HRTEM STUDY OF POPIGAI IMPACT DIAMOND: NANODIAMOND IN AMORPHOUS CARBON MATRIX

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Impact diamonds are formed by a rapid solid-state transformation of mainly sp^2 bonded carbon (graphite or coal) under very high pressure (up to 50 GPa) on the nanosecond timescale accompanied by high temperature (up to 4000K). They are usually polyphase and can consist of cubic and hexagonal diamond, graphite, onion-like carbon and amorphous carbon [1] and exhibit unusual physical properties like extreme hardness. However, only a few (HR)TEM studies has been made on impact diamonds so far, while laboratory synthesis of ultrahard carbon allotropes and their nanostructural investigation is a current topic [2,3].

We applied FIB cutting followed by low energy Ar milling and mechanical cleavage to obtain electron transparent lamellae for HRTEM imaging.

Amorphous rim of about 20 nm of width was formed around the FIB lamella, which has been reduced significantly to 5-6 nm of width by low energy Ar ion milling at 500eV (Figure 1) using Technoorg Gentle Mill. The structure of the amorphous rim has been changing rapidly during high resolution observation, while, the amorphous structure of the cleaved sample remained practically unchanged during several minutes of electron irradiation (Figure 2). EELS spectra also prove the different character of the amorphous component of the FIB-cut and cleaved samples.

HRTEM study of the cleaved sample allowed imaging of nanodiamond particles embedded in the native amorphous carbon matrix of the impact grain (Figure 2). The size of the nanodiamonds ranges between 5-10 and a few hundreds of nanometres. The smaller particles are frequently nanotwinned (twin thickness is 1-2 nm), while the larger ones are either faultless or are characterized by larger twin thickness (5-10 nm). These nanostructural features are reminiscent to those published by Huang et al. [3] who fabricated ultrahard (Vickers hardness 200 GPa) nanotwinned diamond from onion-like carbon precursos and can be related to the hardness of the material. The investigation of the bonding structure of the amorphous matrix can provide a better understanding for the formation and physical properties of impact diamonds.

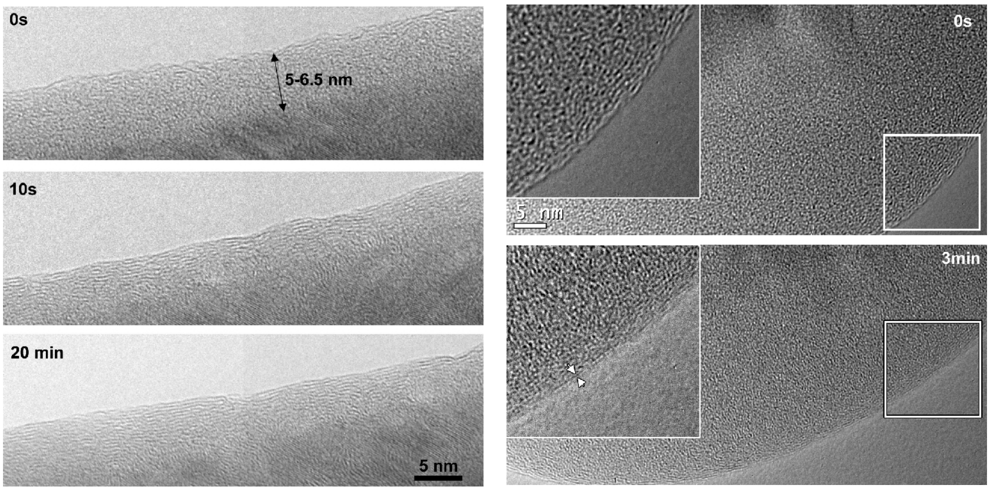

Figure 1: HRTEM image of (a) FIB cut lamella after low energy Ar ion milling (b) cleaved sample. The amorphous component of the cleaved specimen is more stable under the electron beam.

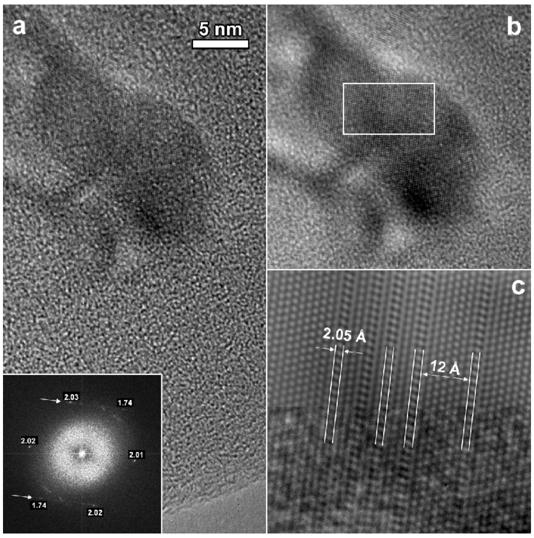

Figure 2: (a) HRTEM image and FFT of the marked area of the cleaved sample. (b) FFT enhanced image of densely twinned nanodiamond in amorphous carbon matrix. (c) nanotwins enlarged from (b) with the inverse FFT. White lines represent stacking faults in the cubic structure.

References
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