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Conductance of Nanowires

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INTRODUCTION

This paper examines the conductivity of a variety of nanowires within the Landauer formalism by taking into account phonon quantization in finite-length nanotubes.

DISCUSSION

The elastic continuum model and dielectric continuum models have been applied to derive acoustic and optical phonon modes for both carbon nanotubes (CNTs) and solid-cylinder quantum wires fabricated of a variety of polar semiconductors. Phonon-confinement and geometrically-determined mode symmetries have taken into account to derive suitable phonon modes for such nanowires [1-4]. Using these confined and interface phonon modes, the Landauer formalism is used to evaluate the conductance of these nanowires in the presence of phonon scattering. For nanowires of finite length these results indicate the presence of phonon-bottleneck effects as a result of the phase space reductions of finite-length wires as compared with idealized nanowires of infinite length. Exemplary phase space reductions, leading to phonon bottleneck effects, in nanowires of finite length are shown Figure 1 and Figure 2 for a 7.0-nm-long (10,10) single-wall CNT clamped at the ends and 2 for a 16.0-nm-long (40,0) single-wall CNT clamped at the ends, respectively. Instead of a continuous wavevector down the axis of the nanowire, as is the case for a nanowire of infinite length, the wavevector is quantized as shown by the discrete normalized wavevectors depicted in Figures 1 and 2. For a variety of finite-length nanowires, such discrete phonon modes are used to demonstrate phonon bottleneck effects. In addition, these phase-space reductions are used in a Landauer formalism to evaluate conductance in finite-length nanotubes. These effects lead to conductivity enhancements as a result of the reduction in the number of scattering channels. These results provide insights into the observed quasi-ballistic transport in nanowires.

CONCLUSION

The condictivity of a variety of finite-length nanowires is modeled in this effort. Enhanced conductivity is attributed to discrete phonon modes that lead to phonon bottleneck effects associated with phase-space reductions for nanowires of finite length.

ACKNOWLEDGEMENT

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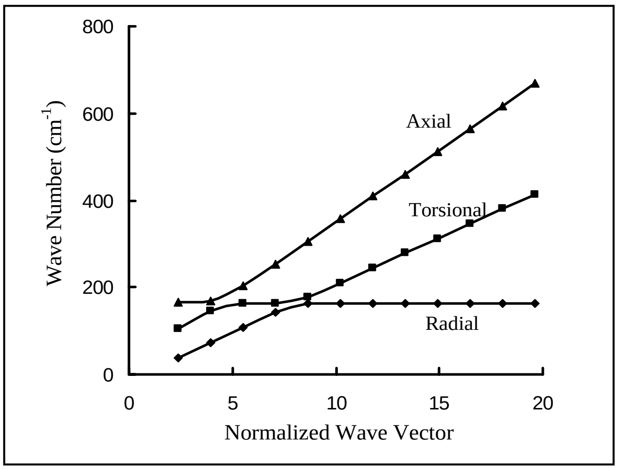

Fig. 1. Dispersion curves for (10,10) single-wall CNT with a length of 7 nanometers.

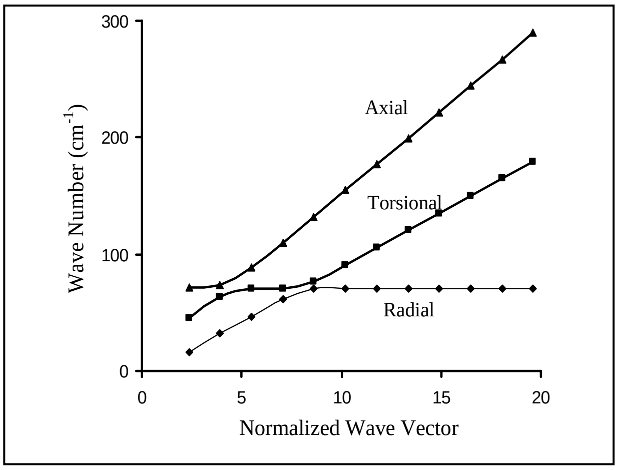

Fig. 2. Dispersion curves for (40,0) single-wall CNT with a length of 16 nanometers.