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TEM Characterisation of Graphitisation Process of Amorphous Layers in Ion Implanted Diamond

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Ion implantation has been successfully employed for fabrication of ultra-thin diamond films and in combination with Ga focused ion beam (FIB) technique for fabrication of device structures in diamond at submicron level [1, 2]. FIB technique could be also used as ion implantation tool in diamond for fabrication of buried amorphous layers and cap diamond layers with thickness of few nanometers [3]. The graphitisation of these amorphous layers is attracting significant interest due to ability to fabricate device structures containing two stable structural forms of carbon: diamond and graphite. In the present work we have performed 30 keV Ga^+ FIB implantation into (001) and (111) synthetic diamond samples and have examined the structure of the implanted regions after implantation and after HPHT annealing by means of TEM.

For the lowest dose 3×10^{14} ions/cm^2 implanted region in (001) sample is metastable and contains islands of amorphous and crystalline materials between two interfaces of distorted diamond (Figure 1a). The swelling of implanted region was not observed which indicates the same density of implanted layer and bulk diamond. The implanted regions have been found to be amorphous with corresponding density reduction and swelling for the dose 4×10^{14} ions/cm^2 and above in (001) diamond and for all doses in (111) sample. HPHT annealing resulted in re-ordering of amorphous and crystalline components in the region implanted with dose 3×10^{14} ions/cm^2 ((001) sample) and formation of sharp interfaces parallel to (111) planes (Figure 1b). For all other fluences and both sample orientations HPHT annealing resulted in graphitisation of implanted layers with predominant orientation of graphene planes parallel to (111) diamond planes (Figure 2).

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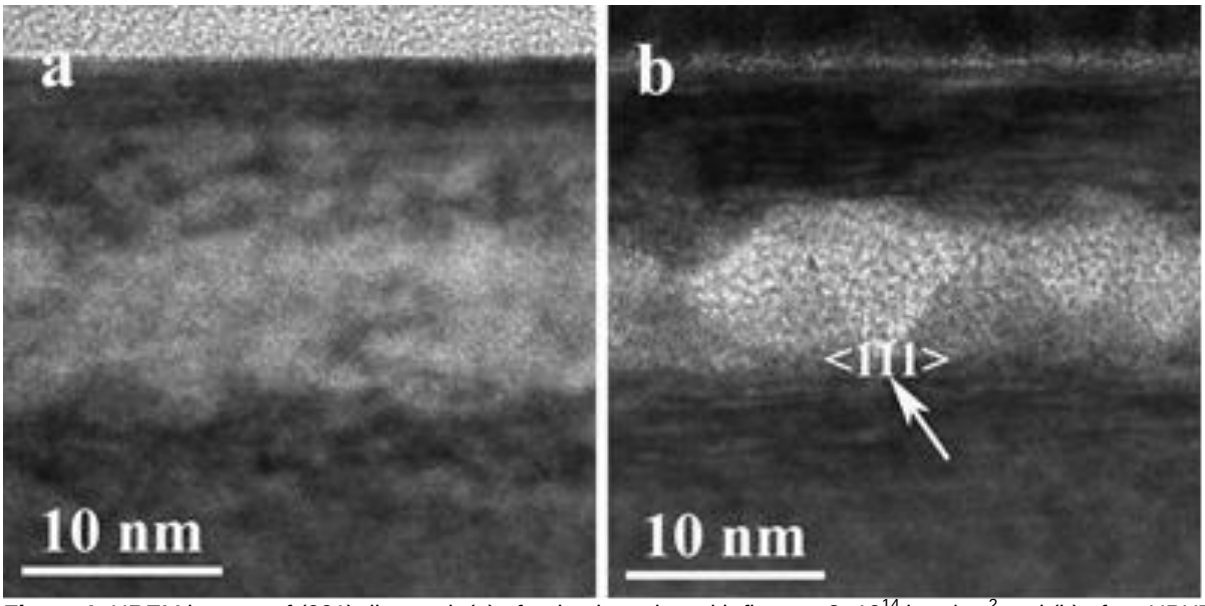

Figure 1. HREM images of (001) diamond (a) after implantation with fluence 3×10^{14} ions/cm^2 and (b) after HPHT annealing.

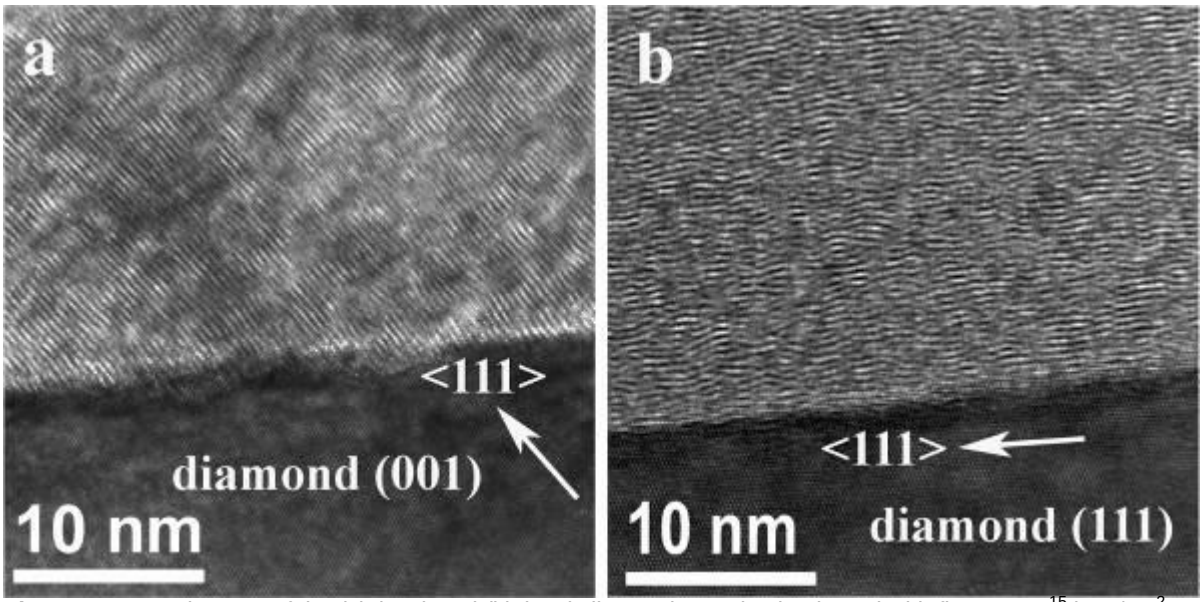

Figure 2. HREM images of the (a) (001) and (b) (111) diamond samples implanted with fluence 10^{15} ions/cm^2 and HPHT annealed at 1200 ^{o}C and 4 GPa.