Large-Area and Low-Temperature Nanodiamond Coating by Microwave Plasma Chemical Vapor Deposition

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We have developed a low-temperature and large-area nanodiamond coating method by microwave-plasma-assisted chemical vapor deposition (MWPCVD) sustained using surface waves. A highly transparent and smooth nanodiamond film was successfully grown on borosilicate glass, soda-lime glass and quartz substrates by this method. The uniformity of the plasma and the low temperature of the substrates were attained using the microwave plasma, which was sustained using surface waves radiated from two sets of eight parallel coaxial antennas. A relatively low gas pressure of approximately 100 Pa was used to avoid the heating of the substrate by the plasma. Under these conditions, a homogeneous plasma over a 30×30 cm² area and a substrate temperature of less than 100°C were successfully obtained. We applied a hydrogen and methane plasma to form the nanodiamond coating, which is a conventional gas mixture for diamond CVD growth. CO₂ was also added to the gas mixture to improve the film properties, such as transparency. The deposited diamond films are transparent, smooth and reasonably uniform over an area of 30×30 cm² on the glass substrate. UV-excited Raman spectroscopy shows the formation of diamond film by the sharp peak at 1333 cm⁻¹. X-ray diffraction analysis and transmission electron microscope measurements indicate that the film consists of nanocrystalline diamond grains of sizes ranging from 5 to 20 nm. Optical applications are expected to be developed from the film properties of transparency to visible light, high refractive index and small degree of double refraction.