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Hallmarks of the mechanical coupling to the substrate in the photoluminescence spectrum of carbon nanotubes.

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The coupling between a localized emitter and acoustic phonons gives rise to characteristic signatures in the PL spectra of nanostructures, known as Huang-Rhys side bands. Such spectra consist of a narrow central line -the so-called zero-phonon line (ZPL)- and of weak temperature-dependent side bands corresponding to the simultaneous emission of a photon and a phonon. In the case of carbon nanotubes the one dimensional nature of the phonon bath leads to a drastic enhancement of this coupling for low energy phonons, which results in a full merging of the ZPL line into the phonon wing [1]. Therefore, typical low temperature PL spectra show a broad (5-10 meV) and asymmetric line-shape. This property may be seen as particularly detrimental for photonic applications since it intrinsically limits the ultimate coherence length of the PL line.

We show that this limitation can be bypassed when the vibrational properties of the nanotube are slightly modified by achieving a weak coupling to the substrate. In this case, a bright and narrow (down to ~ 500 μeV) ZPL is retrieved. We present low-temperature PL spectra of a large set of CoMoCat nanotubes and show that many of the “exotic” PL spectra, including multi-peak spectra, are perfectly reproduced by this model when considering the different possible relative positions of the exciton and of the mechanical contact(s) [2].

[1] C. Galland et al., Phys. Rev. Lett. 101, 067402 (2008)
[2] F. Vialla et al. (submitted)