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Direct Identification of Metallic and Semiconducting Single-walled Carbon Nanotubes in Scanning Electron Microscope

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Due to their excellent electrical and optical properties, carbon nanotubes have been regarded as extremely promising candidates for high-performance electronic and optoelectronic applications. However effective and efficient distinction and separation of metallic and semiconducting single-walled carbon nanotubes are always challenges for their practical applications. In our experiment, horizontally-aligned and high-density SWCNT arrays synthesized via chemical vapor deposition (CVD) on a stable temperature-cut (ST-cut) quartz substrate were used. And we show that these metallic and semiconducting single-walled carbon nanotubes on SiO_2 can have obviously different contrast in scanning electron microscope, and thus can be effectively and efficiently identified. We have demonstrated that semiconducting and metallic single-walled carbon nanotubes on SiO_2, probably a variety of insulator substrates which were positively or negatively charging in low-voltage SEM, can have obviously different contrast in SEM, and thus can be effectively and efficiently identified. The correlation between conductivity and contrast difference has been confirmed by using voltage-contrast scanning electron microcopy, Peakforce Tunneling Atom Force Microscopy, and field effect transistor testing. This phenomenon can be understood via a proposed mechanism involving the e-beam induced surface potential of insulators and the conductivity difference between metallic and semiconducting SWCNTs. This method demonstrates great promise to achieve rapid and large-scale distinguishing between metallic and semiconducting single-walled carbon nanotubes, adding a new function to conventional SEM.