

DANCE OF ELECTRONS IN HYDROGENATED DIAMOND SURFACE

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Diamond is a semiconductor with extreme and unique properties, which enable applications in a variety of fields; yet the tremendous progress in diamond exploitation is now limited by material challenges. As research progresses, new device concepts are being developed based on its outstanding and wondrous characteristics. Among them, one of the most fascinating is the enhanced electrical (p-type) conductivity exhibited by its hydrogen-terminated surface, up to ten order of magnitudes higher with respect to bulk [1]. Ever since its discovery in 1989 (when it was soon envisaged for biological and chemical sensor application), the surface conductivity (SC) of hydrogenated diamond (HD) has been subject of intensive studies. Notwithstanding it has been already successfully used for high-power and high-frequency electronic devices [2], even being potentially envisaged for spintronics applications [3], a complete explication of SC in HD has remained elusive.

The establishment of SC requires that an additional adsorbate on the HD surface should act as an acceptor in order to create a 2-dimensional charge accumulation region confined within few topmost layers. Such surface transfer doping gives rise to a fundamentally altered surface electronic structure from that of the bulk. This has been demonstrated by exploiting the probing depth dependence of photoelectron spectroscopy (PES) applied in a non-conventional photon energy range and *ab-initio* density functional calculations, showing that in air-exposed (100) surfaces, carriers are organized in a twofold band structure, with an effective masse about twice that of the electron rest mass [4].

Nonetheless, the question of which adsorbed molecular species is responsible for the surface charge transfer still awaits for a conclusive answer. One of the central themes in this research, namely the interaction of hydrogenated diamond with airborne adsorbates inducing its SC, has been afforded by comparing macroscopic with microscopic properties of samples that were ex-situ hydrogen-terminated in microwave plasma. Electrical characterization has been correlated with elemental and morphological analysis performed on in-vacuum annealed, air- and O₂*-exposed samples, by combining conductivity measurements with surface-sensitive spectroscopic techniques. The outcomes of our investigation allow: i) to reconcile the two controversial interpretative lines of the X-

Ray-Photoelectron C1s spectrum concerning the contribution of the C-H bond [5]; ii) to give an explanation on the role of oxygen in the SC mechanism [6]; iii) to correlate the coherence between the sheet resistance map and Electron Energy Loss Spectra, which are sensitive to the presence of hydrogen on the diamond surface, resulting as a novel approach to study hydrogen-termination homogeneity [7].

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