Estimation of the Lateral Dimensions of Epitaxial CdSe/ZnSe Fractional Monolayer Quantum Dots

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CdSe fractional monolayer quantum dots (FMQDs) are formed by the epitaxial deposit of a submonolayer (coverage $\Theta < 1$), they present 3D confinement and their emission is in the blue spectral range. The photoluminescence (PL) spectra of these FMQDs present excitonic features that need a clear explanation [1, 2]. Their structural properties are not well known; its characterization by transmission electron microscopy, to determine their lateral dimensions, represents a great experimental challenge, due to their ultra-thin thickness of just one monolayer (ML) and the relatively low contrast between ZnSe and CdSe. Therefore, it is very important to use indirect methods that allow estimating the lateral sizes and density of these FMQDs.

In this work, we present the PL characterization and theoretical modeling of CdSe/ZnSe FMQDs with a nominal coverage of ~0.5 ML. The quantum dots were grown by atomic layer epitaxy within a ZnSe matrix grown by molecular beam epitaxy on a GaAs (001) substrate at ~275 °C growth temperature. The low temperature (19 K) PL spectra show an intense excitonic emission which typically consists in a double peak in the 2.752 to 2.760 eV energy range, with narrow full widths at half maximum, as shown in Figure 1. The excitonic spectra suggest small distributions in form, size, and composition of the CdSe/ZnSe FMQDs. To model the FMQDs we employed the factorized envelope approximation [3]. For simplicity, we considered that the FMQDs have a rectangular shape with L_x and L_y of similar sizes due to the C_4 symmetry of the (001) substrate surface. The calculations indicate that the excitonic emission can be correlated to lateral dimensions in the 4 to 5 nm range, see Figure 2, which result in a FMQDs density of $\sim 3 \times 10^{12}$ cm^{-2} for a CdSe coverage of ~ 0.5 ML.

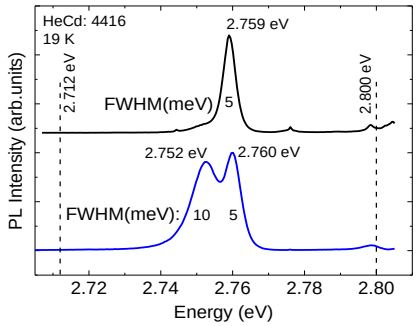

Figure 1. Low temperature excitonic emission of two samples with FMQDs.

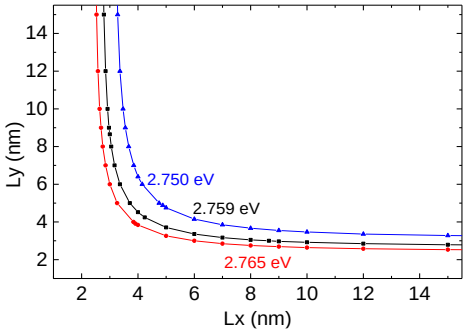

Figure 2. Excitonic emission around 2.759 eV as a function of the lateral dimensions of the FMQDs.

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