# Single-Cathode DC PACVD Process for Large-Area CVD Diamond Wafer Fabrication

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Due to excellent physical properties of diamond, a free-standing diamond wafer has been considered as important materials for various industrial applications [1]. The major problem in these applications is still the high fabrication cost of the diamond wafers. Two typical diamond wafer synthesis methods now being used are DC arc jet CVD[2] and microwave PACVD[3]. Although each method has merits and demerits, both are not still satisfactory

On the other hand, CVD diamond deposition by DC PACVD process using a diode–type electrode configuration is known to have a very simple structure and very high growth rate. However, the unstable plasma and small deposition area have been the critical obstacles to the commercial application of this process. Recently, we have overcome these obstacles [4,5]. In this paper, we briefly review the characteristic features of this process and report recent advances in its capability.

Our single-cathode DC PACVD adopts the diode – type electrode configuration. The cathode diameter varies from 120 mm up to 210 mm according to the diameter of the substrate which serves as the anode. The substrate diameter was nearly same as that of cathode. The diameter of the substrate was varied from 4 inch to 8 inch. Under our experimental condition, the plasma uniformly filled the inter-electrode space. Therefore the lateral dimension of the plasma was nearly same as that of electrode. The plasma uniformly covered the whole surface of the substrate, irrespective of the diameter of the substrate. Scale-up of deposition area is readily achieved by simple increase in the electrode diameter.

The plasma stability was closely related to the carbon contamination of the cathode surface. This contamination could be successfully suppressed in a very simple way by controlling the cathode temperature. In addition, the power supply equipped with rapid arc-managing function with parameters optimized for the characteristic plasma load, was critical for the plasma stability. For this purpose, so-called SMPS (Switched-Mode Power Supply) with response time of μs order was coupled to the system. In this way, the plasma was successfully stabilized for thick diamond wafer fabrication.

Using this large, uniform and stable plasma, the CVD diamond wafers with various diameters ranging from 4 inch to 8 inch, and with various thickness up to 1 mm, could be successfully fabricated. Further scale-up in deposition diameter is readily achievable by simple scale-up of the electrode diameter and input power.

Methane-hydrogen gas mixture was used as the precursor gas. The methane content in hydrogen was 3~9% by volume. The gas flow rate was 200~800 sccm. The chamber pressure was 100~130 torr. The average substrate temperature was varied within the range of 1100~1250$^{o}$C as measured by the optical pyrometer. The power density was around 0.3~0.4kW/cm$^{2}$. The applied voltage was between 850 and 950V.

The characterization was focused on the wafer-scale uniformity. The thermal property was characterized by the converging thermal wave technique. The crystal quality was analyzed by the macro-Raman spectroscopy.

At the optimized deposition conditions, the deviation of thickness and the thermal conductivity could be reduced below 10% of the respective averaged values. The distribution of FWHM of Raman diamond peak over the wafer surface also showed excellent uniformity. The surface microstructure of the wafer was also uniform across the whole diameter. The free-standing wafers were translucent as well as opaque according to the growth. The growth rate linearly increased from 5̃ μm to 17̃ μm/h with methane concentration ranging from 3% to 9%.

## References

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