Bonding changes in compressed superhard graphite

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Inelastic x-ray scattering spectroscopy (IXSS) or x-ray Raman was used to study the near K-edge structure of carbon at high pressure. IXSS reveals that at approximately 17 GPa, half of the π-bonds between graphite layers convert to σ-bonds while the other half remain as π-bonds in the high-pressure form. The x-ray diffraction pattern of the high-pressure form is consistent with a distorted graphite structure in which bridging carbon atoms between graphite layers pair and form σ-bonds, while the non-bridging carbon atoms remain unpaired with π-bonds. The high-pressure form is superhard, capable of indenting cubic diamond single crystals with potential materials science application. The resulting work finally solved the mystery of what happens to cold-compressed graphite, a problem that had puzzled scientists for nearly four decades, and demonstrates the potential for studying the near K-edge structure of low-Z materials at extreme conditions.