Photoluminescence blinking and spectral diffusion of an individual single-walled carbon nanotube

Kazunari Matsuda, Tadashi Inoue, Yoichi Murakami,
Shigeo Maruyama, and Yoshihiko Kanemitsu

The optical properties of single-walled carbon nanotubes (SWNTs) with an ideal 1-dimensional (1D) structure have attracted much attention, because the 1D exciton plays an important role in SWNTs. The photoluminescence (PL) spectroscopy is one of the most useful tools to study the optical properties of SWNTs including characteristics of the 1D exciton. However, the macroscopic PL spectra reflect ensemble average of signals from a lot of SWNTs and this causes an inhomogeneous broadening in the PL spectra. The spectroscopic observation of a single SWNT is needed to reveal fine spectral structures [1]. In this work, we report optical properties and characteristics of the exciton of SWNTs through spectral diffusion (PL blinking) by means of individual SWNT spectroscopy.

We have successfully observed the PL signal of a single SWNT from 20 to 300 K. The PL spectrum of a single SWNT shows a single peak with approximately Lorentzian lineshape and the PL linewidths vary from 7 to 14 meV depending on the nanotube diameter at room temperature [2]. The PL linewidth of a single SWNT becomes narrow with a decrease of temperature and reaches to less than 1.5 meV at 20 K. At low temperatures, the unusual behavior of the PL intensity and energy position fluctuation is observed on the order of several seconds under cw laser excitation condition. These phenomena are attributed to the PL blinking and spectral diffusion in a single SWNT. The PL blinking and spectral diffusion originate from trapped charges in localized states. The charges build a strong and local electric field to the SWNT, which might induce the quantum confined Stark shift of the exciton in the SWNT. From the statistical analysis of the PL intensity and energy position fluctuation, the dynamics and detail mechanism of the PL blinking and spectral diffusion will be discussed.

[1] K. Matsuda, Y. Kanemitsu, K. Irie, T. Saiki, T. Someya, Y. Miyauchi, and S. Maruyama, Appl. Phys. Lett. **86,** 123116 (2005).
[2] T. Inoue, K. Matsuda, Y. Murakami, S. Maruyama, and Y. Kanemitsu, submitted.