Investigation of Growth Processes and Surface Morphology of Fine Grain Diamond Films Grown by High Repetition Rate Pulsed Laser Deposition (PLD) Technique.

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Pulsed laser deposition (PLD) employing a Cu-vapor laser has been used for deposition of nano-crystalline diamond films. Fine grain diamond films have been grown uniformly at room temperature without seeding or abrasion of the substrates (Si, quartz, glass and plastic). It has been found that films deposited by the above mentioned technique are transparent, have very high electrical resistivity (typically of order of 100GΩ-cm) and a peak in the optical absorption at about 6.0 eV. Transmission electron microscopy (TEM) and selected area electron diffraction (SAD) pattern confirmed the nano-crystalline structure of the films. Ten nanometre sized clusters are observed within an amorphous matrix whose diffraction patterns were indexed as a cubic diamond.

We have investigated the effect of the influence of target-substrate angle (incident angle) and distance on the surface morphology of nano-diamond films deposited by the PLD technique. Five Si ($1x1cm^2$) substrates were mounted horizontally under the ablated plume at different distances from the target and were deposited simultaneously (Fig.1). The surface morphology of the films was studied by high-resolution atomic force microscopy (AFM). Changes in the surface morphology and roughness of the films observed by AFM are presented in Fig.2. Flat toped pyramidal structures, whose base dimension is much larger than their vertical dimension were observed. Large islands form through the coalescence of smaller ones (see Fig.3). Significant reduction in the areal density of large islands was observed with the increase of target-substrate distance. The measurements of the surface roughness over a smaller scan area of the background structure of the film between the surface outgrowths show that the roughness gradually increases with the increase of target-substrate distance. For the target-substrate angles higher than 60^0 the surface morphology was found to be dramatically different by comparison to the smaller angles, in that the density of large clusters is dramatically reduced, but the roughness of the film between the clusters increases sharply.

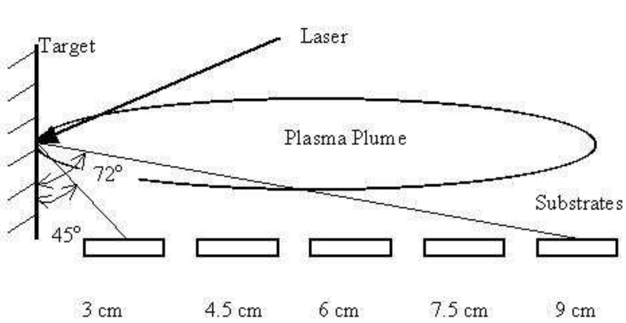

Fig.1. Schematic diagram of the experimental set-up.

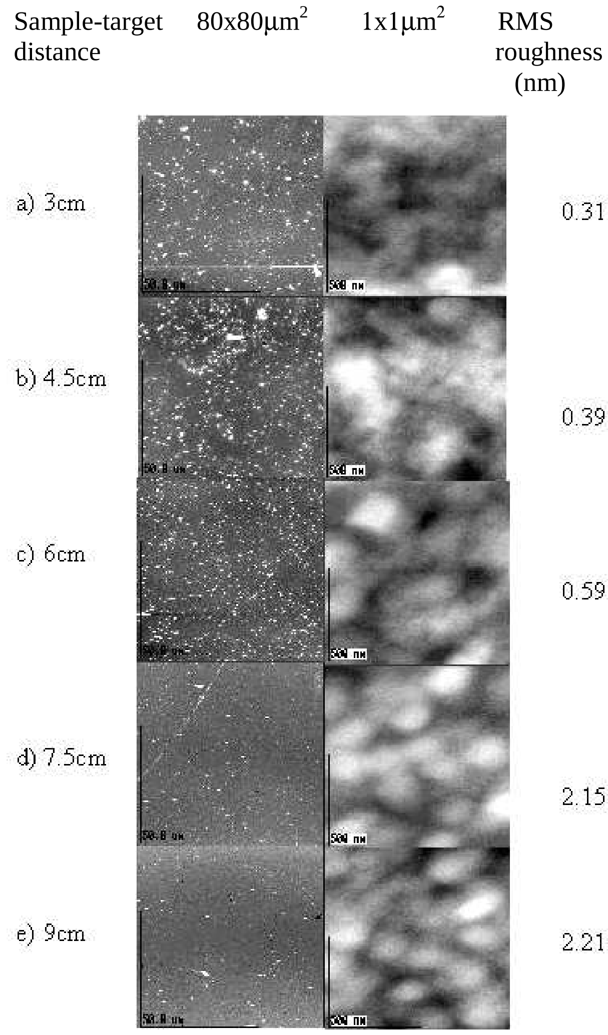

Fig.2.Evolution of the surface morphology of nano-crystalline diamond films depending on the distance between the substrate and the target. RMS roughness is an average of 3-6 measurements taken from smooth areas between the large outgrowth.

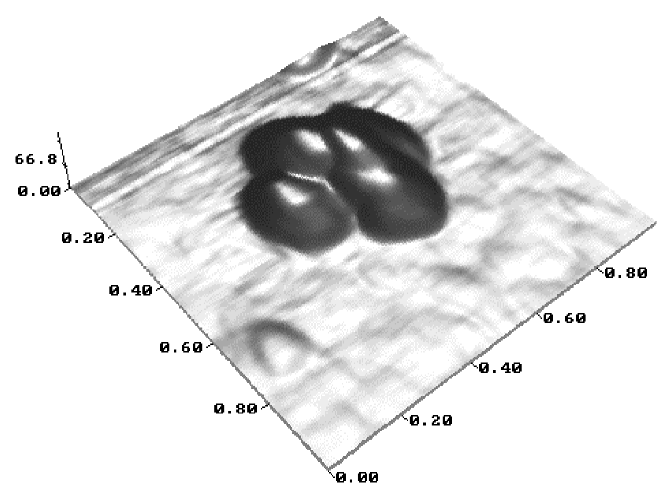

Fig.3. AFM image ($1x1\mu m^2$) of large island formed through the coalescence of smaller ones.

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