Carrier photogeneration and trion observation in single-walled carbon nanotubes

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It is now well established that the optical properties of single walled carbon nanotubes (SWNTs) are dominated by tightly bound one-dimensional excitons [1-2]. Enhanced coulomb interaction and reduced dielectric screening give rise to considerable exciton binding energies, as high as 700 meV.nm for freestanding semiconducting SWNTs (S-SWNT) [3], a value that is of the same order of magnitude as the single-particle bandgap.

Under sufficiently strong cw or pulsed excitation, two or more excitons are likely to coexist within the same SWNT. Multiexcitonic effects can take place for high exciton density and lead to the formation of multi-particle bound states such as bi-excitons or charged excitons. On the one hand, two or more excitons can undergo Auger processes giving rise to a strong exciton-exciton annihilation (EEA) process.

By means of pump-probe experiments, we have observed new spectral features, below the main exciton lines of high quality undoped SWNTs, and studied their dynamics. Supported by micro-luminescence measurements, our time-resolved data suggest that free charges are photogenerated through exciton-exciton collisions and further trapped at local quenching sites. Involving these photocreated long-lived charges, localized trions can then form after absorption of a further photon. Our results [5] are consistent with a recent work by Matsunaga et al.[4], who reported similar spectral features in intentionally p-doped nanotube suspensions, which were assigned to localized hole-exciton bound states. In contrast to this irreversible process, we show here that trions can be reversibly created by light in undoped carbon nanotubes.

Références

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