Selective-Area Deposition of Diamond Films by Combustion Activation CVD

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Abstract: This research was a remarkable point of the new synthesis method that was combustion activation CVD. The synthesized diamond was developed for electronic devices. So it was necessary to determine the area of pattern from of synthesized diamond films. And study on selective deposition of develops diamond electronic devices. Surface preparation of silicon substrate that effects to the diamond nucleation, was varied the different conditions. The important parameters of fundamental circuit design were studied by designing patterns of diamond films. For the pattern fabrication, fabrication techniques are used differently such as silicidioxide mask technique of Mirror-polished technique in order to protect diamond films generation. The diamond films were analyzed by several techniques. Scanning Electron Microscope (SEM) was analyzed diamond growth, grain size and film thickness. Raman spectroscopy was analyzed carbon bonding (sp² or sp³). From the experiment were found that the best method for fabricating diamond films patterns are using Silicon dioxide mask technique compared with using mirror-polished Si for synthesized diamond films protection.

Methodology: 1 The diamond crystal synthesis, the suitable position of oxy-acetylene flame for the diamond crystals synthesis was examined (1). The unpolished Si substrate was used in obtaining the best conditions for the crystal growth. The substrate temperature were various from 500 – 1,350°C. The volumetric ratio of O₂/ C₂H₂ were varied form 0.7 – 0.9 at O₂ flow rate 210 – 285 cc/min, and C₂H₂ flow rate of 300 cc/ min with the substrate temperature 800 °C. Each condition was tested separately (2). The synthesis was fixed at 10 mins, 1 atm. The carbon bonding, grow rate, and grain sizes of the crystals were analyzed by the Raman spectroscopy and SEM (3). 2.Selected area of diamond 2.1 SiO₂ layer was grown on a Si wafer (5,000 7,500 and10,000 Å). 2.2 SiO₂ was patterned by photolithography technique. 2.3 SiO₂ was etched by the buffered HF acid. 2.4 This wafer was cut in 4 mm X 4 mm pieces to be used o the substrate for the diamond deposition, and
substrate were prepared by abrasion with diamond powder in ultrasonic vibration. 2.5 diamond films were deposited by combustion activation CVD, and SiO₂ was etched by the buffered HF acid.

**Result, Discussion and conclusion:** Summarily, to obtain the diamond crystals, the middle-flame as well as 0.85 the ratio of gas used in diamond synthesis yields the maximum growth rate. Using O₂/ C₂H₂ ratio of 0.95 provides high quality of crystals and 180 µm/h of average growth rate. 1 Diamond films synthesis, the substrate pretreatments account for the increase in density of the diamond nucletation by the observation from SEM, the substrate pretreated by the abrasion with diamond powder promoted higher growth rate than that from ultrasonic. The result observed from the Raman spectroscopy was 1,333 cm⁻¹. Showing that the substrate temperature between 560 – 1,040 °C produced high quality diamond films. No any diamond films were found at 500°C . The diamond {111} plane, {100} plane and a combined plane were found in 560 – 820 °C, 840-880 °C and 900 – 1,040 °C, respectively.

![SEM micrographs of the dependence of the growth oriented surface on various substrate temperature](image)

**Fig.1.** SEM micrographs of the dependence of the growth oriented surface on various substrate temperature: (a) 500°C, (b) 560-820°C, (c) 840-880°C, and (d) 900-1,040°C

![Raman spectroscopy](image)

**Fig. 2.** The analysis of diamond film by Raman spectroscopy

2 The selectected area of diamond films, The mirror-polished silicon mask technique can protect diamond films growth. The diamond films grown on the selected area and a few diamond crystals grown on mirror-polished silicon mask. In this fabrication minimum of synthesized time is 15 min because the diamond crystal growth depend by time of diamond films synthesized and the diamond crystal is difficult to removal. The SiO₂ mask technique can protect diamond films growth, and the diamond films grow in the selected area, but several the grain crystals grow on SiO₂. In this technique can synthesized in long time for the requirement thickness, and diamond crystal on SiO₂ was remove by SiO₂ etching procedure, but SiO₂ Thickness is importance for deposition procedure because SiO₂ was etching by combustion activation CVD about 200 Å/min at 850 °C, and the underside of SiO₂ etching made taper on the ending of selected area which made taper on ending of
diamond. This fabrication of diamond films patterns is using silicon dioxide mask technique for synthesized diamond films protection.

Fig. 3. Micrographs of fabrication procedure of diamond films: (a) diamond crystal deposition, (b) diamond films deposition, (c) SiO₂ thickness enough for protection, and (d) diamond films after SiO₂ etching.

References:  
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