Field Emission Study of Carbon Nanostructures

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Abstract

Recently, carbon nanosheets (CNSs), a novel nanostructure, were developed in our laboratory as a field emission source for high emission current. To characterize, understand and improve the field emission properties of CNSs, we have customized in ultra-high vacuum surface analysis system to conduct relevant experimental research in four distinct areas. The system includes Auger electron spectroscopy (AES), field emission energy spectroscopy (TDS). Firstly, commercial Mo single tips were studied to calibrate the customized system. AES and FEES experiments indicate that a pyramidal nanotip of Ca element formed on the Mo tip surface by field induced surface diffusion. Secondly, field emission I-V testing on CNSs indicates that the field emission properties of pristine nanosheets are impacted by adsorbates. For instance, in pristine samples, field emission sources can be built up instantaneously and be characterized by prominent noise levels, and significant current variations. However, when these CNSs are processed via conditioning (run at high current), their emission properties are greatly improved and stabilized. Furthermore, we found that only H desorbed from the conditioned CNSs, which indicates that only H adsorbates affect emission. Thirdly, our TDS study on nanosheets revealed that the predomiant locations of H residing in CNSs are sp2 hybridized C. Fourthly, a fabricating process was developed to coat low work function ZrC on nanosheets for field emission enhancement. The carbide triple-peak in the AES spectra indicated that Zr carbide formed, but with an oxygen impurity. The Zr(CxOy) coating was dispersed as nano-beads on the CNSs surface. The coated CNSs' emission properties were not improved, due to the degeneration of the beta factor. Further analysis suggest that in low emission current (<1 uA), the H adsorbates affect emission by altering the work function. In high emission current (> 10 uA), thermal, ionic or electronic transition effects might be induced, which can affect the field emission process.