Spectroscopic evidences for the low temperature, low pressure conversion of graphenes into diamanoïds

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Since 2009 and until very recently, diamanes, which constitute new synthetic nanoforms after fullerenes, nanodiamonds, carbon nanotubes and graphene, were hypothetical materials of possibly great interest in various applications such as nanoelectronics, quantum information processing and nanomedecine [1]. We studied the hydrogenation of few-layer graphene (FLG) by the chemisorption of H generated from the dissociation of H_2 in a hot filament reactor at low temperature (below 325 °C) and low pressure (50 Torr), and the subsequent conversion of the FLG structure into crystalline sp^3 material. Fourier Transform Infrared (FTIR) microscopy was used to track the formation of C-H bonds, and multi-wavelength Raman spectroscopy and mapping were used to track the structure conversion and the extension of the converted domains. Nanosized and crystalline sp^3-bonded carbon materials were obtained over large surface areas up to ~33x51 μm^2. Hybrid materials were also obtained from the partial conversion of FLG. sp^3-C related peaks from diamond and/or lonsdaleite and/or hybrids of both were detected in UV and visible Raman spectra. C-H bonding was directly detected by FTIR microscopy over an area of ~150 μm^2 and one single component attributed to sp^3-C-H mode was detected in the C-H stretching band showing that carbon is bonded to one single hydrogen and strongly suggesting that the sp^3-C materials obtained are ultrathin films with basal planes hydrogenated. The experimental results are compared to predictions from Density Functional Theory calculations and comprehensively discussed. A new nomenclature for diamanoïds is proposed.

[1] F. Piazza et al, Carbon 145c (2019) pp-10-22.