7th World Conference on Chemistry and Chemical Engineering
November 21, 2024 | Bangkok, Thailand
https://doi.org/10.62422/978-81-981590-9-0-004

Synthesis of Boron-Doped Diamond Using Scale-Up Equipped Scanning In-Liquid Microwave Plasma Cvd

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Boron-doped diamond (BDD) has excellent electrochemical properties and can be used as an electrode for CO2 reduction, replacing precious metals such as platinum. We synthesized BDD films using in-liquid microwave plasma CVD. We enlarged the reactor from 340×220 mm3 to 590×390×250 mm3 to increase the film area. This enlargement made the synthesis challenging due to several factors, such as substrate combustion and microwave instability, which were not issues in previous reactors. In this study, we aimed to identify these factors and achieve longer deposition times. Patterning was then performed by scanning the substrate.

In the experimental setup, methanol, ethanol, tetrahydrofuran, and trimethoxyborane (B/C=1000 ppm) as a boron source were added to a reaction as liquid raw material. After reducing the pressure in the reactor to 60 kPa, microwaves were injected through a 3 mm diameter antenna to generate plasma in the bubbles formed. The substrate used was single-crystal Si, and deposition was carried out for 3 minutes.

New challenges included the burning of the substrate and microwave instability. We addressed these problems by removing bubbles remaining on the substrate and fixing the antenna. Considering the issues, we were able to confirm the formation of a BDD film on a 0.775 mm thick Si substrate after 3 minutes of synthesis. We predicted that solving these problems would enable long-duration synthesis and operation, so we performed scanning using a 2 mm thick Si substrate. As a result, we successfully obtained a film approximately 190 mm2 in size.