

LINKING RESEARCH TO PRACTICE

Message from the Director

It is my pleasure to introduce our seventh annual CTSR newsletter "Going Beyond the Surface". Despite the difficult economic times experienced over the last year, CTSR's research enterprise continues to thrive and flourish with numerous exciting developments and contributions. The *Consortium for Thermal Spray Technology* is now entering its 7th year and has managed to attract some 26 companies including several international organizations. The pre-competitive partnership has benefited all of the industrial members as well as academic participants. Indeed a testament to the interest is excellent attendance during our biannual meetings. The spring meeting involved some 37 industrial participants and an additional 12-15 participating in the web cast. As this newsletter is being developed we are anticipating about 35 participants for the fall meeting to be held on November 5th, 2009.

We have continued to make breakthrough progress in both science and technology over the last year. Notable is the continued interest in measuring anelastic properties of ceramic coatings through our curvature sensor. Both the *in situ* and *ex situ* curvature sensors termed ICP and ECP for coating property sensing have attracted significant industrial attention through our field trip program. To date some 15 field trips have been conducted with the most recent ones to Switzerland and Germany. Through these field trips, we have been able to explore wide ranging thermal spray processes from advanced plasmas to solution and suspension spraying of advanced materials. The knowledge gained from the field

trips have also helped in identifying critical R&D issues for the future.

Several new initiatives were undertaken in 2009 through various sponsored projects. Notable is the development of a novel phosphorescent thermal spray coating as a proton beam mapper for the spallation neutron source at Oak Ridge National Laboratory. A noteworthy element of this project in addition to the material complexity is the speed of implementation. The entire project from concept to initial trials all the way to field implantation at Oak Ridge was completed in three months. More information is provided in this newsletter. New initiatives are underway in the area of novel TBC systems for coal derived gas turbines as well as environmental barrier coatings for composites.

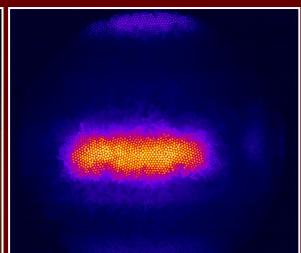
Our collaborations with both US and international organizations have allowed new insights into coating property measurements. Specifically, these partnerships have allowed applications of new measurement tools (e.g. resonant ultrasound spectroscopy, infrared tomography, surface characterization, etc.) to further elucidate the complexities of wide ranging thermal spray coatings. Such expanded and integrated efforts are critical in not only accelerating our understanding of the materials and processes but also providing much needed advanced properties for design.

I invite you to glimpse through these developments in this newsletter and through our new expanded website www.ctsr-sunysb.org.

Sanjay Sampath
Director CTSR

Oak Ridge National Laboratory: Development of a phosphorescent coating for the Spallation Neutron Source target - From concept to field application in three months

ORNL and CTSR researchers embarked on a novel initiative to apply a conformal phosphorescent thermal sprayed ruby coating on the neutron generator target at the Spallation Neutron Source at Oak Ridge National Laboratory. The goal was to deposit a thin functional (luminescent) coating on the face of a neutron generator target for proton beam profiling. The development of such a functional coating required overcoming numerous challenges including optimizing phase and crystallinity of the ceramic layer, application on the target material without significant thermal loading from the process, application of the coating on site at ORNL, limited development time, and challenges with feedstock materials and chemistry optimization. CTSR researchers applied the concepts of process maps and *in situ* coating property sensing to optimize the phase and microstructure of the coatings. Together with luminescence measurements at ORNL, deposition conditions and material chemistry were identified. Finally, a portable application system including robotics, materials handling, and dust collection was designed, fabricated and transported to ORNL resulting in the successful application of the novel luminescent coating. The entire project lasted <3 months and points to the power of advanced scientific concepts in expanding thermal spray applications.



Industrial Consortium News

The Consortium on Thermal Spray Technology continues to thrive and grow. Presently there are some 26 member companies. The consortium meets twice a year with approximately 40-50 industrial participants allowing for dissemination of research efforts at CTSR and collaborative discussions among the consortium members.

Each company contributes \$12,500/year through membership fees which partially supports the research and knowledge transfer activities. Complementary funding to the tune of \$1.7 M has been received from NSF and DoD to support CTSR/Consortium research activities.



Field Trips with the In-situ Coating Property Sensor

In October 2009, CTSR team had four successful field trips to Europe to conduct research and characterization of coatings using in-booth diagnostic sensors. Dr. Alfredo Valarezo (postdoctoral associate) had the opportunity to visit Alstom Power Systems facility at Birr, and Sulzer Metco at Wohlen, both in Switzerland; and Dr. Brian Choi (postdoctoral associate) and Mr. Steve Baader (research engineer) visited the University of Stuttgart and Forschungszentrum Julich in Germany. This was the fifth CTSR field trip to Europe after visiting Volvo-Aero in Trollhattan, Sweden, in January 2009.

This series of field trips in the US and Europe started in 2007, and have proven to be very beneficial not only for students and associates at CTSR, but also for researchers and engineers at akin research facilities at universities, specialized labs, and industries.

For total of ten days, 92 spray experiments were conducted using the in-situ Coating Property (ICP) sensor, developed by CTSR. We look forward to sharing the interesting results out coming from the carried out research.

At Alstom Power Systems, we worked together to validate their spray process conditions. In three days, 25 experiments were conducted spraying TBC's and bond coats by

different processes. Characterization of coatings is still going on. At Sulzer Metco, stress management in carbide coatings by APS was investigated by two different torches and process parameters. In two days, 12 experiments were conducted to find key parameters for optimization of residual stress states.

Brian and Steve spent two days at the Institute for Manufacturing Technologies of Ceramic Components and Composites (IFKB) in University of Stuttgart with Prof. Rainer Gadow, Dr. Andreas Killinger, and graduate students. The ICP sensor was used for the first time to monitor stress evolution of ceramic coatings deposited with High Velocity Solution Flame Spray (HVSFS). This process yields extreme substrate temperature conditions: 750°C at 8" (20cm) spray distance. In Julich, the duo spent three days at the Institute for Energy Research: Materials Process and Synthesis group (IEF-1) in Forschungszentrum Julich with Dr. Robert Vassen and Dr. Georg Mauer. ICP was used to monitor the stress evolution of HVOF steel and plasma sprayed YSZ coatings. The field trips to Switzerland and Germany were a great success, and CTSR is looking forward for continuous and fruitful collaboration with the visited institutes and R&D facilities.



Images from various field trips. Top, left: Alstom Power Systems including Sebastian Mihm, Alfredo Valarezo, and Joerg Sopka. Top, center: Forschungszentrum Julich including Balasundaram Rajasekaran, Georg Mauer, Karl-Heinz Rauwald, Brian Choi, Robert Vassen, and Stephen Baader. Top, right: Sulzer Metco including Alexander Barth, Mischa Weder, and Alfredo Valarezo. Right: Image showing the ICP sensor being used to evaluate coating deposition properties.



CTSR Graduate Students Abroad

Arash Ghabchi



Arash's research focuses on addressing the wear performance and mechanisms of thermal spray composite coatings (carbide-based) by recourse to multi-scale mechanical properties. By using a modeling approach Arash aim to find the effects of crucial microstructural and mechanical properties (e.g. carbide, binder, porosities, etc.) on global mechanical response of composite coatings to external loading conditions such as indentation. Additionally, coating response to wear will be examined through modeling and the results will be compared with experiments leading to a deeper understanding of underlying wear mechanism. During this work, the linkage between process, microstructure and coating properties as well as performance will be studied employing process map approach.

Conducting his research in Technical Research Center of Finland (VTT), which is the biggest research organization in Northern Europe with over 3000 employees, provided Arash great opportunities. State of the art research facilities, expert colleagues in wide variety of research fields, possibility to participate in different international projects with industrial and academic partners are the ways that VTT helps Arash to improve the quality of his research work and achieve his professional goals.

José Colmenares



One of our graduate Students, Jose Colmenares, is attending a 5 month international exchange program at the National Institute of Materials Science of Japan. He is working under the supervision of Dr. Seiji Kuroda, director of the Hybrid Materials Center. Dr. Kuroda and his NIMS team have been instrumental in the understanding of stress evolution and the development of advanced corrosion control coatings in the field of thermal spray technology. One of CTSR's post-doctoral scientist, Kentaro Shinoda has a joint appointment between CTSR and NIMS where he serves as a Visiting Researcher and has developed techniques for visualization of splat impact.

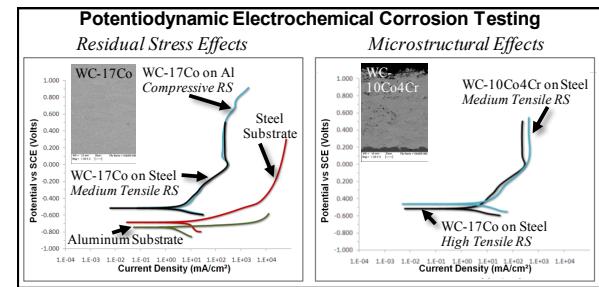
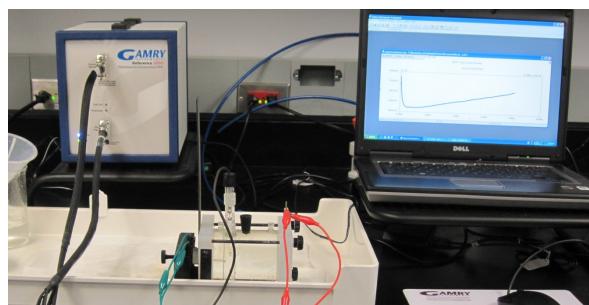
José's work is focused on the development of solution and precursor spraying techniques. He is also learning about the different activities going on in the NIMS coating group, such as the study of their in-house developed warm spraying technique and diverse characterization techniques. He has also interacted with researchers such as Jin Kawakita (Electrochemistry of TiO_2 coatings) KeeHyun Kim (Metallic Splat Impact Phenomena) Hideyuki Murakami (Oxidation Resistance) and Makoto Watanabe (Fail safe thermal spray coatings).

Corrosion and Electrochemistry Research at CTSR

Prof. Chris Weyant has set up facilities at the CTSR in order to conduct electrochemistry-based corrosion studies. He is interested in investigating corrosion and tribocorrosion (simultaneous wear and corrosion) mechanisms in thermally sprayed coatings. A variety of materials including metals, polymers, and cermets, are thermally sprayed to provide corrosion protection in a variety of applications including airplane landing gears, bridges, and naval vessels.

A Gamry Reference 3000 is used to conduct a variety of experiments including potentiodynamic testing during which corrosion is induced in a sample to investigate the nature of degradation within a sample as well as to calculate the corrosion rate in a particular electrolyte solution (e.g. salt water). In addition, non-destructive electrochemical impedance spectroscopy (EIS) testing can be conducted. Impedance measurements combined with equivalent circuit modeling allow for determining characteristics of coatings and how corrosion phenomenon leads to coating degradation. Measurements can be made as a function of exposure to specific environments. Some preliminary experiments, whose results are shown on the right, reveal the impact that thermal spray coating structure has on corrosion performance. In this study, comparison of WC-17Co with WC-10Co4Cr revealed that no additional corrosion protection was afforded by the addition of chromium. However, looking at the coating microstructures, one sees that porosity in

the WC-10Co4Cr coating provided a path for the corrosive solution to reach the substrate. Incorporation of this equipment with existing tribology wear testing apparatuses will allow for future studies into the tribocorrosion behavior of thermal spray coatings.



CTSR Welcomes New Staff Member: Chris Jensen

In September 2009 Chris Jensen joined the Center for Thermal Spray Research as a Senior Research Support Specialist. Chris earned his Bachelor of Engineering in Engineering Science, with a minor in Materials Science, from Stony Brook University in 2003.

After Stony Brook University Chris worked as a process engineer with eele Laboratories, a Long Island based startup company geared towards the production of etendue efficient lighting systems for projection displays. He was responsible for optimizing a nickel based electroforming process used in the manufacture of precision optical reflectors. Chris was also involved in the development of cold mirror and bandpass coatings deposited on the reflectors via an ion beam assisted electron beam evaporation process. During his time with eele Laboratories Chris



traveled to Taiwan where he setup a manufacturing facility to produce the thin film coated optical reflectors in high volume to enter into the Digital Light Projection (DLP) markets.

Afterwards Chris moved to CVD Equipment Corporation where he optimized the Chemical Vapor Deposition processes used to synthesize advanced materials such as carbon nanotubes, silicon nanowires, epitaxial thin films, and transparent conductive oxides. During his time at CVD Chris decided to return to academia to get his masters degree in Materials Science which he is now in the process of completing at CTSR. Chris is excited to become a part of The Center for Thermal Spray Research and looks forward to bringing his knowledge and experience to the team.

Graduate Student Lorena Bejarano Joins TSS Board of Directors



Lorena was nominated and selected to form part of the TSS Board of Directors in March 2009. She participates on the board as a Student Board Member together with Mr. Viktor Drescher, a graduate student at Technical University of Berlin. "Being part of the TSS Board is a great experience that enables me to learn from the outstanding group of board members who work hard to overcome issues of the

thermal spray community" says Lorena. She thinks of this opportunity as a very enriching activity not only to advance her own knowledge and gain firsthand experience but also to contribute to the TSS through her participation in board meetings. Board discussions aim to lead the Thermal Spray Society as a robust and well established organization by developing policies, organizing conferences, and proposing standards and certification methods. The Students Board Members were assigned with a "board mentor", Mr. Raymond Sinatra from Rolls Royce Corporation, to guide them through this experience. Lorena will be serving as Student Board Member through March 1, 2010.

Alumni Focus: John Nerz



In this issue, we are pleased to spot-light John Nerz who is currently at GE Aviation in Evendale, Ohio. John was born in Brooklyn, NY and grew-up in Long Island. He completed his undergraduate degree in Engineering Science at Stony Brook. He graduated in 1988

with a master's degree in Materials Science and Engineering from Stony Brook specializing in thermal spray under the direction of Prof. Herman. John's research, which was sponsored by the US Navy, focused on burner rig thermal cycling of thermal barrier coatings. He first stint in the thermal spray industry was at Chromalloy in Orangeburg where he was a process engineer. In 1988 he moved to then Metco-Perkin Elmer (prior to the acquisition by Sulzer) where he was instrumental in development of HVOF process and materials technology. John was employed at Metco from 1988-1994 and subsequently moved to Chicago to work in Mo-

torola conducting basic research on battery materials and technology. He spent 4 years in Chicago and then 4 years in Motorola's phoenix location. While at Phoenix John obtained an executive MBA degree at Arizona State University. In 2001 he was hired by General Electric's Aviation Division in Lynn, Massachusetts as a coating process engineer as their thermal spray expert. Recently he moved to GE Aviation headquarters in Evendale, Ohio where he is Special Process Technology Leader for Thermal Spray and Diffusion Coatings.

While at Stony Brook John met his wife Tuck Chon. Tuck was also a graduate of the Stony Brook thermal spray program and worked along side John at both Metco and Motorola. They have been married for 19 years and have two children Jonathan, 13 and Christian, 7. John likes to workout in the gym and enjoys watching his two children compete in taekwando competitions: Jonathan is a 2nd degree black belt while Christian is a green belt. He is a frequent visitor to Long Island and Stony Brook as his parents live not too far from Stony Brook University and has taken an active role in the consortium.