Local control of electric current driven shell etching of multiwalled carbon nanotubes

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Abstract: We report on a novel method for local control of shell engineering in multiwalled carbon nanotubes (MWNTs) using Joule-heating induced electric breakdown. By modulating the heat dissipation along a nanotube, we can confine its thinning and shell breakdown to occur within localized regions of peak temperatures, which are distributed over one-half of the NT length. The modulation is achieved by using suitably designed nanomachined heat sinks with different degrees of thermal coupling at different parts of a current-carrying nanotube. The location of electric breakdown occurs precisely at the regions of high temperatures predicted by the classical finite-element model of Joule heating in the MWNT. The experiments herein provide new insight into the electric breakdown mechanism and prove unambiguously that shell removal occurs due to thermal stress, underpinning the diffusive nature of MWNTs. The method demonstrated here has the potential to be a powerful tool in realizing MWNT bearings with complex architectures for use in integrated nanoelectromechanical systems (NEMS). In addition, the breakdown current and power in the nanotubes are significantly higher than those observed in nanotubes without heat removal via additional heat sinks. This indicates future avenues for enhancing the performance of MWNTs in electrical interconnect and nanoelectronic applications.