Low melting temperature thin coating of zinc on Si(l 00) for diamond film growth

Introduction

ln hot filament chemical vapor deposition (HFCVD) the substrate temperature has to be maintained at about ~700 “C. This has resulted in the use of substrates or coatings with a melting point higher than the substrate temperature during the diamond film growth. In this communication we show using atomic force microscopy (AFM), scanning electron microscopy (SEM) and Raman spectroscopy that even low melting point zinc on a scratched Si(l 00) substrate could produce a good quality diamond film at a substrate temperature ~750"C. A liquid substrate can support the growth of diamond film.

Diamond thin films have numerous applications from protective coatings to electronic devices and are widely used in industry. Therefore, several efforts have been made to achieve high quality diamond coatings in terms of density, adherence, purity and desired properties on different substrate materials with a focus on the nucleation and growth rate. This has culminated in exploring different substrate surface treatments and deposition techniques including HFCVD, with substrate temperature around 700 “C, as reviewed in . Roy et al. have proposed that a ‘liquid substrate‘ can be used to achieve ‘rheotaxial‘ growth of diamond films. At such a low melting point. the vapor pressures of participating elements are also lower and growth on a ‘liquid substrate‘ occurs. Fang and Hou [5] and Kao et al. [6] also used liquid substrates for diamond films. Interestingly, Kanda et al. [7] have shown that diamond crystals can be grown using even Cu, Sb, and Ge at temperatures much higher than their melting point. Here we show that dense, good quality diamond films can be deposited on a zinc coated Sill ()0) substrate using the HFCVD technique. Boron doped Sill 00) substrates (I5 X 7 X 0.650mm3) were scratched manually using diamond paste (lpm size) and washed with acetone and de-ionized water. Zinc (99.9%, Aldrich) flakes were evaporated from tungsten filament in a separate vacuum chamber 10^{-6} Torr). Zinc coated Si substrates were transferred to the HI-‘CVD set up,

as described elsewhere [2]. For growth, the filament temperature was ZISO i 50°C and the substrate temperature was ~700+50 C with a mixture of H_2 (99.999%) and CH_4 (99.5%) in 1:100 proportion (total flow rate of l00sccm, chamber pressure of 30 Torr). Initially the substrate was negatively biased to 280V for 30min and deposition was continued with- out bias for a further 90min. AFM in the tapping mode, (NS-IV from di Digital Instruments) and SEM were used to examine the surface morphology of the substrate and films. Raman spectra were recorded using argon ion laser source, /1 = Sl4.5nm. Fig. la, a planar AFM image, shows the presence of random scratches on scratched and Zn coated substrates. The RMS roughness of both samples is ~2.5 nm. The zinc film is thin and probably follows the morphology of the substrate: the particles appear to be mostly aligned along scratch directions indicating the growth of zinc particles on scratches. The surface roughness of the diamond film, estimated from AFM images, on silicon is 88nm (Fig. lb), slightly larger than that on zinc (7lnm). Besides, the film on zinc is denser than that on bare silicon surface. The difference between the film density on the scratched and Zn coated substrate can be clearly seen in SEM images (Fig. 2a and b). Larger and randomly