Excitonic effects and chirality dependence of photoluminescence intensity of single wall carbon nanotubes

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Photoluminescence (PL) has been widely used for the optical characterization of semiconducting single wall carbon nanotubes (SWNTs) because the PL intensity and PL energy depend on the diameter and chirality of SWNTs [1,2]. The optical absorption and emission energies of the PL of SWNTs, which are corresponding to the PL peak positions, are also known the exciton energies. Experiments and theoretical studies have been demonstrated that the excitonic effect in the presence of electron-hole and electron-electron interaction and the screening from the environment occurs to the change of the PL intensity and the energy shift of the PL peak position [3,4]. In the previous theoretical work [2], the chirality dependence of the PL intensity was calculated by multiplying the photon absorption, relaxation and photon emission matrix elements in the frame work of the tight-biding scheme in the one-electron picture. To consider the excitonic effect in the PL, we need to consider and calculate the PL intensity in the exciton picture.

In this paper we will discuss that the excitonic effect of the PL intensity and the dependence of the PL intensity on the diameter and chirality. The PL intensity is considered from the photon absorption, relaxation and photon emission in the exciton picture. Here we use the exciton-phonon and exciton-photon matrix elements in the framework of the tight-binding scheme [5]. The exciton energy dispersion of SWNTs in order to calculate the PL intensity is calculated by solving the Bethe-Salpeter equation in which the one particle energies are given by the tight-binding method [3,6]. Here the screening from environment and nanotubes itself is expressed by the dielectric constant. The relation between the exciton energy and dielectric constant is also discussed. We compare our calculation results with the experimental results.

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