Nanocrystalline Diamond and CNTs for MEMS fabrication

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Abstract

MEMS are a well-established growing technology with high impact in sensors and actuators, with applications in bioscience, medicine, communications, and inertial sensing. However, some emergent new high-tech applications require alternatives to the standard materials (in particular, Si) with improved electromechanical properties. Micro-crystalline diamond (MCD) and nano-crystalline diamond (NCD) films keep many of the outstanding intrinsic diamond properties relevant for applications in MEMS, namely their rigidity and low intrinsic energy losses, far exceeding those of the traditionally used materials[1,2].Therefore, diamond films (Fig. 1) grown by microwave plasma chemical vapour deposition (MPCVD) were micro machined to produce simple MEMS structures. The nano-crystalline diamond resonators were fabricated on silica coated silicon substrates, the silica acting both as the electrical insulator and sacrificial layer (Fig. 2). The vibrational response analysis of the suspended resonators confirmed a high NCD Young modulus of ~1000 GPa.

Additionally, in order to enhance the NCD properties, the incorporation of multiwall CNTs (with excellent thermal/electrical conductivities and extreme unidimensional mechanical toughness) was attempted, foreseeing enhancement of toughness, elasticity and both thermal and electrical conductivities, which are critical properties in MEMS[2]. Thus, in a first approach, a hybrid NCD/CNT structure was obtained after simultaneous synthesis by MPCVD, demonstrating that both materials can interconnect (Fig.3). In a different approach, a NCD/CNT/NCD sandwich structure was produced by a multi-step technique (Fig.4). Work on the synthesis, characterization and processing of these materials, with the objective of integration in MEMS structures is under way.

Figures

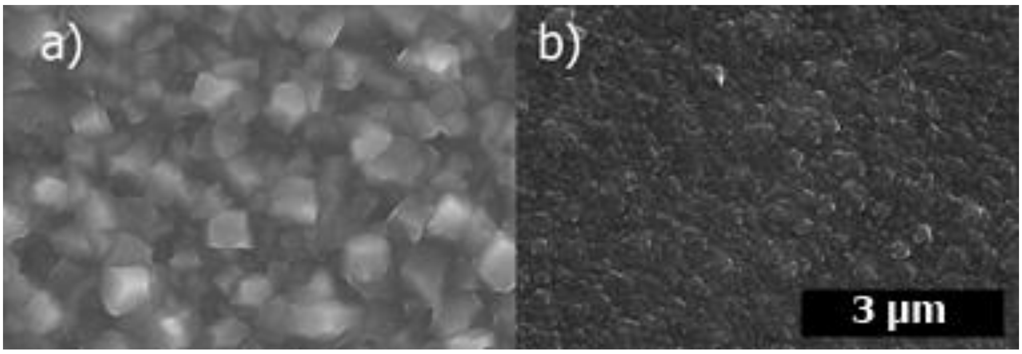

Fig. 1 – SEM micrograph of a) MCD and b) NCD diamond film grown by MPCVD.

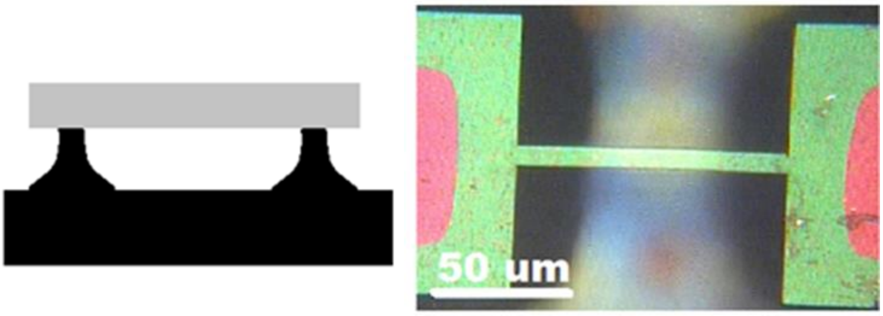

Fig. 2 – a) Schematic illustration of the bridges obtained by bulk micromachining (black representing Silicon and grey the diamond film). b) Micrograph of a released diamond bridge by bulk micromachining of silicon.

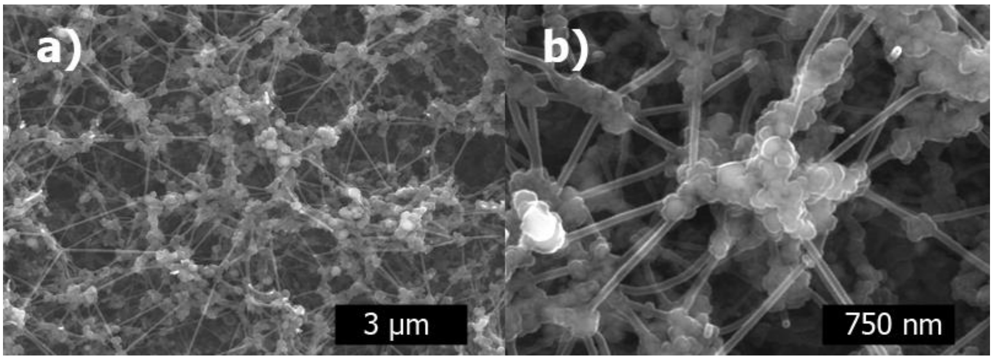

Fig. 3 – SEM micrographs of a) Hybrid NCD/CNT structure obtained after simultaneous synthesis by MPCVD and b) diamond clusters interconnected with CNTs.

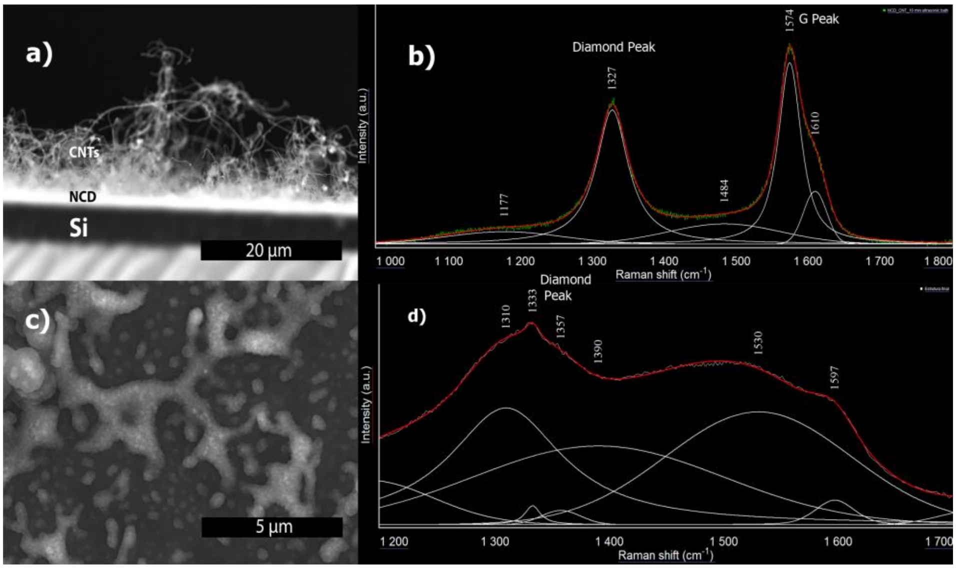

Fig. 4 – a) SEM micrograph of CNT's grown on Si/SiO_2/NCD substrate and respective b) Raman spectrum. c) SEM micrograph of NCD grown on CNTs and respective d) Raman spectrum.

References

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