Small-Scale Batch Fabrication and Characterization of Carbon Nanofiber Probes

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Due to their high aspect ratios, nanoscale tip radii, high chemical stability and high mechanical strength, carbon nanotubes (CNTs [1]) and carbon nanofibers (CNFs) are thought to be an ideal probe for scanning probe microscopes (SPMs). Thus, much effort has been devoted to fabricate CNT- or CNF-based SPM probes since the discovery of CNTs [2]. Nevertheless, the batch fabrication of CNT- or CNF-tipped probes is still quite challenging because of several unsolved difficulties in conventional fabrication methods, such as the manual attachment of single CNTs or chemical vapor deposition growth of CNTs onto SPM chips.

Here we challenged the batch-growth of linear-shaped single CNFs onto commercially available Si cantilevers (3 – 9 chips / batch) using a newly developed Ar^+-ion-irradiation method [3]. In the present work, the growth parameters were optimized and the electric properties of ion-induced CNF probes were revealed.

Single CNFs pointing in the Ar^+-ion-beam direction grew on the tips of arrayed chips (Fig. 1). CNFs increased in length with an increase in the growth time, and the discrepancy in length was estimated to be typically +/- 10 % in an array of 9 SPM chips grown under the optimized condition. CNFs grown at room temperature, for instance, reached about 1 um in length for the 10 min-growth. In the I-V measurements, commercial-type Si probes (without CNF) showed a typical semiconductive characteristic. By contrast, Si probes with ion-induced CNFs (CNF probes) displayed a metallic characteristic with a high signal-to-noise ratio in the I-V curves and possessed a high AFM resolution. Thus, it was believed that batch-fabricated ion-induced CNFs were quite promising as practical SPM probes.

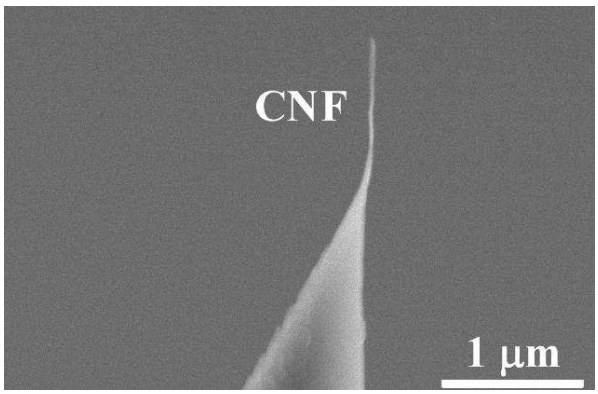

Fig. 1 SEM image of a typical CNF probe taken after repeated AFM measurements.

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