System

Scientists and engineers at the Materials and Manufacturing Directorate developed two advanced nondestructive evaluation (NDE) systems for imaging and characterizing surface-breaking cracks. Developed with assistance from the University of Dayton's Center for Material Diagnostics, the new systems use laser ultrasonic principles to image microscopic cracks that are invisible to the naked eye and difficult to measure with traditional NDE techniques. The systems use laser interferometry and holography principles to visualize cracks based on their near-field ultrasonic scattering signatures. This permits technicians to observe detailed, microscopic images of the cracks, which could have a significant impact on inspection processes for substrate materials and other structural components.

The advanced NDE systems provide a new capability for imaging surface-breaking cracks that are both noncontact and remote in nature. Both systems are able to characterize the cracks with microscopic resolution, which dramatically lowers crack detection limits and provides an opportunity to characterize surface-breaking cracks in full three-dimensional detail. Compared to traditional and other state-of-the-art NDE techniques, the new laser ultrasonic systems provide increased sensitivity to local features, enhanced signal levels, and simplified characterization. This should permit technicians to monitor materials and structures more effectively for defects that, over time, could degrade integrity.

Traditional ultrasonic NDE techniques use surface acoustic waves (SAW) to detect and characterize surface-breaking cracks. A typical measurement involves careful evaluation of SAW energy scattered from a defect site and noted by alterations in SAW amplitude/phase, reflection/transmission coefficients, and frequency content. In most cases, the probes used for conducting the measurements are far away from the cracks. As a result, the vast majority of experimental and theoretical work to date focused on the measurement and understanding of far-field scattering effects. In contrast, researchers have not examined in detail the behavior of SAW scattering in the immediate vicinity of the crack.

Directorate scientists and engineers developed a near-field scanning interferometry system and a real-time holographic

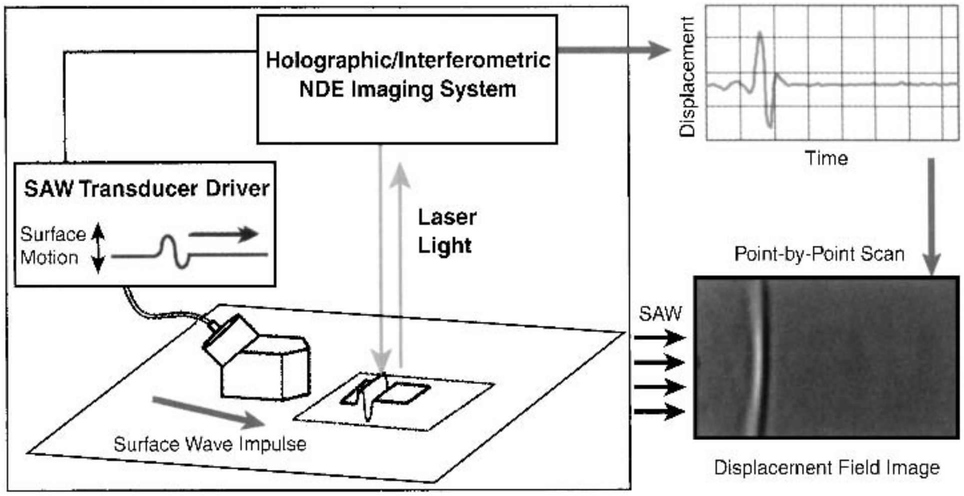


Fig. 1 New NDE system

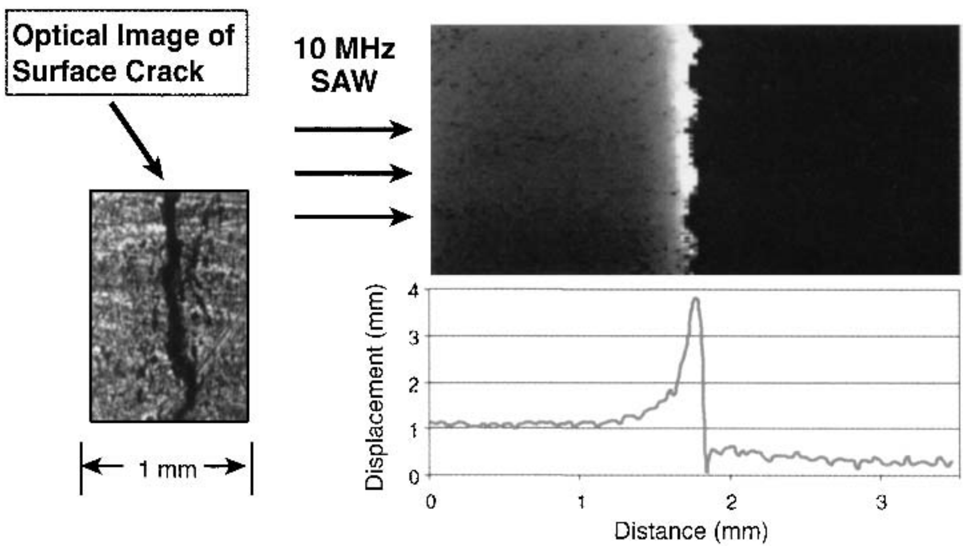


Fig. 2 Detection of a long surface crack

system for imaging surface-breaking defects in advanced aerospace materials (see Fig. 1). Both systems use laser ultrasonic principles to image the defects as modulated laser light, where ultrasonic motions induced in the material substrate create the modulation. Near-field ultrasonic scattering processes result in increased signal levels in the immediate vicinity of the crack, which are imaged as higher-intensity levels in the reflected laser light.

Researchers investigated three realistic surface-breaking cracks during this research effort: (1) a through-the-thickness crack in aluminum, (2) a long surface crack in aluminum (see Fig. 2), and (3) a 250 μm fatigue crack in titanium. In all three cases, researchers used a 10 MHz SAW impulse as the excitation source with the wedge-coupled transducer (1/4 in. diameter) positioned 2 cm from the cracks. They measured the propagating SAW and near-field scattering features using the interferometry and holography systems, which provided high-resolution, time-averaged displacement field images as their outputs.

In all cases, the near-field displacements in the immediate vicinity of the cracks were larger than the average displacements away from the cracks. This resulted in a brightness increase at the crack site when imaged, using the interferometric/holographic NDE techniques. Cracks which are otherwise invisible to the naked eye show up as dramatic brightness increases in the image, improving crack detection capabilities.

Excerpted from article by Mr. James L. Blackshire and Dr. Pete Meltzer, Jr. (Anteon Corporation), of the Air Force Research Laboratory's Materials and Manufacturing Directorate, for *AFRL Technology Horizons,* March 2003. For more information contact TECH CONNECT at 800/203-6451 or place a request at www.afrl.af.mil/techconn/index.htm. Reference document ML-02-21.

News from GTS

The GTS booth at ITSC 2003, Orlando, Florida. From left: Peter Heinrich, Peter Richter, Erika Fischer, and Werner Krömmer.

News from TSS

The ASM Thermal Spray Society is one of four affiliate societies of ASM International that serve the unique needs of specific member groups. These groups offer dedicated leadership, a focused mission, specific goals, and benefits including member publications and specialized annual events.

ASM TSS members are dedicated to learning about thermal spray performance, processes, properties, and applications. They exchange information using forums, programs, and services, bringing the aerospace-proven advantages of thermal spray to other industries.

Mission: The ASM Thermal Spray Society will be the leading member-driven, international society for thermal spray to foster communication, information development, technology advancement, education, and scientific understanding.

Contact: ASM International Customer Service; tel: 800/336-5152 or 440/338-5151; fax: 440/338-4634; e-mail: custsrv@asminternational.org; Web: www.asminternational.org/TSS.

ASM TSS Board of Directors. Left to right, sitting: Mark Smith, Richard Knight, Christopher Berndt, Al Kay, Peter Hanneforth, Andrew Nicoll (ASM International Board Trustee Representative). Left to right, standing: Joseph Stricker, William Scott (Executive Director), Robert Unger, Edmund Rybicki, Mitchell Dorfman, Pierre Fauchais

Douglas G. Puerta: Vice Chairman of the TSS "Accepted Practices Committees"

Doug received his Bachelor of Arts degree in Chemistry from Franklin and Marshall College and his Masters in Materials Science and Engineering from Lehigh University. While at Lehigh, his graduate research focused on the processing and properties of electrophoretically deposited functionally graded materials (FGMs).

After graduation, he was as a Process Engineer for Multi-Arc, Inc. While with Multi-Arc, Doug learned a great deal about industrial physical vapor deposition (PVD) and chemical vapor deposition (CVD) coatings and applications. He next worked as a Plant Metallurgist for Pennsylvania Metallurgical, Inc. (PMI), a large commercial heat treater in Bethlehem, PA. Then Doug spent a little over a year with Buehler, Ltd. as a Sales Engineer. He now serves as the Manager of the Metallurgical Services department for Ithaca Materials Research and Testing (IMR Test Labs) in Lansing, NY.

Founded in 1984, IMR Test Labs has grown into one of the nation's leading testing laboratories. IMR services a number of prominent names in the aerospace industry including G.E., Pratt & Whitney, Rolls Royce, Lockheed Martin, and many others. The firm specializes in analysis of metals, plastics, elastomers, electronic circuits, process chemicals, and composites. In addition to routine materials testing, about 30% of the firm's business involves analysis of product failures, defects, and processing problems.

People in the News

Michael Breitsameter is Vice President of Marketing and Business Development

The NanoSteel Company, an advanced nanomaterials company, named Michael J. Breitsameter as Vice President of Marketing and Business Development.

Michael J. Breitsameter

Breitsameter brings more than 15 years experience in global industrial sales in coating technologies and services. "We are very excited to have someone of Michael's caliber as part of our team," said Joe Buffa, TNC Chief Executive Officer. "His broad range of experience will be instrumental in establishing TNC's innovative products as key players in the industry."

Before joining TNC, Breitsameter was the national sales manager for Sulzer Metco Canada. Prior to this, he held various positions in product management, sales, and sales management while at Praxair TAFA. Breitsameter started out as district manager of sales and marketing, having responsibility at various times for Europe, the Western United States, the Pacific Rim, the Middle East, Africa, and his homeland, Australia.

"TNC is a true disruptive technology company," said Breitsameter. "It is an incredible opportunity to be involved in a start-up that I believe will exhibit tremendous short-term growth and help move thermal spray into the 21st century."

Dean Hackett Appointed Global Business Manager

Dean Hackett

Dean D. Hackett has been appointed Global Business Manager for Praxair Surface Technology's thermal spray products business. Hackett will be responsible for defining and implementing a successful business strategy worldwide for thermal spray powders, wires, and spare parts.

Hackett is a graduate of North Carolina State University where he obtained a Bachelor of Science degree in Engineering. He has been employed by Praxair Surface Technologies since 1988 and has held a variety of leadership roles, including Sales and Marketing Manager, Global Product Manager, and International Markets Manager for the thermal spray products business. He has been instrumental in expanding Praxair's presence across the globe over the last decade.

Troy Robinson is Manager—Turbine Markets

Troy Robinson

Sulzer Metco named Troy Robinson as Manager—Turbine Markets, Americas. Robinson started his career as a Plasma Process Engineer with Chromalloy in Harrisburg and then transferred to TAFA Inc. as a Technical Service Manager, where he assumed the role of Southeast Regional Sales Manager. When TAFA was purchased by Praxair Surface Technologies, he continued to serve as a Sales Manager.

Robinson has a diverse thermal spray background, including industrial market applications, with a specialization in Aero and IGT coatings, as well as equipment sales. He majored in Mechanical Engineering Technology at Penn State University. Robinson will head up the North and South American turbine market sales efforts for Sulzer Metco.

Wall Colmonoy Los Lunas Welcomes New Process Engineer

Wall Colmonoy announces the addition of a new engineer at its Los Lunas production facility. Mike Weinstein joins Wall Colmonoy Los Lunas as a Process Engineer. Weinstein has 17+ years experience as a metallurgical engineer. He holds a Bachelor of Science in Mechanical Engineering from New Mexico Tech.

Bruce Bodger Appointed Director of Sales and Marketing

Bruce Bodger

HITEMCO, a Barson Company, announced that Bruce Bodger has joined the company as Director of Sales and Marketing. Having been involved in global account management and contract negotiations with multinational accounts, Bodger is well suited to head up Hitemco's global sales, marketing, and customer service activities. During his 13 years in the coatings industry he has published several technical papers dealing with hard chrome replacement, has sponsored several AMS specifications, and is a 1997 Robert C. Garland Award recipient.

David Hart is Technical Services Manager

David Hart

MEC Welding, Eutectic Corporation, located in Menomonee Falls, WI, has appointed David Hart as Manager of Technical Services. This division supports the company's welding, coatings, brazing, wear plate, and automation business groups. Hart brings more than 20 years of international experience, having previously worked for Eutectic in Australia and Canada. He holds degrees in metallurgy and materials and recently completed his MBA. Hart will assist in developing the MEC business activities throughout the NAFTA and South America regions.

In Memoriam: Robert C. Uhl

Robert C. Uhl

Robert C. Uhl, 55, Ohio, former Executive Director of the ASM Thermal Spray Society, died on 24 March 2003.

Born in Pittsburgh, PA, he was graduated from Bethany College with Bachelor's degrees in mathematics and physics. He was a staff engineer for the Society of Automotive Engineers. Uhl joined the staff of ASM International in August 1981 as manager of technical divisions. During his 21 years with ASM, he served in positions of increasing responsibility and worked closely with many volunteer leaders of ASM.

As Executive Director of ASM TSS and a member of the International Thermal Spray Association, Uhl worked closely with all thermal spray industry leaders helping to strengthen both organizations and enhance communications throughout the entire global community. Uhl was instrumental in negotiations developing the jointly sponsored (ASM, TSS, DVS, IIW) International Thermal Spray Conference.