Vertically coupled indirect excitons in a double bilayer structure

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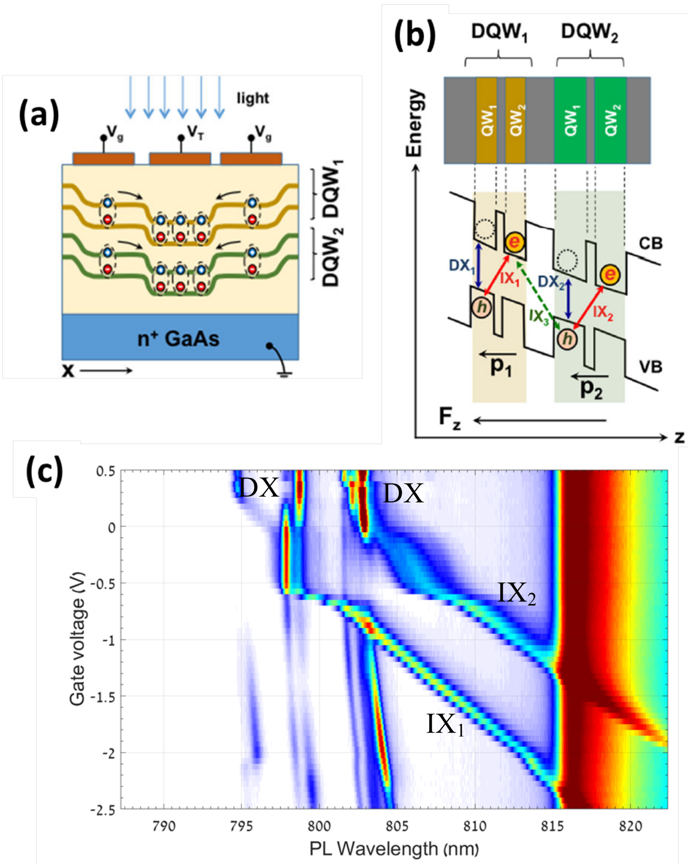
Abstract

We propose and study a *double bilayer* structure composed of two *vertically stacked* double quantum wells (DQWs), separated by a small vertical distance. Such a proximity results in an attractive part for the dipole-dipole interaction between the dipolar excitons formed in each of the bilayers. These attractive interactions open new possibilities, such as observing the formation of dipolar molecules composed of bound pairs of excitons from the two vertically coupled DQWs, transitions between "atoms" (single dipolar excitons) and molecules as the density in each well is modified, as well as dipolar drag between excitons in the two coupled layers and.

Here we demonstrate for the first time an experimental realization of such a system. By making the DQWs of different widths we can resonantly excite them, thus independently controlling the density of dipolar excitons in each bilayer with respect to the other. Spectroscopy enables us to differentiate between the bilayers, as each dipolar exciton has its own energy. We show that with two synchronized lasers, each resonant with a direct exciton transition in a corresponding layer, we can accurately control and probe the dipolar excitons densities in the two DQWs separately. Different time sequences of the pulses of the two lasers allow performing experiments that can probe the expected complex inter-layer dynamics.



(a) An illustration of a sample containing two DQWs, vertically separated by a small distance. Dipolar excitons can be excited using laser light, and trapped by applying a gate voltage. (b) Energy bands diagram of the same structure, showing the possible direct (DX) and indirect (IX) optical transitions and the two dipoles p_1, p_2 formed in each bilayer. These dipoles can interact under certain conditions and bind together to form a dipolar molecule. (c) Experimental results showing the photoluminescence wavelength under non-resonant excitation as we change the gate voltage. The two distinct diagonal lines are the stark-shifted indirect excitons from each of the DQWs.