105th Annual Meeting & Exposition of the American Ceramic Society

Symposium Title / Indentation Techniques in Ceramic Materials Characterization: Theory and Practice
Session Title / Future Trends in Indentation Techniques: Improvement, Development and Applications

NANO-COMPRESSION OF CARBON MICRO-BALLOONS ON A XP-NANOINDENTER

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ABSTRACT

Microballoons are thin hollow spheres that are bonded together with resins to form "syntactic foams". These foams exhibit very high specific compressive strength. Mechanical properties of the microballoons are integral to the mechanical properties of the syntactic foams and will also be useful in modeling of the system. This paper will present nano-compression results obtained for individual carbon microballoons (CMBs) tested between 5 and 50 mN on a XP nano-indentation device (MTS) customized with a special cylindrical tip. Details of the procedure will also be presented.

CMBs ranging in diameter from 5 to 80 μm were randomly chosen for testing, which allowed for a statistical analysis (140 tests). Less than 25% of the CMBs were found to be nearly perfect spheres (from comparison between the "horizontal" diameter measured with a microscope and the "vertical" compressed diameter). CMBs smaller than 10 μm and greater than 50 μm were markedly ellipsoidal and about one third of the CMBs exhibited "sequential" cracking, revealing the existence of flaws. SEM and optical microscopy of the foams revealed these flaws as either voids in the wall thickness or compartments in some CMBs. Conventional Berkovich nano-indentation was performed on segments of CMB walls after nano-compresseion and yielded a value of approximately 31 GPa for Young's modulus. The measured thickness was between 0.3 and 2.2 μm, showing no correlation with the diameter of the pristine CMBs.

Finally, a power law was found to relate the maximum deformation to the diameters and a "pseudo-modulus" was defined for comparison between CMBs. The formula relates the load and deformation at each stage of the compression to the diameter of the CMB.