Dielectric screening effects on photoluminescence of carbon nanotubes on hexagonal boron nitride

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Hexagonal boron nitride (*h*-BN), a two-dimensional (2D) material, is atomically flat with low defect density, which is widely used to support other 2D materials for both electronics and photonics.[1,2] We expect that the advantages of *h*-BN can also be utilized in mixed dimensional heterostructures, and single-walled carbon nanotubes (CNTs) would provide a unique opportunity in this context. The one-dimensional nature of CNTs results in enhanced Coulomb interactions, giving rise to tightly bound excitons that show photoluminescence (PL) at room temperature. CNTs directly attached on solid-state substrates such as SiO_2/Si, however, suffers from the strong substrate quenching effect, hindering applications in all-solid-state optical devices.[3] By using *h*-BN as a substrate, the quenching effect is expected to be suppressed. Moreover, excitons in CNTs are sensitive to the dielectric environment, and intimate contact with the 2D *h*-BN substrate could result in large modifications in excitonic energies.

Here, we study *h*-BN effects on PL excitation (PLE) spectra of CNTs by transferring *h*-BN flakes over air-suspended CNTs grown over trenches on SiO_2/Si substrates.[4] Figure 1 shows PLE maps of a suspended CNT before and after the *h*-BN transfer with the excitation power fixed at 10 μW. Before the *h*-BN transfer, the values for the E_{11} and E_{22} are consistent with those for a (10,8) air-suspended nanotube. After the *h*-BN transfer, the PL intensity is decreased to approximately half of the initial value. This PL reduction caused by the *h*-BN flake is much weaker than that in the conventional SiO_2/Si substrates. The linewidth for the E_{11} emission peak is slightly increased from 7.9 meV to 8.0 meV with just 0.1 meV difference, and the average broadening in the measured 20 tubes is less than 2 meV. We also observe redshifts in both E_{11} and E_{22} of 27 and 17 meV, respectively. Although the shift values show tube-to-tube variations, all the CNTs show redshifts for both E_{11} and E_{22}, which is consistent with the dielectric screening effect from *h*-BN flakes.

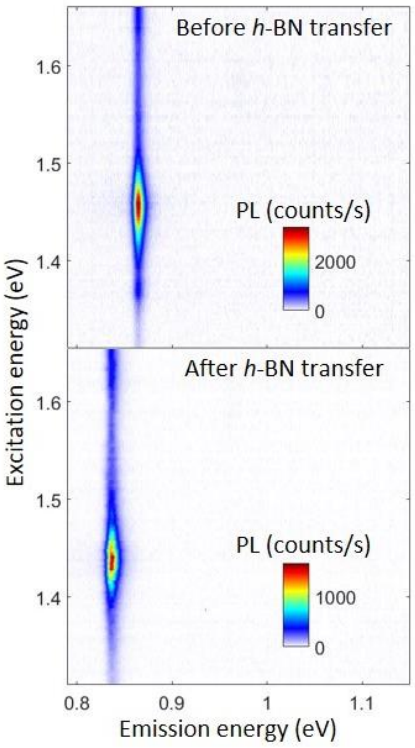

Figure 1 PLE maps of an air-suspended CNT before and after the *h*-BN transfer.

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