Laser Induced Conductive Layers Formation and Surface-Structural Modification on Diamond for Optoelectronic Devices Fabrication

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Name

論　文　名　： Laser Induced Conductive Layers Formation and Surface-Structural Modification on Diamond for Optoelectronic Devices Fabrication （光電子デバイスのためのダイヤモンド上へのレーザー誘起伝導層の形成と表面改質）

Title

区　　分 : 甲

Category

論 文 内 容 の 要 旨
Thesis Summary

Diamond has received much attention as a next-generation wide bandgap semiconductor with favorable physical and electrical properties. It is applicable to electronic and optical applications such as ultraviolet light emitting diodes (UV-LED), cold cathode electron emitters, and high-power and high-frequency devices. The device fabrication of diamond has serious problems in the doping, physically and technically. Boron is a representative dopant for the production of p-type conduction, and the doping is achieved during the deposition by chemical vapor deposition (CVD). On the other hand, for the production of n-type conduction, there have been no dopants that activate donor levels around room temperature. Phosphorus has a donor level of 0.57 eV and a prime dopant at present. However, the doping is not easy owing to its large atomic size and different covalent bond length. Although the doping has been experimentally demonstrated by employing plasma enhanced CVD using a phosphine gas as a dopant source by S. Koizumi, an enhancement in the carrier concentration by doping is limited. It is known that defects such as (P-H) vacancies might act as accepters, which results in the compensation of carriers. In addition, producing a high conductive layers on the insulating diamond surface still one of the physically and technically challenge features.

In this work, we applied laser-induced dopants incorporation to single-crystal diamond for producing of highly conductive layers on the diamond surface. To the best of our knowledge, it is the first time that such study is proposed. Experimentally, ArF laser irradiation was carried out for a single-crystal diamond plate immersed in the dopant acid solutions, acting as a dopant source. The phenomena were physically discussed based on diagnostics of time-resolved reflectivity and modeling of irradiation process.

Since electronic technology is targeting smaller devices and shallower junctions. laser irradiation in a

suitable dopant atmosphere could provide the best alternative, where the thickness of the doped layer is determined by the depth of the molten layer. This process allows the incorporation of the dopant into very shallow layers without radiation induced damage. The proposed method could be the alternative for the formation of a very shallow junction. The above-mentioned results were divided into a several chapters as follows:

Chapter 1: presents a brief survey of the different classes of carbon nanomaterials and a comparison of their purity, structure, and physical properties. The primary focus of this chapter is on mainly single-crystal diamond with highlighting the excimer laser irradiation process, as the core of our study.

Chapter 2: Presents the experimental techniques that have been employed along the study, with the explanation of physical meaning and mechanisms behind each technique. Started from film preparation methods and ended by the optical and electrical characterization techniques.

Chapter 3: Measurements and calculations were carried out to fully understand the influences of laser parameters on substrate responses and induced temperature upon irradiation. Simulations of the irradiation process were carried out in addition with reflectivity experiments to help characterizing the laser bean and identifying best parameters for irradiation.

Chapter 4: Excimer laser irradiations were carried out at different conditions for single-crystal diamond substrate immersed in dopant acids (phosphoric acid) for the production of n-type phosphorus doped diamond. The films were optically, electrically and physically characterized to investigate doping level. Also parameters effect on doping is partially investigated.

Chapter 5: Excimer laser irradiations were carried out at different conditions for single-crystal diamond substrate immersed in dopant acids (Boric acid) for the production of p-type boron doped diamond. The films were optically, electrically and physically characterized to investigate doping level. Also parameters effect on doping is partially investigated.

Chapter 6: Excimer laser irradiations were carried based on results obtained from chapter 4, to employ it in fabrication of diamond radiation detectors. Laser induced heavily doped areas were fabricated on top of diamond substrate, acting as an ohmic electrodes for detector device.