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CONVENTIONAL AND ANALYTICAL ELECTRON MICROSCOPY STUDY OF PHASE TRANSFORMATION IN IMPLANTED DIAMOND LAYERS

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Abstract

Graphitization of ion-beam induced amorphous layers in diamond has attracted significant interest due to ability to fabricate device structures containing two structural forms of carbon. The graphitic layers can be chemically etched to form free-standing diamond films. In the present work the graphitization process was studied using conventional and analytical transmission electron microscopy (TEM). It was found that annealing at 550 ^{o}C results in a partial graphitization of the implanted volume with graphitic phase in the middle of the amorphous layer. Annealing at 1400 ^{o}C resulted in complete graphitization of the amorphous layers.

Introduction

Single crystal diamond has attracted enormous interest as a solid state platform for quantum information processing. Nitrogen-vacancy (N-V) color centers in diamond show remarkable quantum properties such as long coherence times and single spin readout, and can be used as qubits in a quantum computer architecture [1-2]. In order to take advantage of these properties, it is desirable to fabricate photonic components in diamond at the nano-scale level. In a previous work we demonstrated the fabrication of three-dimensional structures in a single crystal diamond [3]. High fluence MeV ion implantation was used to create a buried damage layer and eventually a graphite-like layer upon annealing. The etchable graphitic layer can be removed to form a free-standing membrane into which the desired structures can be sculpted using focused ion beam (FIB) milling. Using a double-implantation technique we also demonstrated the fabrication of ultrathin (~200 nm) membranes in diamond [4]. The combination of double-implantation technique and FIB milling allows device fabrication in diamond at the nano-scale level. The optical properties of these devices are assumed on the model of sharp diamond-air interface. Kalish et al. [5] reported complete graphitization of the implanted layer in diamond after a 20 min annealing at 600 ^{o}C. However, a recent study [6] using high-resolution electron microscopy (HREM) revealed the presence of a transition area after thermal annealing of implanted layer in diamond. Thus, the real quality of the diamond surface after chemical removal of graphitic layer can be far from ideal.