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Abstract
In this study, the carbon nanotubes (CNTs) have been grown on Si substrates using electron cyclotron resonance chemical vapor deposition (ECR-CVD) at low temperature of 500℃. The aim of this study is to investigate the correlation between field emission characteristics of carbon nanotubes and the surface morphologies of nickel catalysts. The effects of flow stream on the characteristics and structures of multi-wall carbon nanotubes (MWNTs) were studied in detail. To modify the surface morphologies of nickel catalysts, a series of plasma treatments and differing film thickness are performed. For the structure analysis, the morphology and microstructure of carbon nanotubes were observed by the scanning electron microscopy (SEM), transmission electron microscopy (TEM), and Raman spectrometry. The field emission measurements were used to confirm the optimized process parameters for the growth of carbon nanotube.
The results show that the CNTs grown on 3-nm-thick catalyst film have better field emission characteristics. No matter that catalyst film is with or without pre-treatment, the turn-on field is lower than 4V/um, when the substrate is facing upward and the growth of CNTs is dominated by the diffusion process. Besides, the CNTs grown directly on the pretreated catalyst substrate exhibits a current density of 1mA/cm2 at the 7.3V/um. Nevertheless, while the thickness of catalyst film decreases from 3nm to 1.5nm, the grown CNTs appear obviously bamboo-like micro-structure. The compartment distance of the bamboo-like CNT is estimated to be 15nm. This is attributed to that the size of catalyst particle decreases, and then the bulk diffusions were dominated. The turn-on field of bamboo-like CNT exceeds 4.5 V/um, and the emission current density is lower than o.1mA/cm2 at an electric field of 7.3 V/um.
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