Materials & Coatings

Measuring Moisture Levels in Graphite Epoxy Composite Sandwich Structures

John F. Kennedy Space Center, Florida

Graphite epoxy composite (GEC) materials are used in the construction of rocket fairings, nose cones, interstage adapters, and heat shields due to their high strength and light weight. However, they absorb moisture depending on the environmental conditions they are exposed to prior to launch. Too much moisture absorption can become a problem when temperature and pressure changes experienced during launch cause the water to vaporize. The rapid state change of the water can result in structural failure of the material. In addition, heat and moisture combine to weaken GEC structures. Diffusion models that predict the total accumulated moisture content based on the environmental conditions are one accepted method of determining if the material strength has been reduced to an unacceptable level. However, there currently doesn't exist any field measurement technique to estimate the actual moisture content of a composite structure.

A multi-layer diffusion model was constructed with Mathematica to predict moisture absorption and desorption from the GEC sandwich structure. This model is used in conjunction with relative humidity/temperature sensors both on the inside and outside of the material to determine the moisture levels in the structure. Because the core materials have much higher diffusivity than the face sheets, a single relative humidity measurement will accurately reflect the moisture levels in the core. When combined with an external relative humidity measurement, the model can be used to determine the moisture levels in the face sheets. Since diffusion is temperature-dependent, the temperature measurements are used to determine the diffusivity of the face sheets for the model computations.

This work was done by Mark Nurge, Robert Youngquist, and Stanley Starr of Kennedy Space Center. Further information is contained in a TSP (see page 1). KSC-13499

Marshall Convergent Spray Formulation Improvement for High Temperatures

Lyndon B. Johnson Space Center, Houston, Texas

The Marshall Convergent Coating-1 (MCC-1) formulation was produced in the 1990s, and uses a standard bisphenol A epoxy resin system with a triamine accelerator. With the increasing heat rates forecast for the next generation of vehicles, higher-temperature sprayable coatings are needed.

This work substitutes the low-temperature epoxy resins used in the MCC-1 coating with epoxy phenolic, epoxy novalac, or resorcinolinic resins (higher carbon content), which will produce a higher char yield upon exposure to high heat and increased glass transition temperature.

High-temperature filler materials, such as granular cork and glass ecospheres, are also incorporated as part of the convergent spray process, but other sacrificial (ablative) materials are possible. In addition, the use of polyhedral oligomeric silsesquioxanes (POSS) nanoparticle hybrids will increase both reinforcement aspects and contribute to creating a tougher silacious char, which will reduce recession at higher heat rates. Use of expanding epoxy resin (lightweight MCC) systems are also useful in that they reduce system weight, have greater insulative properties, and a decrease in application times can be realized.

This work was done by Jack Scarpa and Chat Patterson of United Space Alliance for Johnson Space Center. For further information, contact the JSC Innovation Partnerships Office at (281) 483-3809. MSC-24644-1

Real-Time Deposition Monitor for Ultrathin Conductive Films

John H. Glenn Research Center, Cleveland, Ohio

A device has been developed that can be used for the real-time monitoring of ultrathin (2 Å or more) conductive films. The device responds in less than two microseconds, and can be used to monitor film depositions up to about 60 Å thick. Actual thickness monitoring capability will vary based on properties of the film being deposited. This is a single-use device, which, due to the very low device cost, can be disposable.

Conventional quartz/crystal microbalance devices have proven inadequate to monitor the thickness of Pd films during deposition of ultrathin films for hydrogen sensor devices. When the deposited film is less than 100 Å, the QCM measurements are inadequate to allow monitoring of the ultrathin films being developed. Thus, an improved, high-