Field emission and strain engineering of electronic properties in boron nitride nanotubes

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Abstract
The electrical properties of boron nitride (BN) nanostructures, particularly BN nanotubes (NTs), have been studied less in comparison to the counterpart carbon nanotubes. The present work investigates the field emission (FE) behavior of BNNTs under multiple cycles of FE experiments and demonstrates a strain-engineering pathway to tune the electronic properties of BNNTs. The electrical probing of individual BNNTs were conducted inside a transmission electron microscope (TEM) using an in situ electrical holder capable of applying a bias voltage of up to 110 V. Our results indicate that in the first cycle a single BNNT can exhibit the current density of ~1 mA cm⁻² at 110 V and the turn-on voltage of 325 V μm⁻¹. However, field emission properties reduced considerably in subsequent cycles. Real-time imaging revealed the structural degradation of individual BNNTs during FE experiments. The electromechanical measurements show that the conductivity of BNNTs can be tuned by means of mechanical straining. The resistance of individual BNNTs reduced from 2000 to 769 MΩ and the carrier concentration increased from 0.35 × 10¹⁷ to 1.1 × 10¹⁷ cm⁻³ by straining the samples up to 2.5%.