Heteroepitaxial Diamond on Iridium for Dosimetry

This PhD work aims to synthesize heteroepitaxial diamond film of very high crystalline quality on iridium buffer layers deposited on $SrTiO_3$ (001) substrates and qualify them as radiotherapy dosimeters. This work will be performed at CEA LIST in collaboration with partners of the French ANR HIRIS project. The Diamond Sensors Laboratory started diamond heteroepitaxy on iridium in 2007. Diamond crystalline quality close to the state of art was still obtained [1].

Two main challenges still remain for heteroepitaxial diamond films on iridium:

- First, the ***crystalline quality*** must be improved. Indeed, the reported dislocations densities in heteroepitaxial diamond films (> 5. 10^8 / cm^2) still limit the electronic transport properties. The crystalline quality of diamond layers could be improved by a better **control of a homogeneous pattern of domains** on iridium (001) substrates. This needs a deeper knowledge of the surface mechanisms occurring at the iridium surface during the Bias Enhanced Nucleation (BEN) process. According to the literature, the surface chemistry associated to the unique diamond nucleation mechanism is still not completely understood. After BEN, the surface chemistry (XPS, AES, UPS) and the topography (AFM) modifications of the iridium surface will be investigated using a UHV set-up at CEA LIST. It allows a sequential monitoring of the surface without air exposure. Complementary FEG-SEM observations will be done to characterize the morphology of domains. Specific CVD conditions adapted to the **growth of high crystalline quality diamond** with a low impurity level will be applied to achieve thick free-standing heteroepitaxial (001) diamond films with a thickness of 300 µm.

- Second, the ***up-scaling*** onto substrates 20x20 mm^2 may allow reproducibility. After cutting, it will provide a set of 5x5 mm^2 diamond samples grown in the same conditions by CVD assisted by Microwave Plasma in a home-made reactor If these limitations were overcome, heteroepitaxial diamond films could constitute a convincing alternative to single crystal diamond for detection and dosimetry applications. The use of **alternative substrates**, bulk $SrTiO_3$ (001) or $SrTiO_3$ epitaxial (001) layers grown on Si will allow an easier up-scaling. It is expected to significantly improve the crystalline quality of the iridium buffer layer for diamond heteroepitaxy.

The development of heteroepitaxial diamond for **medical dosimetry** is new. Selected layers will be mounted as detector at CEA-LIST using a new dosimeter packaging developed by our team. Dosimeters will be tested according to the recommendation advocate by IAEA (International Atomic Energy Agency) to be used in hospital. Their characteristics will be compared to diamond single crystals and other existing devices used for novel radiotherapy techniques.

[1] A. Chavanne, J. Barjon, B. Vilquin, J. Arabski, J.C. Arnault, Diam. Relat. Mater. 22 (2012) 52–58.

The financing has been already obtained.

Research area

Solid state physics, surfaces and interfaces / Condensed matter, Material science

Skills

Creativity - teamwork

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