Design and Fabrication of Ultrananocrystalline Diamond Nanowire Based Nanoelectromechanical Switches

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Nanoelectromechanical (NEM) switches are currently being studied as complements of complementary metal oxide semiconductor field effect transistors (MOSFETs). NEM switches have advantages of zero leakage current, ultra low power consumption and switching speeds reaching 100 ns. NEM switches aim to address the increasing power dissipation and overheating issues of FET technology.

Ultrananocrystalline diamond (UNCD) thin films were developed and patented at Argonne National Laboratory. The properties of the UNCD films, such as negligible force of adhesion, high Young's modulus, low temperature synthesis (CMOS compatible), electrical conduction via B-doping (BUNCD) or N_2-incorporation (NUNCD) and adequate heat dissipation make them an excellent candidate material for NEM switches [1].

We demonstrate the fabrication of both NUNCD and BUNCD nanowires using electron beam lithography (EBL) patterning and lift-off/reactive ion etching (RIE) processing [2]. The nanowire lengths are 10-100 μm long and with widths ranging from 30-100 nm. Our NEM switch has a movable source anchored at both ends. An immobile drain electrode is separate from the center of the source beam by a narrow gap. Two electrically connected gate electrodes are separated from the source by the gate gap, which is larger than the drain gap [3]. Our BUNCD film is 300 nm thick, has a 1.0μm thick SiO_2 sacrificial layer, a 100 nm positive-tone resist layer and a 20 nm thick Ni layer that served as a hard mask for the lift-off/RIE processing. We also designed and modeled a switch with vertically driven actuation. The results of the modeling are also presented. This switch uses SiC as the hard mask. We aim to fabricate reliable switches with fast switching times (sub 100 ns) and low actuation voltages (~1V).

Keywords: Nanoelectromechanical switch, Electron beam lithography, Reactive ion etching

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