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Center for Thermal Spray Research

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STONY BROOK
STATE UNIVERSITY OF NEW YORK

Going Beyond the Surface

LINKING RESEARCH TO PRACTICE

Message from the Director

It gives me great pleasure to introduce our 9th annual CTSR newsletter "Going Beyond the Surface". Our successes of 2010 have continued through 2011 and we continue to make significant strides in research, scholarship, human resources and knowledge transfer. 2010-2011 featured a number of major successes in terms of grant applications. We reported last year that our NSF-GOALI grant was renewed with a commitment of over $600K to continue the consortium partnership. In addition, work is well underway on the Department of Energy project on coating development for high hydrogen turbine systems. 2011 also saw two major new awards. The Transportation Research Board of the National Academy of Sciences selected CTSR for a pilot project under their IDEA program (Innovation Deserving Exploratory Analysis). This project seeks to critically assess the capability of high velocity thermal sprayed overlays as a possible structural and corrosion resistant reclamation of infrastructure steel that has undergone environmental degradation. The important attribute under examination is the role of impact stresses on the parent metal's mechanical characteristics as well as the ability of the coating material to transfer some of the load. Initial results are promising. Our Office of Naval Research project on ship-deck thermal management is entering a crucial evaluation phase with testing planned by the Navy in December.

CTSR was also selected for another major grant from the National Science Foundation through its Partnership for Innovation program. This highly competitive project is unique in that it seeks industry-university linkages to explore radical new applications of platform materials technologies. Through this grant CTSR seeks to explore fundamental and technological issues of thermal sprayed functional oxides with applications in fuel cells, batteries and thermoelectrics. The 3 year $600K award has recently been formalized and work has begun.

The Consortium continues to thrive and make a significant impact. The membership has grown to some 35 companies. Our biannual meetings are very well attended with some 60-80 industrial participants. We are also strategically organizing the consortium meetings at partner sites to promote new interactions. The fall 2010 meeting was held in Key West Florida co-hosted by the Naval Research Laboratory's corrosion center. As this newsletter goes to press, the fall 2011 meeting will be held in Cincinnati co-hosted by GE Aviation.

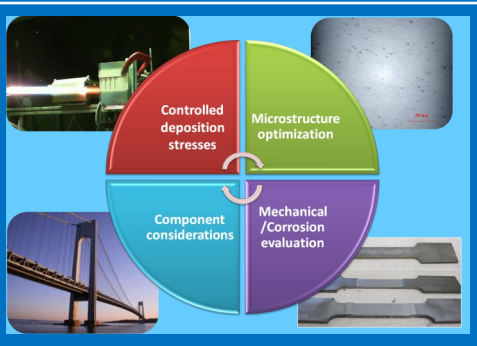
We continue to impact on the human resources front. CTSR's graduate and even undergraduate interns are highly sought after by industry. Some examples are included in the newsletter.

This newsletter is dedicated to Scott Goodspeed, a patron and friend of the Center and an inspiration to the thermal spray industry. Scott passed away recently after a valiant bout with Cancer. Even through difficult days of his treatment, Scott made it a point to attend the consortium meeting last June. We will miss him dearly. A more detailed tribute is included in this newsletter. As always, I invite you to join the CTSR team to realize our common goal: to make thermal spray a household word.

Sanjay Sampath Director CTSR

Can thermal spraying rise as a solution for material reclamation of infrastructure?

CTSR was recently selected by the Transportation Research Board of the National Academy of Sciences under its IDEA program (Innovations Deserving Exploratory Analysis) to explore thermal spray-based on-site reclamation of corroded infrastructural components such as bridges. The project seeks to determine if high velocity thermal sprayed coatings applied onto steel structures can provide reinforcement and recover load bearing capability to enable extended utilization of degraded structural components while simultaneously providing enhanced corrosion resistance to prevent further deterioration.



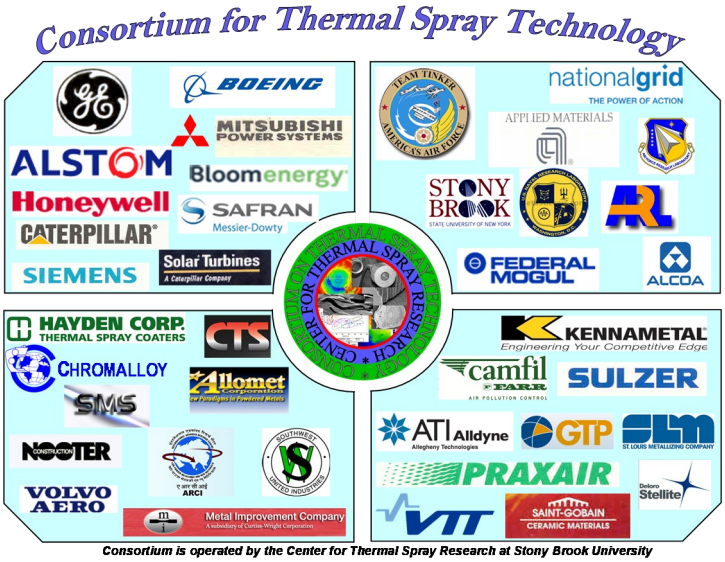
Although thermal spray coatings have long been used for material reclamation, their load bearing capability and ability to transmit load through the coating-structure interface has not been systematically or scientifically investigated. Of particular interest is peening stresses imparted on the parent metal via grit blast/high velocity impact and their potential contribution to stiffening and strengthening of the parent material surface. CTSR's on-going activity has developed a methodology to address these issues through simulated laboratory tests of the component conditions. Discussions are also underway with DoT for

Center for Thermal Spray Research
Department of Materials Science and Engineering
Stony Brook University
www.ctsr-sunysb.org

130 Heavy Engineering
Stony Brook, NY 11794-2275
Ph: (631) 632-8480 Fax: (831) 632-7878
Email: sanjay.sampath@stonybrook.edu

Industrial Consortium News

The Consortium for Thermal Spray Technology hosted by CTSR continues to expand and provide benefits to industry across the supply chain. 2010-2011 saw the biggest growth in membership expanding to some 36 companies. New members include Boeing, SW United, Bloom Energy, Allomet, Honeywell, Cincinnati Thermal Spray and Camfil FARR. The fall 2010 consortium meeting was held in Key West, Florida co-hosted by Naval Research Laboratory's corrosion center. This meeting was held over two days including a one-day focused theme on corrosion control coatings. The spring 2011 meeting was held at Stony Brook last June and was the largest ever in terms of attendance with over 90 participants. As this newsletter goes to press, we are preparing for our fall 2011 consortium meeting to be held in Cincinnati, OH co-hosted by GE Aviation.

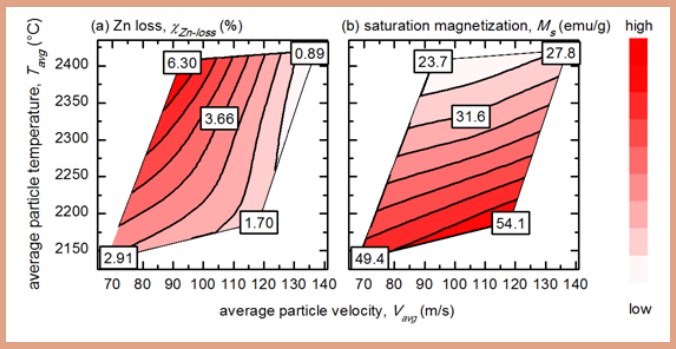


Consortium is operated by the Center for Thermal Spray Research at Stony Brook University

Each company contributes $12,500/year through membership fees which enable self-sustaining operation of CTSR following its 11-year National Science Foundation grant enabling continued research, knowledge transfer and human resource development activities. Complementary funding to the tune of $3M has been received through NSF, DoE, DoD and the University enabling CTSR to thrive and continue to be the focal point of thermal spray research in the US.

New NSF Grant to Study Thermal Spraying of Functional Oxides

CTSR is pleased to announce that our team was selected for a $600,000/3 year National Science Foundation – Partnership for Innovation (PFI) grant to enable new applications of thermal spray in arena of functional oxides. Functional ceramic oxides are important classes of materials that display resistive, semi-conductive, conductive (electronic, ionic or mixed), magnetic and even superconducting behavior. In general, these materials are multi-component, and their electrical characteristics are achieved via manipulation of the defect chemistry imposed through alloying. Due to their unique characteristics, they have been a subject of significant interest in electronics, sensors and energy systems. A common attribute among these applications is the desire to fabricate these materials in the form of thin films or as thick film multi-layers so as to harness their capabilities within devices. Numerous applications now exist which utilize such devices including *RF/microwave systems, power electronics, sensors, batteries and fuel cells*. Materials of interest include *doped zirconias, ferrites, indium tin oxide (ITO), doped $LaMnO_3$, and doped titanates*. Wide ranging future opportunities are foreseen utilizing these materials, especially those related to high temperature/harsh environment applications.



This NSF PFI project brings together an industry-academia innovation team to capitalize on emergent opportunities in thermal spray (TS) deposition of functional oxides for applications in high temperature sensing and electrical energy conversion systems. It has long been appreciated that successful development of functional oxide deposition via TS (a platform technology) would provide an enabling new capability for a high rate, economical approach to large area deposition of components in fuel cells, batteries, and a range of thick film sensors. Many of these inventions have been contemplated for several decades but have not been translated into innovative applications, largely due to the complexity in materials science of TS systems as well as limitations in process science and control. Over the last decade much has changed in both knowledge and technology which has resulted in a reconsideration of the capability for functional

Focus on CTSR Students & Postdocs

CTSR students continue be sought after by the membership for internship and employment. Over the last year, there have been many requests from member companies to hire students with exposure and experience in thermal spray technology and materials engineering. In response to this, we have taken an aggressive approach to the recruiting and involvement of undergraduate students in the laboratory enabling both hands-on learning and fundamental insights. The Engineering Systems Laboratory undergraduate class ESM 450 developed by Prof. Sampath introduces the gas turbine system as a platform to study materials. Over the last four years more than 150 students have participated in the class which also includes a hands-on thermal spray coating and materials testing component. In addition to students from Engineering Science/Materials Science programs, Prof. Sampath through his joint affiliation with Mechanical Engineering has been involving undergraduates and graduates from mechanical engineering as well.

Riston Rocchio and Sal Marino, recent graduates of the Engineering Science program and long time interns within the Center have both received employment offers to work at GE Energy at Greenville, SC. GE Energy's recruitment team visited campus earlier this year with a specific goal to develop a strategic partnership with the Center for human resource development. Riston and Sal spent last summer as interns and will be starting full employment early next year. We wish them well in their careers and proud of their accomplishments.

Dr. Yang Tan, CTSR post-doctoral associate, recently joined Alcoa Technical Center in Pittsburgh as a coatings development engineer. He received his Ph.D. in Mechanical Engineering in 2005 and worked as a post-doctoral fellow afterwards. Yang has contributed significantly to consortium efforts. I expect he will continue to be involved with Consortium through Alcoa.

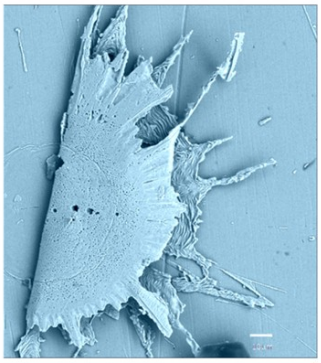
Dr. Arash Ghabchi, recent CTSR graduate (Sept. 2011) has joined the Boeing Company as an engineer in the thermal spray group. Arash conducted his PhD work jointly with VTT Research Center in Finland (co-advised by Dr. Turunen and Dr. Holmberg) in the area of coatings Tribology. He will work closely with Marc Froning (Consortium colleague-formerly of BASF) in furthering thermal spray applications at Boeing. Best of luck to both Arash and Marc.

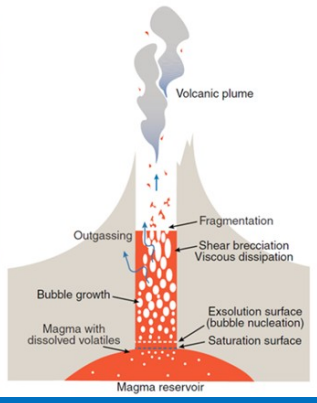
Ari Sagiv (MS 2011) and Adel Djam (BS 2011) both have joined Sulzer Metco in Westbury as process engineers. Ari completed his MS thesis working with Prof. Weyant in the area of Environmental Barrier Coatings, while Adel was an undergraduate intern at CTSR.

Vaishak Vishwanathan, a PhD student in the group was selected to received the 2011 International Thermal Spray Association graduate student fellowship.

We wish our graduates the best for the future and gratified by their interest in thermal spray.

Thermal Spray and Volcanology





Recently, Prof. Andrew Gouldstone, a CTSR faculty Alum now at Northeastern University, was awarded an NSF Grant under the inaugural IDR - Inter-Disciplinary Research program, slated for programs that clearly and radically crossed the boundaries between disciplines. A previous CTSR-based effort led by Gouldstone and Professor Sampath involved the discovery of nanoporosity on the bottom surfaces of Ni splats; this was attributed to rapid depressurization on impact, leading to bubble nucleation and 'freezing' into tiny pores. The physics of this process has been studied heavily by volcanologists, as bubbles tend to nucleate and grow rapidly in a column of magma as it ascends within a volcanic cone. Accordingly, Gouldstone and Professor Helge Gonnermann of Rice University Earth Sciences with advisory participation by Prof. Sampath put together a successful $600k/3 year NSF proposal to launch an experimental and numerical study for spraying splats of natural geologic materials, e.g., silicates found in magma. Both communities benefit from this interaction; Dr. Gonnermann's input of nucleation physics may allow the TS community to 'dial in' spray conditions for high volume production of nanoporous materials, and the 'harsh environment' imparted to the silicate materials as they splat on substrates will give insight into the high-strain rate behavior of natural silicates, at or above their melting temperature, which is valuable to volcanologists in eruption modeling and

Remembrances of Scott Goodspeed

Scott Goodspeed was a great friend and a loyal colleague. During our time as professors at Stony Brook University Scott was there when we needed him, both as a gracious (complimentary!) supplier of materials for our research studies and sage advice on all matters, professional and personal. He would give us leads of who was giving what away, and he told us first. I used to think that Scott felt sorry for our then very tight finances. I eventually realized that he really liked our gang and the University. When Scott walked into a room his personality lowered the stress level (and it was quite high with us in those years). His humor and good nature were infective. Scott's "Let's go to lunch" was what we looked forward to because we knew that a relaxing hour was imminent.

As anyone in the industry who knew Scott would attest, he was always ready with professional help and a kind word. His knowledge of thermal spray technology was both comprehensive and wide ranging. He knew so many secrets of the trade and people within it, that he was a font of knowledge on equipment, materials and methods. His was a happy life. He loved to talk about Maine, in that "down south" accent, and of his family and home: the kids and what they were doing – a proud and doting father. He told us of the business Cheri and he had to give up and their relocation to a lake in Maine. In asking if this were difficult for him, you would get the typical Scott-like reply: A shrug of his shoulders and a vague smile that said "That's life". He was rarely perturbed and if we were smart enough to learn from him, we would have been happier people.

Scott put many miles on his SUV going from his numerous business stops to home in Maine. If he had worries, you would never know. During one lunch in particular, with his then sidekick and dear friend Dennis Hewitt, after covering the latest gossip, we discussed long distance driving. The exact words of his response are now gone, but in essence he responded that "…I love the freedom of the road, and, anyway, it's a living."

Some people come into our lives and quickly go. Some stay for a while and leave footprints on our hearts. And we are never, ever the same.

-Herb Herman and Sanjay Sampath

CTSR earns another outstanding paper award from JTST

Following the 2009-2010 recognition of CTSR's work with the JTST Best Paper Award, CTSR's work received another notable accolade from JTST in 2010-2011. Prof. Sampath's review article "Thermal Spray Applications in Electronics and Sensors: Past, Present and Future" was recognized as an Outstanding Review Paper by the journal. One judge stated "The paper gives a comprehensive and convincing overview of the range of coatings that can be used to manufacture electronic circuits and sensors". We thank the JTST awards committee for recognizing CTSR's contributions. This is indeed an inspiration to the team to continue to elevate its thinking and more notably effective documentation of the research into peer reviewed publications.

Alumni Focus: Dr.Ravi Shankar

In this year's newsletter, we are pleased to recognize one of our distinguished alumni, Dr. Ravi Shankar, Director, Coating and Process Technologies, Chromalloy Gas Turbine LLC, in Orangeburg, NY. Ravi was one of the "early" graduates of the Stony Brook thermal spray program, obtaining his PhD in Materials Science & Engineering under the tutelage of Prof. Herbert Herman in 1984. Born in India, Ravi completed his Bachelor's degree in Metallurgical Engineering from the prestigious Indian Institute of Technology in Madras, prior to moving to the US. At Stony Brook his research focused on studying relationships between structure and properties of ceramic coatings. Ravi shed some early light relative the complexities of modern day TBC coatings. He pioneered the use of neutron diffraction and acoustic emission in the study of phase relations and microcracking. Ravi's work was not only seminal but highly innovative and brought much needed materials science into industrial plasma sprayed coatings.

Upon completion of his PhD, Ravi went on to join the NY division of Chromalloy in Orangeburg, NY and has been a loyal and effective contributor to Chromalloy's coating development. His pioneering spirit continued at Chromalloy; Ravi led the development efforts that resulted in the establishment of the world's first EB-PVD TBC coater which went into full scale production in 1988. At Stony Brook, Herman and his colleagues fondly chided him a "turn-coat" as he favored the competitive EB-PVD process over the thermal spray: the religion of Stony Brook graduates.

During the next ten years, Ravi worked on all aspects of aero and industrial coatings with significant contributions to both plasma spray and diffusion aluminide coatings. In 1998 he moved the repair side of the business extending his reach in to brazing, welding, laser drilling, EDM etc., enhancing the full scale turbine repair and coating technologies at Chromalloy. Along the way he became the Designated Engineering Representative of FAA providing him unique authority in approving technical data.

In 2008 soon after Chromalloy became part of the Carlyle Group, a private equity firm, he was elevated to his current position as Director of Coating and Process Technologies as a part of the Corporate Technology Group. Ravi lives in Mahwah, NJ and enjoys playing golf and traveling.