Advanced Characterization Techniques for Coatings, Thin Films, and Small Volumes
Room On Demand - Session H3

Characterization of Coatings and Small Volumes in Harsh Environments

H3-1 INVITED TALK: Investigating Plasticity Effects on Failure and Fracture at the Microscale*, **Nathan Mara (mara@umn.edu)**, K. Schmalbach,* University of Minnesota, USA*; R. Ramachandramoorthy, J. Michler,* Empa - Swiss Federal Laboratories for Materials Science and Technology, Switzerland*; W. Gerberich,* University of Minnesota, USA **INVITED**

Due to pronounced effects of sample size on the measured mechanical response, a major challenge persists in correlating microscale measurements to macroscale measurements, especially for ductility and fracture. For brittle materials with small plastic zone size relative to the sample size (e.g., Si), micro cantilever and 3-point bending have shown promising results. However, for semi-brittle (e.g., W) materials, the plastic zone size becomes comparable to the sample dimension and thus the conventional analysis methods based on linear-elastic and elastic-plastic fracture mechanics prove difficult or impossible to apply. We intend to address the challenges of diminished sample size inherent to evaluating fracture behavior at the microscale through investigation of the Ductile-to-Brittle Transition (DBT) in materials such as Si, SiC, and W. By using the DBT as our benchmark to bulk fracture behavior, we present an investigation of the interplay of sample size with the onset of increasing plasticity with temperature on fracture behavior. Trends in activation parameters will be discussed in terms of changes in dislocation-based mechanisms as a function of test temperature, strain rate, and loading state, and used to predict fracture behavior based on an analytical model.

H3-3 High Temperature Erosion Performance Evaluation of Advanced Materials*, **Debdutt Patro (debdutt.p@ducom.com)**, S. Josyula, H. Prasanna,* Ducom Instruments, India*; F. Alemano, D. Veeregowda,* Ducom Instruments, Europe

High temperature erosion testing at temperatures exceeding 600°C involves simultaneous erosion-oxidation interactions that can affect the interpretation of the erosion rates reported from such experiments. Ducom high temperature air jet erosion tester was used to conduct erosion tests at 1000°C on both alumina ceramic and Inconel 600 superalloy using alumina as an erodent. Erosion tests were conducted on as-received samples as well as pre-conditioned samples. Gravimetric and profilometric analysis was conducted after the test to obtain erosion rates and volumetric loss and SEM was conducted on the scar to identify the damage mechanisms. The magnitude of oxidative weight gain was found to be comparable to erosion related weight loss. Observed erosion rates were different for as-received and pre-conditioned samples with the pre-conditioned samples showing better repeatability. The high temperature erosion rates of IN 600 vs. alumina tested at different angles and SEM images indicate characteristic ductile and brittle erosion behavior respectively. The study highlights the importance of pre-conditioning of samples on (a) accurate erosion performance assessment of materials and (b) repeatability during high temperature erosion testing of materials.

H3-4 Characterization of Selective Solar Absorbing Coatings Under Operating Conditions*, C. D'Alessandro,* ***Antonio Caldarelli (antonio.caldarelli@na.isasi.cnr.it)****, D. De Maio, E. Gaudino,* UniNA and CNR - ISASI, Italy*; M. Musto,* UniNa - Univeristà degli Studi di Napoli "Federico II", Italy*; D. De Luca,* UniNA and CNR - ISASI, Italy*; E. Di Gennaro,* UniNa - Università degli Studi di Napoli "Federico II", Italy*; R. Russo,* CNR - ISASI, Italy

Thermal energy is an important fraction of the worldwide energy that is annually demanded, and it mainly used to produce industrial process heat, such as high pressure steam. Evacuated flat collectors, thanks to the high vacuum insulation, can respond to the mid-temperature (100 °C – 250 °C) heat request without concentration. The Selective Solar Absorber (SSA) is the key component of the solar collector: it should efficientlyconvert the incident solar irradiation into heat for the transfer fluid. Thanks to the high-vacuum insulation, the thermal radiation is the main loss mechanism that limits the panel efficiency. Solar absorptance and thermal emittance of the SSA are the radiative properties that, in first approximation, define the overall efficiency of the evacuated panel. Typically their evaluation is made at ambient temperatureand comes from optical analysis, such as FT-IR Spectroscopy and Optical Reflection Spectroscopy. Unfortunately at the operating temperature,the radiative properties can differ from the optical analysis performed at room temperature..In this work we describe a calorimetric emissiometer and the related procedure aimed at measuring the spectrally averaged absorptivity and thermal emittance under operating conditions (direct illumination and high vacuum insulation). The presented system has been validated with a commercial absorber under SUN and LED illumination. It has been used to perform calorimetric tests of novel SSAs designed to work at different operating temperatures [1] and other innovative absorbers. We will present the temperature dependence of radiative properties for several SSAs obtained using different substrates and different multilayer structures.

The system can detect variation in absorpted or emitted power of the order of 1% and it is a powerful tool to measure the SSA properties as function of temperature. It can be also adopted to perform thermal stress tests, i.e. keeping the SSA at a temperature higher than the stagnation temperature under the Sun irradiation by using a well calibrated LED system[2]. This allowsto estimate the possible coating degradation over the lifetime of the collector.

[1] D. Demaio et al . *"Multilayer design and deposition for efficient thermal energy conversion in high vacuum flat solar thermal panels"*submitted to this conference

[2] D' Alessandro, C. et al *"Low Cost High Intensity LED Illumination Device for High Uniformity Laboratory Purposes"*Preprints 2020, 2020060322 (doi: 10.20944/preprints202006.0322.v1).

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