ULTRA-FINE PATTERNING OF THE N-DOPED CVD DIAMOND FILMS I. - N_2 ADDITION IN THE GAS PHASE FOR THE NANO-FABRICATION -

H. Gamo[1], M. N.-Gamo[2], K. Shimada[2,3], K. Nakagawa[3], and T. Ando[3]

[1]*Technical Research Institute, Toppan Printing Co. Ltd., Sugito, Saitama 345-8508, Japan.*

[2]*Sensor-photonics Research Center and Department of Applied Chemistry, Toyo University, Kawagoe, Saitama 350-8585, Japan.*

[3]*Advanced Materials Laboratory, National Institute for Materials Science, Tsukuba, Ibaraki 305-0044, Japan.*

Diamond has been attracted much attention because of its outstanding properties such as a high hardness, a wide bandgap, a chemical inertness, a high thermal coefficient, and a wide potential window for electrodes. The applicable form of the diamond is usually to be a polycrystal thin-film grown by a chemical vapor deposition (CVD). Its crystal size is in the range from several to several-tens micrometers. Such a polycrystal diamond film surface has a rough surface, i.e., the value of the surface roughness, Rms is several-hundreds micrometer order. In order to use the excellent potential of diamond films for wider applications, it is necessary to establish the fabrication technique of the diamond films for desired patterns.

Dry etching techniques are suitable for the fabrication[1)-3)] as the difficulty of the wet etching for diamonds. In order to fabricate the diamond films for desired fine patterns, to elucidate how the surface roughness, crystallinity, and crystal size of diamond films affect the fabricated patterns is indispensable. For the purpose of elucidating the relation, it is important that a wide variety of diamond films including a wider range of crystal quality, surface roughness, and crystal size should be grown and fabricated. It is known that an impurity addition in the gas phase strongly influences the diamond growth and its crystallinity[4),5)]. In other words, impurities, for example, B, N, O, F, P, and S enable to vary the surface morphology, crystallinity, and crystal size of diamond films. Some of these impurities are incorporated in the crystal and yield electrical and/or optical properties. In this study, the effect of nitrogen addition on the surface morphology, crystallinity, and properties of the grown diamond films has been investigated for the nanometer-scale fabrication. Although the properties of N-doped diamonds have been extensively studied, a small number of publications describe the relation between the added nitrogen and the crystallinity of grown N-doped diamond films[4),6),7)].

A cylindrically coupled microwave plasma reactor was used for the diamond growth. For the nitrogen doping, we used N_2 gas as a dopant gas. A polycrystal diamond film was grown on a silicon wafer. The surface morphology of the polycrystal diamond films was observed by Atomic Force microscopy (AFM). and field emission scanning electron microscopy (FE-SEM). Micro Raman spectroscopy was used to examine the crystal quality.

The addition of N_2 into the gas phase influenced the surface morphology, as observed by AFM. Fig, 1 shows AFM images of polycrystal diamond films under the addition of various amounts of N_2: (a) 0 %; (b) 0.1 %; and (c) 1.0 %. With increasing of N_2 in the gas phase, both the crystal size and the value of Rms decreased. Adding N_2 thus influenced the surface morphology and decreased the surface roughness. The effect of N_2 addition on the crystallinity, nitrogen incorporation, and properties will be discussed.

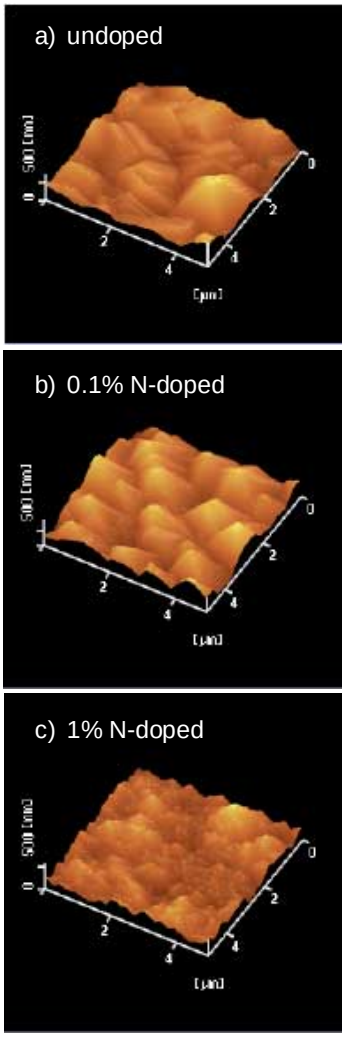

Fig.1 AFM images of N-doped CVD diamond films

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