S3 – 17

Field Emission Properties of Morphologically-Controlled Single-Walled Carbon Nanotubes and their Combinatorial Evaluation

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Among the various types of carbon nanotubes (CNTs), the large field amplifying effect of single-walled CNTs (SWCNTs) makes them ideal for significantly reducing driving voltage in field emission (FE) devices. Our work aims to control the emitter morphologies in order to increase the emission sites and therefore current uniformity, or in other words, to decrease the emission current per SWNT-emitter. For implementation of SWCNT-emitters on micro-cathodes, both fast, low-temperature growth process and also protrusive morphologies with a moderate spacing are desirable. By using combinatorial masked deposition (CMD)[1,2], we can investigate catalyst compositions promoting growth of SWCNTs in a single experiment. Extending this approach, preferable field emitters are thus determined by the combinatorial FE-evaluation in a single experiment. We report here the FE properties of SWCNT-emitters with a large range of morphologies.

SWCNT-emitters were prepared on Si substrates with Co/Al_2O_3 layers through alcohol catalytic CVD (ACCVD)[3]. For a textured Si cathode with well separated SWCNT-bundles, a turn-on electric field to extract a current density of 1 $\mu A/cm^2$ at 2.3 $V/\mu m$, and a current density of 1.2 mA/cm^2 at 4 $V/\mu m$ were recorded. Large-area uniform luminescence (0.5 cm^2) was also obtained. The protrusion of emitters is a critical factor and optimization of the number density, protrusion length and inter-protrusion distance is necessary for a uniform FE and an increased lifetime.

FE properties of CNTs were comparatively evaluated by using combinatorial libraries. One library reproduces a lot of types of single- and multi-walled CNTs with different morphologies. The luminescence property observed from one combinatorial evaluation showed a good agreement with the results from individual evaluations for specific CNTs. Protrusive SWNT-bundles indicated the best FE properties.

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