Probing Optical Transitions in Individual Carbon Nanotubes using Polarized Photocurrent Spectroscopy

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Carbon nanotubes show vast potential to be used as building blocks for photodetection applications. Their direct band gap and high mobilities make them an attractive choice for near-infra red optoelectronic devices. However, measurements of fundamental optical properties, such as the absorption coefficient and the dielectric constant, has not been accurately performed on a single pristine carbon nanotube. Although optical absorption have been previously studied [1], quantitative measurements of the absorption coefficient for an individual carbon nanotube without environmental influence has not been reported.

In this work we show polarization dependent photocurrent spectroscopy from a single suspended semiconducting carbon nanotube p-n junction, bridging a 4 μm wide trench with two local gates. Using the polarization of the incident laser the E₁₁ and E₂₂ optical transitions could be probed for a polarization parallel to the nanotube axis and quenched for perpendicular polarization.

By studying the photocurrent spectroscopy on and off resonance with the van Hove singularities, we obtain a quantitative number for the quantum efficiency and attribute this to a lower limit for the absorption coefficient. Enhanced absorption on the carbon nanotube optical resonances gives an external quantum efficiency of 12.3 % and 8.7 % for the E₁₁ and E₂₂ transitions, respectively. In addition we obtain a value for the dielectric constant through measurements of the polarization dependent photocurrent. A dielectric constant of 3.6 ± 0.2 was experimentally determined for this semiconducting carbon nanotube [2].