DEVELOPMENT OF DIAMOND THIN FILMS ON VARIOUS SUBSTRATES

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1. Introduction

The recent development of material deposition methods leads also to thin diamond film production on various substrates. The technologies used for the diamond thin film formation are based on chemical vapour deposition. Except for the natural diamonds as gemstones, which have superlative properties of hardness, highest room temperature thermal conductivity, etc., also the artificial ones have similar properties. The diamond thin films are very useful for many applications, maybe the biological one [1] is the most attractive in these days. The superior properties like biocompatibility, homogeneity, chemical inertness, reproducibility, considerably low background current, predestinate the diamond thin films for *in vivo* electronic applications as well as a transducer material for biofunctionalization and biosensing [2].

2. Experimental details

The diamond thin films were prepared by Hot Filament CVD. The conditions of seeding and also the growth process parameters can be varied [3, 4]. The morphology and the electrical parameters are dependent on the growth process substrate biasing too and the process environment [5, 6]. The growth process evolution follows the various substrates of Si, SiO_2 and Fused Silica (JGS1).

Using the hot filament CVD method the reactor reaches almost 2000°C and the substrate temperature is usually in the range between 600°C and 800°C. The diamond thin film growth series contains one Si substrate, one Si substrate covered by thermally created

Si/SiO_2, one SiO_2 substrate and one special fused silica (JGS1) [7] substrate. All other variables like the time of the deposition - 30 min, 15:300 for CH_4:H_2 ratio, 3 kPa pressure in the chamber and 600°C the temperature of the holder were used the same. The nucleation process was initiated using diamond powder in ultrasonic bath in acetone.

Optical microscopy, SEM investigations (LEO 1550), Raman spectroscopy measurements (Horiba Jobin Yvon, Labram with He-Ne laser in backscattering geometry) SIMS depth profile analysis (Ion TOF, Bi^+ primary ions for analysis and 2 keV Cs^+ for sputtering) and XRD measurements were performed in order to get an overview and quality information of produced diamond thin films. The diamond thin film samples were examined without surface chemical cleaning before the analysis.

3. Experimental results

For experimental evaluation in first approach the optical evaluation and microscopy was used. The prepared diamond thin film surface in a view of SEM microscopy shows different size and cluster structures of diamond seeds, fig. 1. The surface coverage is homogeneous, larger and smaller crystal clusters were found in some specific parts of the surface. This effect of crystal clustering can be attributed to the nucleation results, where the nucleation was slightly different.

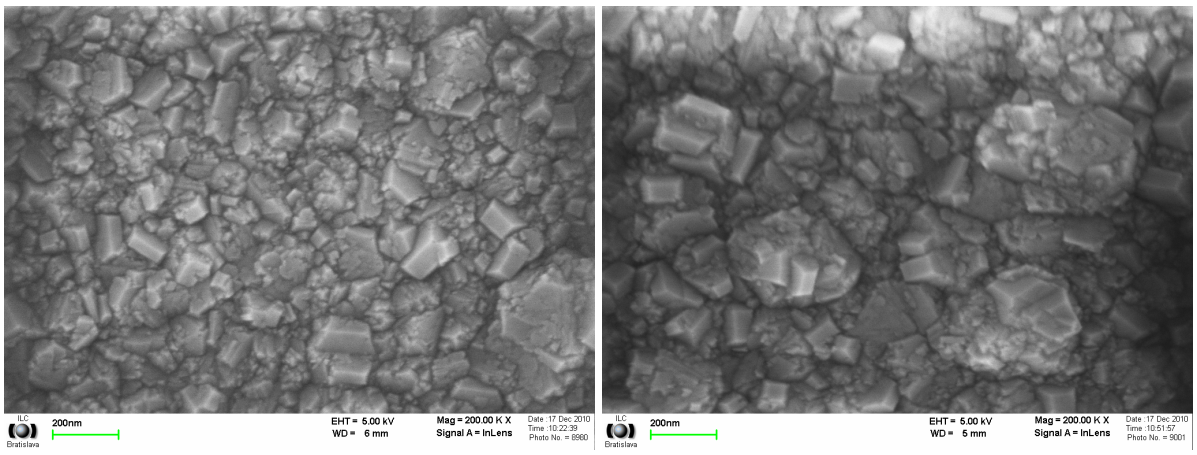

Fig. 1: *Diamond thin films from a SEM view a) on Si substrate b) on JGS1 substrate*

The Raman spectroscopy results confirmed the dimaond bonds at the peak 1333 cm^{-1}. The peak at 1580 cm^{-1} confirm the fact, that the diamond thin films also contains bonds to graphite, which are in these thin films dominating, fig. 2. At this point we started to investigate in paralel the diamond thin films using XRD to find the relations in the frowth parameters and also by the SIMS, where the composition can clarify the results.

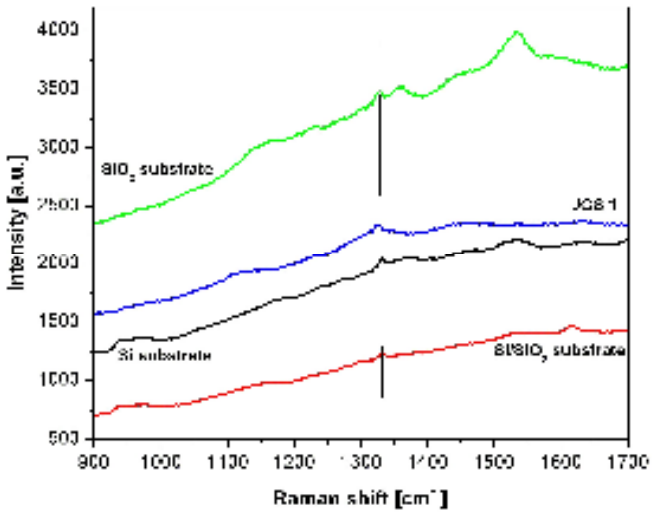

Fig. 2: *Diamond thin films from a Raman spectroscopy view on a) Si b) Si/SiO_2 c) SiO_2 and d) JGS1 substrates*

The XRD results shows very sharp peak at 44°, which is belong to the diffraction from the crystallographic plane (111). Also was detected the peaks at 75°, crystallographic plane (220) and in lower intensity at 92° assigned to plane (331), fig. 3.

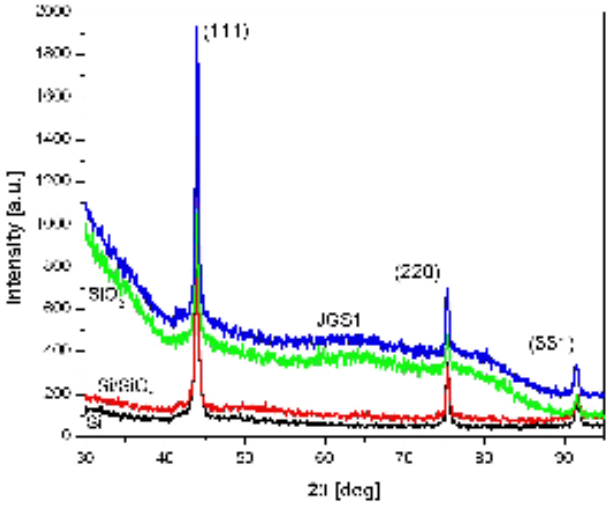

Fig. 3: *XRD patterns of the diamond thin films for all substrates*

The SIMS results revealed differences caused by growth conditions and seeding layers, which influence mainly the interface between substrates and diamond thin films. The main elements are the C, H, O for the diamond films, differences were found in the H and O concentration, which is increased in the surface region for the sample thermally Si/SiO_2 substrate. However the same deposition time was used for all samples, using the same sputtering ions and conditions the same diamond thin film thicknesses were expected. This is in fact not really true. The highest diamond thin film thickness was identified for Si substrate,

a little bit lower for JGS1, substrate and then the thermal Si/SiO_2 followed by the SiO_2 substrate, fig. 4.

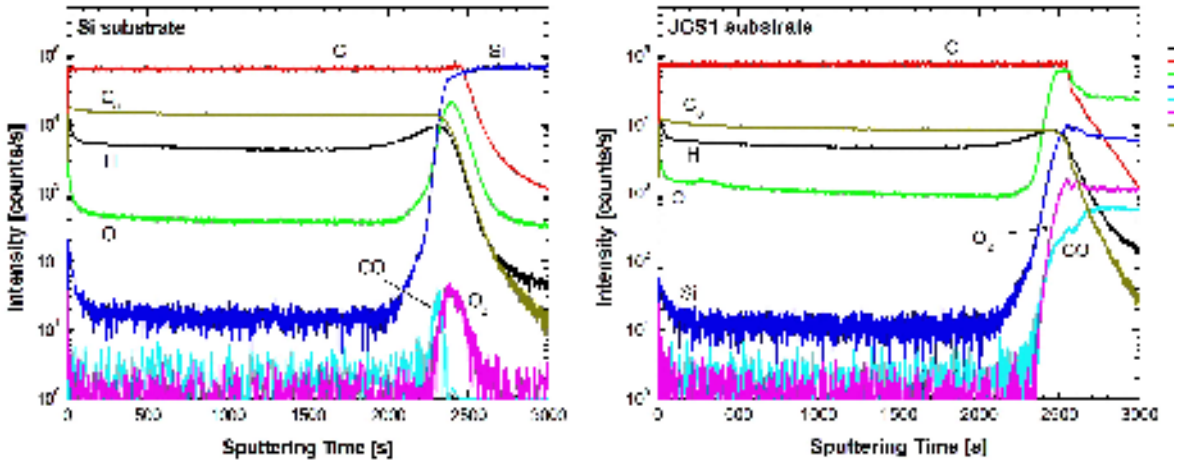

Fig. 4: *SIMS depth profiles for diamond thin films on Si and JGS1 substrate*

4. Conclusions

In this contribution we compared a series of diamond thin film samples produced by HF CVD method using the same conditions in different substrates. Characterization by methods of SEM, SIMS, XRD and Raman spectroscopy were done. XRD confirmed the crystalline planes, while RS clarified the evolution and that the diamond thin films contains bonds to graphite, which are in these thin films dominating. The SIMS depth profiles shows only small changes in the H, C at the surface region.

Acknowledgements

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