Electronic Properties of Nanostructured Diamond: NCD, UNCD and Nano-powders Compared

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Many important applications are emerging for both nanostructured diamond thin films and nanometre sized diamond powders. In many cases it is important to control the electronic properties of the diamond. For this reason it is important to understand the influence of grain boundaries in the thin film nanostructured diamond films, and the electronic nature of the surface of the nano-powders. We have therefore initiated a programme which uses Impedance Spectroscopy (IS) and Hall effect measurements to elucidate the electronic properties in different forms of nano-diamond.

This paper will present results achieved for two types of thin film nanodiamond, namely nanocrystalline diamond (NCD), grown at the Naval Research Labs in Washington, USA and so-called ultra-nanocrystalline diamond (UNCD) produced at Argonne National laboratories, USA. In addition, information on two powders type will be presented, natural micron-sized diamonds, and ultra-disperse detonation nano-diamonds, whose size is of the order of 5nm.

The results achieved are intriguing. In the case of NCD, high temperature annealing procedures can lead to a near-perfect dielectric material, where the grain boundary conduction essentially vanishes. Boron-doping these films can also result in p-type characteristics with mobilities (surprisingly) as high as 50cm^2/Vs. In the case of UNCD, purposeful addition of nitrogen to the grow gases produces an n-type material, with little thermal activation required to generate free carriers, contrary to the case of single crystal diamond. With natural diamond powders H-termination can lead to 'surface conductivity' and we have used this p-type surface layer to make individual nano-diodes. We have been able to produce highly resistive detonation nano-diamonds, whilst also being able to make them highly conductive. A selection of results from each form of nano-diamond will be presented such that the versatile nature of the electronic properties of this form of diamond can be appre! ciated.

[1] S.W.J. Scully et al. *Phys. Rev. Lett.* **94**, 065503 (2005).

[2] R.G. Polozkov, V.K. Ivanov, A.V. Solov'yov, *J. Phys. B* **38**, 4341 (2005).