

Fabrication of Semi-conducting Single-wall Carbon Nanotube Arrays

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Single-walled carbon nanotube (SWNT) is a rolled-up graphene and it is one of the most important materials in nano-technology, owing to the excellent physical, chemical and mechanical properties. Forward many SWNT applications, the control of the electric conductivity (metallic or semiconducting), which depend on the atomic structure (so-called chirality), is quite important. However, it is difficult to synthesize only semi-conducting SWNTs in the growth stage so far, and the separation or purification techniques are necessary. Here, we synthesized horizontally-aligned SWNTs (HA-SWNTs) and performed selectively removal of metallic SWNTs based on electrical breakdown method. The resulting structure (semi-conducting SWNT arrays) is preferred for the fabrication of integrated circuits using SWNTs.

HA-SWNTs were synthesized on crystal quartz substrates (R-cut) by using alcohol catalytic CVD method [1, 2]. After the substrates with iron nano-particles was heated at 800 °C, ethanol vapor was supplied with Ar/H₂ buffer gasses. Ethanol molecules decomposed and SWNTs were grown from the iron nano-particles. SWNTs interacted with the substrate surface and they were aligned along the x-axis of crystal quartz. Figure 1 shows SEM image of HA-SWNTs, which are highly oriented. The as-grown SWNTs were mixture of metallic or semi-conducting SWNTs. HA-SWNTs were coated with polymer thin-film (PMMA) and they were Joule-heated. Figure 2(A) shows metallic and semiconducting SWNTs, which were connected with a pair of electrodes. During Joule-heating, SWNT temperature increased and only metallic SWNTs exhibited breakdown, owing to high current density. A part of metallic SWNT were removed, as shown in Fig. 2(B). While the removal length is generally 100 nm without polymer coating, the polymer thin film clearly enhanced the removal length. It suggests that the polymer film affects the temperature distribution of SWNTs and the heat of chemical reaction during breakdown.

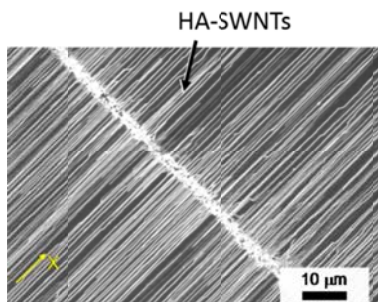


Fig. 1: SEM image of HA-SWNTs grown on crystal quartz substrates.

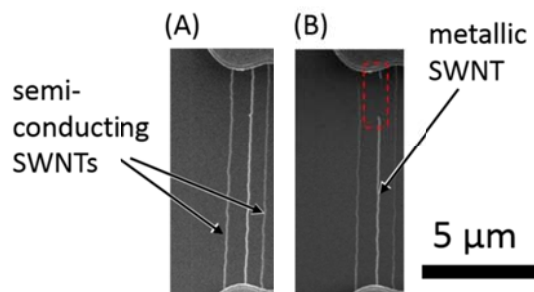


Fig. 2: SEM image of (A) as-grown SWNTs and (B) after polymer film-assisted electrical breakdown.

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