

# Electrochemical Surface Transfer Doping: The Mechanism behind the Surface Conductivity of Hydrogen Terminated Diamond

Jürgen Ristein, Marc Riedel and Lothar Ley  
Institute of Technical Physics, University of Erlangen  
Erwin-Rommel-Str. 1, D-91058 Erlangen, Germany

Intrinsic diamond with a band gap of 5.4 eV exhibits a two-dimensional surface conductivity (SC) of the order of  $10^{-5} \Omega^{-1}$  when terminated by hydrogen. This conductivity is carried by a hole accumulation layer close to the surface with an areal carrier concentration of about  $10^{13} \text{ cm}^{-2}$ , and it has already been utilized for a unique kind of field effect transistor [1].

We have combined conductivity measurements in ultra high vacuum (UHV) and under atmospheric conditions with spectroscopic methods such as photoelectron emission spectroscopy and infrared (IR) spectroscopy in the attenuated total reflection (ATR) mode to elucidate the connection between surface conditions and SC. The experiments show that besides the hydrogenation of the surface also exposure to atmospheric conditions is necessary to induce the observed hole accumulation close to the surface. Based on those experiments we propose a new surface transfer doping mechanism by which electron transfer from the valence band to adsorbed, hydrated ionic species at the surface creates the holes for the surface conductivity. This electron transfer is mediated by an electrochemical reaction and governed by the line-up of chemical potentials for the electrons in the diamond and in the surface adsorbate system. The unique features of the diamond surface which enable this unusual form of atmospheric electrochemistry, and the influence of surface and bulk defects will be discussed in the light of the model.

[1] H. Kawai, *Surf. Sci. Rep.* **26**, 205 (1996)