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Biophysical and biochemical applications of CVD diamond by means of AFM technology

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Abstract

CVD diamond epitaxial layers are generally deposited on diamond (HPHT, Ib), which have small dimensions. Recently (1), good epitaxial layers have been obtained also on silicon, which a more common and very cheap substrate with larger dimensions. This result opens the way to a CVD diamond electronics on defect-free wafers with the common planar technology. More recently, (2) CVD diamond samples have been produced as free standing wafers, as for silicon. Electrical and optical properties are however outstanding with respect to silicon : electron mobilities are 3 times higher, and lifetimes are of the same order of magnitude. Moreover, CVD diamond is fully transparent from distant IR to UV, displays a thermal conductivity four times that of copper and it is fully biologically compatible. The true potential of diamond within the field of biotechnology may lie within the area of the growth of biological material onto its surface, creating carbon-to-carbon junctions. If this were possible, the many applications can be envisaged, from " cell-laboratory-on-a-chip " to eletronic devices truly integrated within the body by biological connections (3). Another excting prospect is for the integration of single cells, such as brain cells, within micro and nanoscale diamond circuits for research into cells functions, since current approaches require connections to many cells within relatively crude electronic environment before any analysis can take place. Patterned hydrogenated surfaces, as obtained by local oxidation through the help of an AFM, can be used to create different connection geometries and hence simple circuits within the biological system to be envisaged.

Diamond field effect transistors have operated in electrolyte solution (4) for the first time. The hydrogenated diamond surfaces are stable enough for the use as an electrochemical electrode, the diamond surface channels are exposed directly to the electrolyte in the transistor structure. Pinch-off and electrical characteristics are perfect within the potential window, which is 3 V, a value much higher than for other semiconductors.Threshold voltage are almost constant in electrolytes with different pH values from 7 to 13. Based on this pH insensitive surface, ion selective regions can be fabricated to form transistor-based biosensors.

Immobilization of DNA on diamond surfaces (5) and the detection of its covalently bonded nature were explored by direct spectroscopic analysis. Diamond was successfully modified by oxidation followed by esterification. DNA covalently immobilized onto diamond by ester linkage was detected by diffuse reflectance infrared spectroscopic analysis.

References:

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