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Direct measurement of mean free paths in single-walled carbon nanotubes by Kelvin probe force microscopy ELLIOT J. FULLER, DENG PAN, BRAD L. CORSO, O. TOLGA GUL, PHILIP G. COLLINS, Dept. of Physics and Astronomy, University of California Irvine, Irvine, California 92697 — The inelastic mean free path λ of a conductor is determined by the scattering mechanisms relevant to its electronic resistance. The behavior of λ is of particular interest for single-walled carbon nanotubes (SWNTs) because they are quasi-one-dimensional conductors believed to have minimal acoustic phonon scattering. Previous measurements of λ used very long SWNTs contacted by large arrays of electrodes, but this is impractical for studying the device-to-device variability that results from SWNT chirality and environmental effects. Here, we use Kelvin probe force microscopy (KPFM) to directly measure potential gradients in biased SWNT field effect transistors with short channel lengths. The KPFM measurements directly determine λ as a function of bias in individual devices and can distinguish contact resistance and disorder from homogeneous inelastic scattering. At 185 K, we observe λ decreasing from nearly 1 μm at low bias to 150 nm at high bias. Fitting λ to established models determines the roles of surface plasmon-polariton scattering in one limit and optical phonon emission at the other. We find the optical phonon mean free path for spontaneous emission to be 40 to 60 nm at 300 K, significantly longer than observed in previous experimental studies. The results demonstrate KPFM as a powerful tool for studying SWNT physics and suggest usefulness for studying other nanoscale circuits.

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