Preparation of Diamond-Like Carbon Films Using a Cathode Localized Glow Discharge Under Sub-Atmospheric Pressure Excited by a High-Repetition Nanosecond Pulsed Voltage Application

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Diamond-like carbon (DLC) films have attracted considerable attention because of their significant potential applications in a wide range of industrial fields. This study demonstrates a new plasma process to obtain a DLC film with a deposition rate of 100 nm/min, which is 5 times higher than that of a conventional plasma CVD process. The present technique employs a recently developed novel technology of a SiC-MOSFET inverter power supply for the plasma generation which enables to produce nanosecond voltage pulses with a high-repetition frequency. Then, a repetitive pulsed glow discharge with a pulse duration of 200 ns is generated in a pair of parallel plate metal electrodes without insertion of dielectrics. The maximum driving frequency is 300 kHz. At the low-repetition frequency operation, a pulsed glow discharge is volumetrically produced in the electrode gap space. On the other hand, a cathode localized glow discharge can be driven at the high-repetition frequency operation, which is desirable for material processing [1]. In this study, a mixed gas of helium (He) and methane (CH_4) with a gas pressure of 1 kPa was used as a process gas. The gas flow rates of He and CH_4 were 3 and 0.8 L/min, respectively. Silicon wafers were used as substrates. The substrates were installed on the high voltage electrode. After the plasma exposure for 15 min, a carbon film with a thickness of 1.5 ?m was identified on the Si substrate. At the repetition frequency of 30 kHz, the film hardness was about 4 GPa. On the other hand, the DLC film with a hardness of 13 GPa was prepared with a repetition frequency of 200 kHz [2]. Raman spectroscopy and glow discharge-optical emission spectroscopy (GD-OES) depth profiling analyses showed that the hydrogen content in the DLC film decreased with increasing repetition frequency. A film mass density will also be discussed.

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[2] Y. Kikuchi et al., Jap. J. Appl. Phys. 56 (2017) 100306.

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