DECLARATION

This is certify that

- the thesis comprises only my original work
- due acknowledgement has been made in the text to all other material used
- the thesis is less than 100,000 words in length, exclusive of tables, maps, bibliographies, appendices and footnotes.
TEM and Structural Investigations of Synthesized and Modified Carbon Materials

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Thesis submitted in total fulfillment of the requirements of the degree of Doctor of Philosophy

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Abstract

Due to the extreme properties of diamond, such as extreme hardness, high thermal conductivity, high electrical breakdown strength, high electron and hole mobilities and large band gap, it is of interest to study this material in detail. Before advantage can be taken of diamond’s properties for high-temperature, high-power electronic applications successful doping/ion implantation of diamond must be achieved. This requires an understanding of the types of defects produced during ion irradiation. In the present work, type IIa diamond has been irradiated with various doses of 320keV Xe ions at room temperature. Analytical techniques used are electron spin resonance spectroscopy, Raman spectroscopy, transmision electron microscopy and electron energy loss spectroscopy. Previous models have suggested that upon ion impact, amorphous and/or graphitized clusters are formed in diamond, which will overlap at a critical dose to form a semi-continuous graphitized layer. However, in this study careful TEM measurements showed that diamond remains essentially single crystalline even up to high dose of $1 \times 10^{15}$ Xe/cm$^2$. This result favours the gradual amorphization model for the ion beam transformation of diamond.

We attempted to fabricate carbon nitride ($C_3N_4$) films using high-energy plasma deposition of carbon and nitrogen species into quartz substrates. Deposition parameters were varied in order to characterize the films and conditions. Morphology, compositional and structural studies of the films were performed using scanning electron microscopy, Auger spectroscopy, photon induced xray emission spectroscopy, Rutherford backscattering spectroscopy, Raman spectroscopy, transmision electron microscopy and electron energy loss spectroscopy. The films were found to display a great deal of inhomogeneity in the local bonding, posing great difficulties in analysis and attempts to co-relate structure with the deposition conditions. The films were mainly amorphous or polycrystalline in nature, with vary small regions of single-crystalline materials. It is concluded that the main bulk of the film is $(CN)_x$ in nature, with tiny regions of $C_3N_4$ and also $Si_3N_4$.

Finally, we investigated high dose ion irradiation of carbon into quartz. Subsequent annealing of the samples caused the formation of a buried layer of nanocrystalline diamond. At the dose of $5 \times 10^{16}$C/cm$^2$, the clusters were observed to be almost single-crystal in nature. Above this dose, the clusters were found to be more polycrystalline and contain more graphite components. The cluster sizes also were found to increase with increasing dose.
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