Photoluminescence mapping of various \((n, m)\) nanotubes by cross-polarized light

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Photoluminescence excitation (PLE) spectroscopy of single-walled carbon nanotubes (SWNTs) have been extensively studied for characterization of their unique electronic properties due to the one-dimensionality. Theoretical studies and recent experiments have demonstrated that these optical transitions in SWNTs are dominated by strongly correlated electron-hole states in the form of excitons. Major peaks in a PL map correspond to the excitation transition energy of the second subband \((E_{22})\) and the photon emission energy of the first subband \((E_{11})\) of a specific SWNT, and these peaks are assigned to particular \((n, m)\) nanotube species [1]. On the other hand, we can also find lower-intensity features around main PL peaks in a PLE spectrum. Recently, we have clearly identified that some of these features are phonon sideband peaks by measuring isotopic shift in PLE measurement using SWNTs consisting of carbon-13 [2]. In addition to the direct experimental proof of the strong exciton-phonon interaction [3], we also found low-intensity ‘pure electronic’ features whose origin has never been elucidated [2]. To investigate the origin of these unassigned ‘pure electronic’ peaks, we have performed polarized-PLE spectroscopy on independently aligned SWNTs in a gelatin thin film, and some unassigned PL peaks of \((7, 5)\) nanotubes were attributed to excitation by cross-polarized light to the nanotube axis [4].

In this report, we have studied polarized PLE spectra of various \((n, m)\) nanotubes. Fig. 1 shows PL peaks attributed to excitation by cross-polarized light. Detailed experimental techniques for identification will be discussed. Obtained experimental Kataura plot for cross-polarized light will be compared with tight-binding calculation of SWNTs considering geometry optimization and curvature effect [5].


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Fig. 1 Polarized PL map of dispersed SWNTs in surfactant solution. Peaks indicated by circles were attributed to excitation by cross-polarized light. Configuration of polarizations was for enhanced cross-polarized absorption.