Electronic Conduction Mechanisms in Y-Junction Carbon Nanotubes

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Nanoscale junctions create the intriguing possibility of forming active device elements whose characteristic length scale is determined solely by the intrinsic size of the junction region. A promising type of nanoscale junction which has been attracting increasing interest is the Y-branch or Y-junction structure, consisting of 3 intersecting low-dimensional electronic transport paths [1-3]. In particular, recent advances in controlled growth of carbon nanotubes (CNTs) have allowed individual, densely packed Y-junction CNTs to be fabricated in a well-ordered array via template growth (Fig. 1) [4]. Previous electronic transport measurements at room temperature showed the Y-junction nanotubes acted as nanoscale current rectifiers [5].

In this work we present a study aimed at elucidating the nature of rectification in the Y-junction CNTs and thereby gain insight into the mechanism of transport occurring in these nanostructures. Using temperature dependent transport data (Fig. 2) we examine the plausibility of different types of transport models including drift-diffusion, ballistic, and combinations thereof by considering the effect of structural asymmetry on electron transport through the Y-junction region. From these analyses it appears asymmetric conduction can arise merely from local symmetry breaking across the Y-junction. A thorough understanding of the Y-junction CNT electronic transport will help enable ongoing efforts to create novel 2- and 3-terminal devices for nanoelectronic switching and amplification based on the Y-geometry [6].

References

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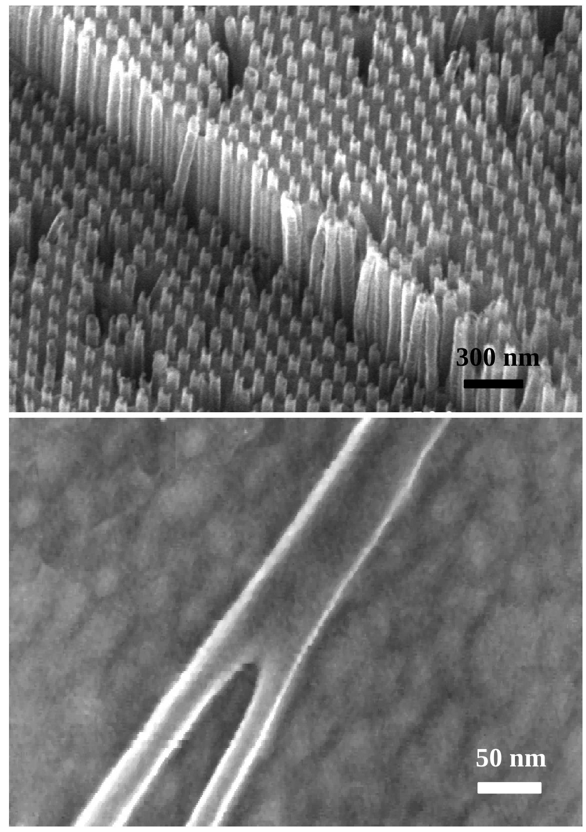


Fig. 1. Template grown Y-junction carbon nanotubes. Top figure shows SEM image of hexagonal array of exposed Y-junction ends embedded within an anodic alumina matrix. Bottom image is a close-up of the Y-junction branching region for a tube removed from the template.

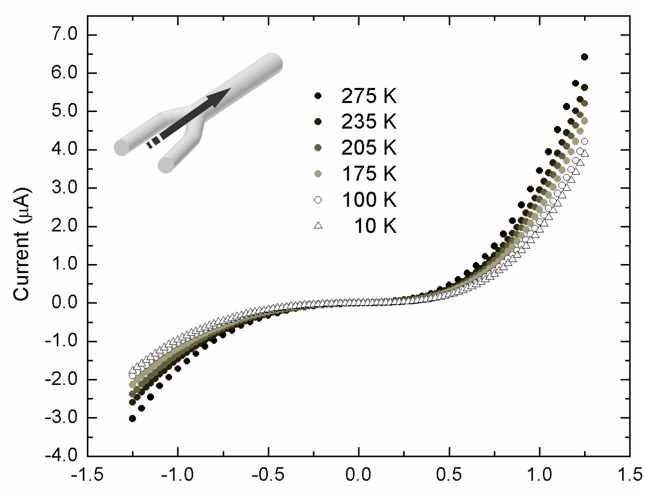


Fig. 2 Temperature dependent Y-junction CNT *I-V* curves displaying rectification down to low temperature with a strong suppression of current around zero-bias. The data shown corresponds to approximately 1000 junctions measured in parallel with a two-terminal configuration as shown in the inset.