Employing a Grinding Technology to Assess the Microbial Density for Encapsulated Organisms

Applications include medical device manufacturing and the commercial paint industry.

NASA's Jet Propulsion Laboratory, Pasadena, California

Projects that utilize large volumes of nonmetallic materials of planetary protection concern pose a challenge to their bioburden budget, as the most conservative value of 30 spores/cm^3 is typically used. The standard laboratory procedures do not provide any direction into the methodologies to understand the embedded bioburden within such nonmetallic components such as adhesives, insulation, or paint. A project can elect to conduct a destructive hardware study to experimentally derive a source-specific encapsulated microbial density, and the experimental value can be utilized for a project.

A tailored, novel, destructive hardware technology employing a household box grater was developed to assess the embedded bioburden within the adhesives, insulation, and paint for the Mars Science Laboratory (MSL) project.

Similar technologies used for the destructive analyses of nonmetallic components include chemical/solvent-based methods, blenders, mortar and pestle crushing, French press, pulverizing, and bead beating methods. These similar technologies are typically lethal to viable biological cells due to the excess generation of heat or adverse chemical interactions that render cells non-viable. These typical destructive hardware methodologies proved ineffective in breaking up the material into suitable size particles due to the material composition of the adhesives, insulation, and paint. Therefore, a novel approach had to be devised.

The **Box Grater** (left), and the size of **Cured Paint Particles** that were generated upon grating (right).

Samples were placed on a sterile tray and cut into three 5×5 cm pieces. The cut piece was wiped with a sterile wipe and 2-propanol. The cleaned material was then grated gently on the smallest grading plane on the box grater into sugar-crystal-sized pieces. The box grater approach is advantageous due to the ease and ability of the entire system to be sterilized, minimal (or negligible) impact to recontamination if performed in a Class 100 flow bench, and controllable heat generation upon material destruction. The recovery percentages of spores seeded on flight or surrogate materials were <10% for surrogate and <50% for flight, and could be applicable along with other chemical or physical technologies.

This work was done by James N. Benardini, Fabian Morales, Wayne W. Schubert, Gayane A. Kazarians, and Robert C. Koukol of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-48299

Demonstration of Minimally Machined Honeycomb Silicon Carbide Mirrors

This manufacturing process eliminates machining and steps for mirrors and optomechanical structures.

Marshall Space Flight Center, Alabama

Honeycomb silicon carbide composite mirrors are made from a carbon fiber preform that is molded into a honeycomb shape using a rigid mold. The carbon fiber honeycomb is densified by using polymer infiltration pyrolysis, or through a reaction with liquid silicon. A chemical vapor deposit, or chemical vapor composite (CVC), process is used to deposit a polishable silicon or silicon carbide cladding on the honeycomb structure. Alternatively, the cladding may be replaced by a freestanding, replicated CVC SiC facesheet that is bonded to the honeycomb. The resulting carbon fiber-reinforced silicon carbide honeycomb structure is a ceramic matrix composite material with high stiffness and mechanical strength, high thermal conductivity, and low CTE (coefficient of thermal expansion). This innovation enables rapid, inexpensive manufacturing.

The web thickness of the new material is less than 1 mm, and core geometries (pocket depth, pocket size) are easily tailored. These parameters are based on precursor carbon-carbon honeycomb material made and patented by Ultracor. It is estimated at the time of this reporting that the HoneySiC™ will have a net production cost on the order of \$38,000/m^2. This includes an Ultracor raw material cost of about \$97,000/m^2, and a Trex silicon carbide deposition cost of \$27,000/m^2. Even at double this price, HoneySiC would beat NASA's goal of \$100,000/m^2. Cost savings are estimated to be 40 to 100 times that of current mirror technologies.

The organic, rich prepreg material has a density of 56 kg/m^3. A charred carbon-carbon panel (volatile organics burnt off) has a density of 270 kg/m^3. Therefore, it is estimated that a HoneySiC panel would have a density of no more than 900 kg/m^3, which is about half that of beryllium and about one-third the density of bulk silicon carbide. It is also estimated that larger mirrors could be produced in a matter of weeks.

Each cell is completely uniform, maintaining the shape of the inserted mandrel. Furthermore, the layup creates pressure that insures node bond strength. Each node is a composite laminate using only the inherent resin system to form the bond. This contrasts starkly with the other known method of producing composite honeycomb, in which individual corrugations are formed, cured, and then bonded together in a secondary process.

By varying the size of the mandrels within the layup, varying degrees of density can be achieved. Typical sizes are 3/8 and 3/16 in. (≈10 and 5 mm). Cell sizes up to 1 in. (≈25 mm) have been manufactured. Similarly, the shape of the core can be altered for a flexible honeycomb structure.

This work was done by William Goodman of Trex Enterprises Corporation for Marshall Space Flight Center. For more information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-32866-1.