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Extreme synthesis and characterization of an ultrananocrystalline diamond aerogel in a diamond anvil cell
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High-surface-area mesostructured carbon materials have attracted a great amount attention in recent years because of a growing number of applications in energy storage, chemical catalysis, separations, and sensing. In particular, amorphous carbon aerogels have attracted much interest since the 1980's due to their low density, large intrinsic surface areas ($>1000 \text{ m}^2/\text{g}$), large pore volume, low dielectric constant, and high strength. In this talk we present the use of high-pressure ($>20 \text{ GPa}$) laser-heating ($>1500^\circ\text{C}$) within a diamond anvil cell (DAC) to convert the amorphous network of a low-density (40 mg/cc) carbon aerogel into an ultrananocrystalline diamond aerogel. Raman spectroscopy is used to probe the amorphous-to-diamond phase transition at pressure within the DAC. High-resolution transmission electron microscopy images of recovered material indicate diamond crystallite sizes range from 1 to 100 nm, with electron diffraction and electron energy loss confirming the presence of the diamond phase. Photoluminescence spectroscopy and confocal time-correlated single-photon counting indicate the recovered material contains both negatively-charged and neutral nitrogen-vacancy (NV) complexes. Synchrotron scanning transmission x-ray microscopy (STXM) is used to compare the carbon electronic density-of-states of the amorphous starting material with the recovered diamond aerogel with $<100 \text{ meV}$ energy resolution. Finally, we use nanoscale secondary ion mass spectrometry to investigate doping of the resorcinol-formaldehyde starting material with the aim of chemically tuning heteroatomic point defects within this diamond material system.