Diamond Nano-wires for Biosensing

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Next generation gas-, chemical and bio-chemical sensor platforms will require significant improvements in sensitivity, specificity, parallelism, chemical stability, and bio-compatibility in order to meet the future needs in various fields. Nanowires are new materials, which have characteristics of low weight with sometimes extraordinary mechanical, electrical, thermal and multifunctional properties. Up-to-now applied materials do not possess desired chemical stability in electrolyte solution, reproducibility and biochemical surface modifications. Only diamond is known to be outstanding with respect to electrochemical properties. Diamond is chemically inert, bio-compatible and ultra-hard (50-150 GaP) which is promising with respect to mechanical stability of diamond nano-wires. In addition, the surface of diamond shows unique properties as it can be terminated with hydrogen, oxygen or OH and can be functionalized for bio-chemical sensing.

In this paper, we introduce the application of diamond nano-particle etching masks for the fabrication of diamond nano-wires from metallically boron doped single crystalline CVD diamond, to be used in oligonucleotide biosensor devices for gene screening. A top-down procedure is optimized where firstly atomically flat diamond is grown by homo-epitaxy of metallically (p-type) doped single crystalline diamond on insulating Ib substrates. Then (2) a self organized etching mask from nano-diamond particles is deposited on the surface with particles of typical 10 nm diameter. 3) Reactive ion etching in O_2/CF_4 gas mixture is applied to form patterns of vertically aligned diamond nano-wires. 4) These wires are functionalized by use of an electrochemical phenyl-linker molecule attachment schema,[1] which preferentially bonds phenyl linker-molecules to the tips of wires, thereby forming a well defined bonding arrangement of oligonucleotide molecules. This bio-sensor from diamond combines for the first time the outstanding electrochemical properties of diamond as transducer with the advantages coming by dispersed and controlled bonding ‘like in aqueous solution” of DNA molecules in geometrically well defined patterns to diamond.

[1] C.E. Nebel, B. Rezek, D. Shin, H. Uetsuka, N. Yang, *J. Phys. D: Appl. Phys.* **40**, 6443–6466 (2007).