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Characterization of UV irradiated nanocrystalline diamond

G. Speranza [a], S. Torrengo [b], L. Minati [a], M. Filippi [a], M. Castellino [b], Cl. Manfredotti [b], Ch. Manfredotti [b], M. Dipalo [c], A. Pasquarelli [c], E. Kohn [c], Hayssam El-Hajj [c], E. Vittone [b,*]

[a] *Physics and Chemistry of Surfaces and Interfaces, Fondazione "Bruno Kessler", Trento (I), Italy*
[b] *Department of Experimental Physics and "Nanostructured Interfaces and Surfaces" NIS Centre of Excellence, University of Torino, via P.Giuria 1, 10125 Torino (I), Italy*
[c] *Department of Electron Devices & Circuits, Ulm University (D), Germany*

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Abstract

The exposure of H-terminated nanocrystalline diamond (NCD) to ultraviolet (UV) light in air and at room temperature modifies the features of the diamond surface, in terms of wettability, electrical conductivity and chemical reactivity. This allows the development of a soft, dry and non invasive method to tailor the surface properties for the development of new chem- or bio-sensors.

In this work, we report about the analysis of hydrogen terminated nanocrystalline diamond films grown by hot-filament technique and of their surface modification following UV light exposure. This UV treatment induces an hydrophobic to hydrophilic transformation and an outstanding increase of the electrical resistivity ($>10^5$). X-ray (XPS) and ultraviolet (UPS) photoelectron spectroscopy provide insight into the role of chemisorbed oxygen on the modification of the valence band and on the transformation of the electron affinity (from negative to positive) at the diamond surface.

Keywords: Nanocrystalline diamond; Surface properties; Electron affinity; Hydrogen termination; Oxygen termination

1. Introduction

Nanocrystalline diamond, because of its nanostructured surface, mechanical, optical, electrical/electrochemical properties, as well as for its biocompatibility combined with the possibility of controlled surface bio-modification, is considered a suitable platform for biointerfaces and biosensors [1]. Two surface terminations are usually considered: H-terminated diamond surfaces are biocompatible, transparent, electrically conductive and biomolecules can be attached covalently at the surface through photochemical processes [2]; oxygen termination induces an optically transparent and hydrophilic surface which promotes cell adhesion and growth [1].

Among the various methods to tailor the electrical properties of the diamond surface, the exposure to ozone has recently attracted the interest of various researchers for fundamental studies [3], for the fabrication of highly sensitive chem-FET [4], or for cell adhesion and biocompatibility studies [1]. Such treatment can be produced by the exposure of diamond to ultraviolet (UV) radiation, even if controversial data are reported on the synergic combination of UV and ozone on the surface treatment [5].

In this paper we report about the effects of UV irradiation in air on the surface electronic characteristics of NCD. The chemisorbed species, in particular the role of oxygen, as well as the modification of the valence band, were monitored by XPS and UPS in order to evaluate the photochemical effects of the UV treatment. To assess the role of the surface photochemical modification on electrical and hydrophobic properties of the surface, XPS/UPS analyses have been correlated to conductivity and contact angle measurements.

2. Experimental

2.1. Diamond samples

NCD samples preparation consisted of 3 steps. Firstly a 4" silicon wafer (100) was nucleated in Hot Filament CVD by mean of BEN (Bias Enhanced Nucleation) [6]. Subsequently a

* Corresponding author.
E-mail address: vittone@to.infn.it (E. Vittone).

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