Field Emission Properties of Single-Walled Carbon Nanotubes with a Variety of Emitter-Morphologies

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A number of issues are important for future CNT-FED development: (I) A low-temperature and/or short-time growth directly on cathodes through simple and safe processes, (II) a giant tip-enhancement of an applied field and (III) a uniform spacial current distribution, that is, a large number density of emission sites resulting in a mild current per emitter. We focus here on SWNT-emitters prepared using alcohol catalytic CVD (ACCVD)[1]. Prior to application of ACCVD for device fabrication, suitable catalyst compositions to promote a rapid growth of high quality SWNTs and the FE properties of the obtained SWNTs must be systematically studied. We report field emission properties of SWNT-emitters with different morphologies and discuss their potential for FED-applications.

SWNT-emitters were prepared on Si substrates with Co/Al_2O_3 layers through ACCVD, which realizes a reaction time of 10 s to grow a 4 μm-thick SWNT film. FE properties of SWNTs are tunable by the morphological control of the top-surface (Fig. 1). For a textured Si cathode with well separated SWNT-bundles (Fig. 1d), the turn-on electric field to extract a current density of 1 $\mu A/cm^2$ was 2.4 V/μm, and a current density of 0.8 mA/cm^2 was recorded at 4 V/μm. Large area uniformity of luminescence (0.5 cm^2) was also obtained. Protrusion of emitters is crucial and the optimization of number density, protrusion length and inter-protrusion distance is necessary for uniform field emission and increased operating life. Texturing of substrates effects a large and selective field enhancement at specific protrusive emitters. Currently, SWNTs prepared from ethanol via a fast and safe process showed field mission characteristics suitable for electron sources.

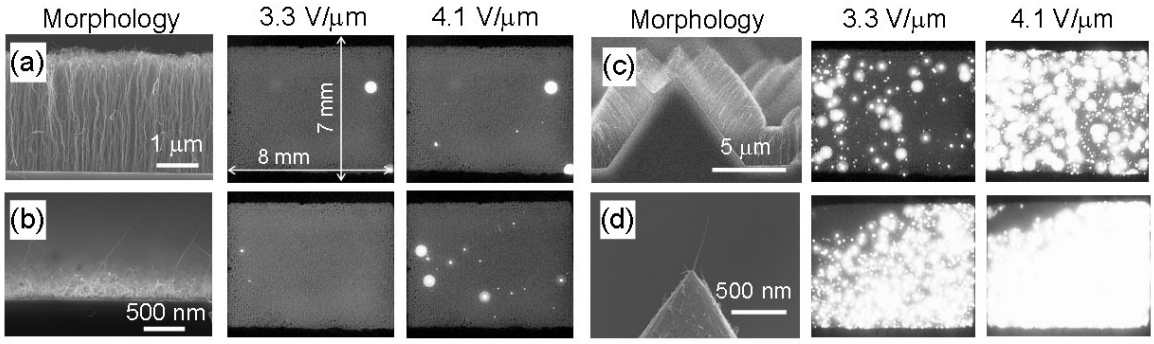

Fig. 1. Cross-sectional SEM micrographs and pictures of luminescence from the rear surface of the anode at 3.3 and 4.1 V/μm; (a) VA-SWNTs, (b) CNT-grass, (c) VA-SWNTs on Si pyramids and (d) free-sanding bundles on Si pyramids.

[1] S. Maruyama, R. Kojima, Y. Miyauchi, S. Chiashi, and M. Kohno: Chem. Phys. Lett. **360** (2002) 229.

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