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ABSTRACT:

Laser Engineering Nanocarbon Phases within Diamond for Science, Sensors and Electronics

Richard B. Jackman

London Centre for Nanotechnology and the Department of Electronic and Electrical Engineering UCL (University College London), 17-19 Gordon Street, London, WC1H 0AH, UK. r.jackman@ucl.ac.uk

Diamond, as the densest allotrope of carbon, displays a range of exemplary material properties that are attractive from a device perspective. Despite diamond displaying high carbon-carbon bond strength, ultrashort (fs) pulse laser radiation can provide sufficient energy for highly localized internal breakdown of the diamond lattice. The less-dense carbon structures generated on lattice breakdown are subject to significant pressure from the surrounding diamond matrix, leading to highly unusual formation conditions. By tailoring the laser dose delivered to the diamond, it is shown that it is possible to create continuously modified internal tracks, with varying electrical conduction properties. In addition to the widely reported conducting tracks, here conditions leading to semiconducting and insulating written tracks have been identified. This holds great promise for future devices, where NCNs can be controllably manufactured within a diamond wafer, providing not only buried conductive wires, but 3D structures with active device junctions (depletion or tunnelling). High resolution transmission electron microscopy (HRTEM) is used to visualize the structural transformations taking place and provide insight on the different conduction regimes. The HRTEM reveals a highly diverse range of nanocarbon structures are generated by the laser irradiation, including many signatures for different so-called diaphite complexes which have been seen in meteorite samples, and seem to mediate the laser-induced breakdown of the diamond [1]. The work offers insight into possible formation methods for the diamond and related nanocarbon phases found in meteorites.

In addition to discussing the fascinating nanoscience occurring in this work, practical technology examples, currently undergoing commercial development, of radiation detectors, chemical sensors and even 3D transistors for power electronics fully

embedded in single crystal diamond wafers (20x20mm) using this methodology will be described. 'Show and tell' samples will be available.

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