Carbon superlattice based on diamond-like carbon films for high speed electronics

S. Ravi P. Silva

Advanced Technology Institute, University of Surrey, Guildford, United Kingdom

Traditionally, Diamond-like carbon (DLC) thin films have only been considered as a mechanical coating material, despite its rich diversity in terms of bond hybridisation. These variations in bonding with carbon and doping elements can give rise to many highly varied band gaps and electronic properties. As of yet, this diversity has not properly been exploited due to the highly resistive nature of the DLC film family. In this paper we show how tunnelling phenomena of charge carriers subject to high electronic fields can be used to overcome the limited mobilities present in these systems. The high breakdown strength of DLC is ideal in enabling the design of such devices. The beauty of the electrons within the carbon structures have yet to be fully exploited in the disordered carbon systems, and we believe we have made the first steps in making these materials viable for high speed electronics.

In this talk we develop a radical route to utilise the highly controllable band gap properties of DLC to unlock the carrier localisation in these films [1]. The variation in the sp^2 to sp^3 ratio enables one to carefully control the band gap of these material systems down to nanometre precision thin films. Band-modulated DLC deposited with PECVD and Excimer laser ablation show evidence for quantum size effects and quantised conduction memory switching. Negative differential resistance in DLC double barrier resonant tunnel diodes with a cut-off frequency in GHz is reported [1]. By applying high bias these structures are modified and reversible current switching by four orders of magnitude with a signature NDR and multiple peaks for resonant tunnelling observed. Strategies to make large area electronic devices are proposed and evidence as to the potential of the devices produced demonstrated.

Energy Loss Spectroscopy Profiling combined with TEM is used to show abrupt junctions within the superlattices produced, and nano-heterojunction characterisation using energy loss profiling is illustrated. The measured effective mass for the electron for carbon of 0.07me, using optical methods is confirmed by modelling of the electron wavefunction in a potential well within a superlattice. This low effective mass and the high electric breakdown strength of DLC, combined with the variations in bond hybridisation allow this material system to be highly suitable for high speed electronics. Most recent results show quantisation effects are present even in the electron field emission properties of these superlattices.

[1] S. Bhattacharyya et al. *Nature Mater.* **5,** 19 (2006).