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Exciton Spectroscopy and Absorption Cross-section of Individual Single-Walled Carbon Nanotubes

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Semiconducting Single-Walled Carbon Nanotubes (SWNTs) display intrinsic exciton luminescence which is highly sensitive to the nanotubes environment. For instance single-molecule chemical reactions with individual SWNTs could be observed through the stepwise changes of the luminescence intensity within submicrometer segments of single nanotubes. Analysis of the step amplitudes revealed an exciton diffusion range of $\sim$90 nm. Each exciton thus visits approximately 10^4 atomic sites during its lifetime, providing highly efficient sensing of local chemical and physical perturbations [1]. SWNT luminescence decays are also sensitive to extrinsic factors. Using highly luminescent individual (6,5) SWNTs, time-resolved spectroscopy revealed however systematic biexponential luminescence decays, with short and long lifetimes around 45 and 250 ps. This intrinsic behavior is attributed to the band-edge exciton fine structure with a dark level lying a few meV below a bright one. Combining such time-resolved studies with cw luminescence ones, the absorption cross-section of individual SWNTs was determined. A mean value of $\sim 1.10^{-17}$ cm^2 per carbon atom is obtained for (6, 5) tubes excited at their second optical transition [2]. This was further corroborated by independent photothermal heterodyne measurements. Because this highly sensitive method relies only on light absorption, it readily detects metallic nanotubes as well as the emissive semiconducting species in various environments and allowed recording for the first time images and absorption spectra of individual SWNTs of both types [3].

[1] Cognet et al *Science* **316**, 1465 (2007)
[2] Berciaud et al *Phys.Rev.Lett.* **101**, 077402 (2008)
[3] Berciaud et al *Nanoletters* **7**, 1203 (2007)