Mechanical and electrical evaluations of FIB-CVD carbon nanowire using MEMS device

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This dissertation is directed at the development of Electrostatic Actuated NAno Tensile testing devices (EANATs) for the evaluation of material properties in FIB-CVD carbon nanowires (CNWs). Uniaxial tensile tests and the electrical measurements for the CNWs were carried out under severe strain.

EANATs were composed of a specimen, actuator and a measurement part. The measurement part had a cantilever used as a lever motion amplification system for measuring tensile displacement of the CNWs. Experiments involved the use of the measurement part in conjunction with a CCD camera system and a block matching image analysis, and resulted in the EANATs achieving the minimum resolutions in tensile load and displacement of 123 nN and 0.29 nm, respectively.

Experimental averages for Young's modulus and fracture stress of the CNWs were 59.9 GPa and 4.3 GPa, respectively, although the Young's modulus exhibited the scatter caused by the deposition condition. FE-SEM observations revealed that nonlinear deformation behavior was attributable to contraction produced just before failure of the CNWs.

As the result of electrical measurement under severe strain of the CNWs, the total gauge factor fluctuated with increasing tensile strain. Composition analyses of the CNWs revealed that the CNWs comprised hydrogenated amorphous carbon (a-C:H) domain and a gallium core. On the basis of these results, the parallel circuit model for the a-C:H domain and the gallium core was proposed to explain the resistance change of the CNWs with increasing tensile strain. The model was able to estimate the gauge factor for only the a-C:H domain of CNWs to be ranging from -27.8 to -56.8.

In this dissertation, I succeeded in the development of EANATs and suggested that the CNWs would be available for usage of structural and functional materials in NEMS and nanodevices.