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Quantum Wells in $Zn_{1-X}Cd_XSe$ by High Resolution Electron Microscopy.

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Quantum wells of the ternary semiconductor alloy $Zn_{1-x}Cd_xSe$ (QWs), with $x \leq 0.3$, have been employed in the elaboration of blue-green lasers. The excitonic emission of pseudomorphic CdSe/ZnSe ultra-thin quantum wells (UTQWs) with thickness in the 1 to 4 monolayer (ML) range can be tuned from the yellow-green to the blue spectral range [1]. Thus they are very attractive systems to be employed in the fabrication of LEDs and lasers. When dealing with binary compounds 1 ML is the thickness of a cation-anion layer, it is given by a/2, where a is the lattice constant of the fcc lattice characteristic of zinc blende compounds. Above 4 ML thickness the accumulated strain energy of the CdSe films is relaxed through the generation of misfit dislocations and extended defects and the QW presents a broad and very weak emission that is not appropriate for light emitting devices [1]. However QWs with thicknesses between 1 and 3 ML are growth normally fully strained (*a* is 0.567 and 0.608 nm for ZnSe and CdSe, respectively). The knowledge of their structure and composition is of prime importance, so far these QWs have been successfully characterized by non-localized techniques such as photoluminescence. The excitonic spectra indicate the absence of thickness fluctuations in the whole sample.
In this paper, QWs with different thickness are characterized by high resolution electron microscopy techniques, including TEM and STEM modes. Figure 1 shows STEM images in bright and medium annular dark field of a QW nominally made of 1 ML. The contrast indicates a higher thickness but homogeneous along the sample. The image contrast decreases considerably when a higher angle is used. Figure 2 shows an amplitude image obtained after following a procedure for exit wave reconstruction with a focal image series in TEM. The QW thickness is nominally 1 ML. TEM contrast is strongly affected by strain and the image in Fig 2 is unfiltered showing a QW thickness greater than expected and homogeneous along the sample but with spatial irregularities (see arrows). Fig. 2b shows a magnified section of the amplitude image after coloring to increase the contrast and Fig 2c shows an intensity profile across the QW. This shows the variation of lattice parameter as a result of the QW larger *a*. A clearly larger parameter is measured on the CdSe QW as compared to the structure of ZnSe. The width of the rectangle in Fig. 2b represents the lattice distance on the QW, it is larger that the peak to peak distance in the ZnSe structure. Such a difference is measured for two to three ML producing and explaining the contrast image in TEM. Thus it is likely that the QW thickness is actually 1 ML and that the observed contrast is due to the influence of strain in TEM images. A similar conclusion is likely for STEM images under MAADF conditions. Image simulation in both conditions is necessary to support these observations and it is currently in preparation.

References

[1] I. Hernandez-Calderon, Advanced Summer School in Physics 2005, Am. Inst. Physics. CP809 (2006) 343. I. Hernandez-Calderon *et al*., Phys. Status Solidi (b) **24**, 558 (2004).
[2] Financial support from IPN (COFAA-SIP) and CONACYT (Grant 58133) are gratefully acknowledged. DAAD (Germany) and ER Center (FZJ-Jülich) are acknowledged for a research grant and the use Titan microscopes, respectively. JEOL Co. Japan is acknowledged for the use of an ARM microscope and NCEM-LBNL for the use of the TEAM05 microscope.

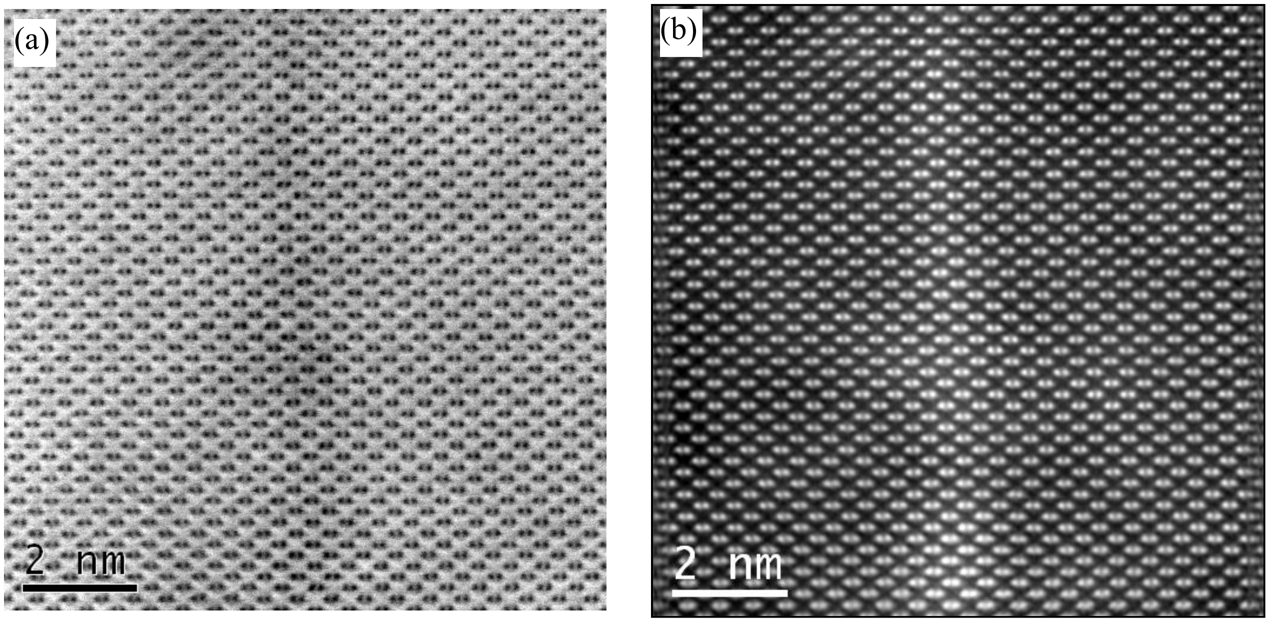

Figure 1. STEM images of a CdSe Quantum well in ZnSe. (a) Bright field. (b) Medium angle dark field.

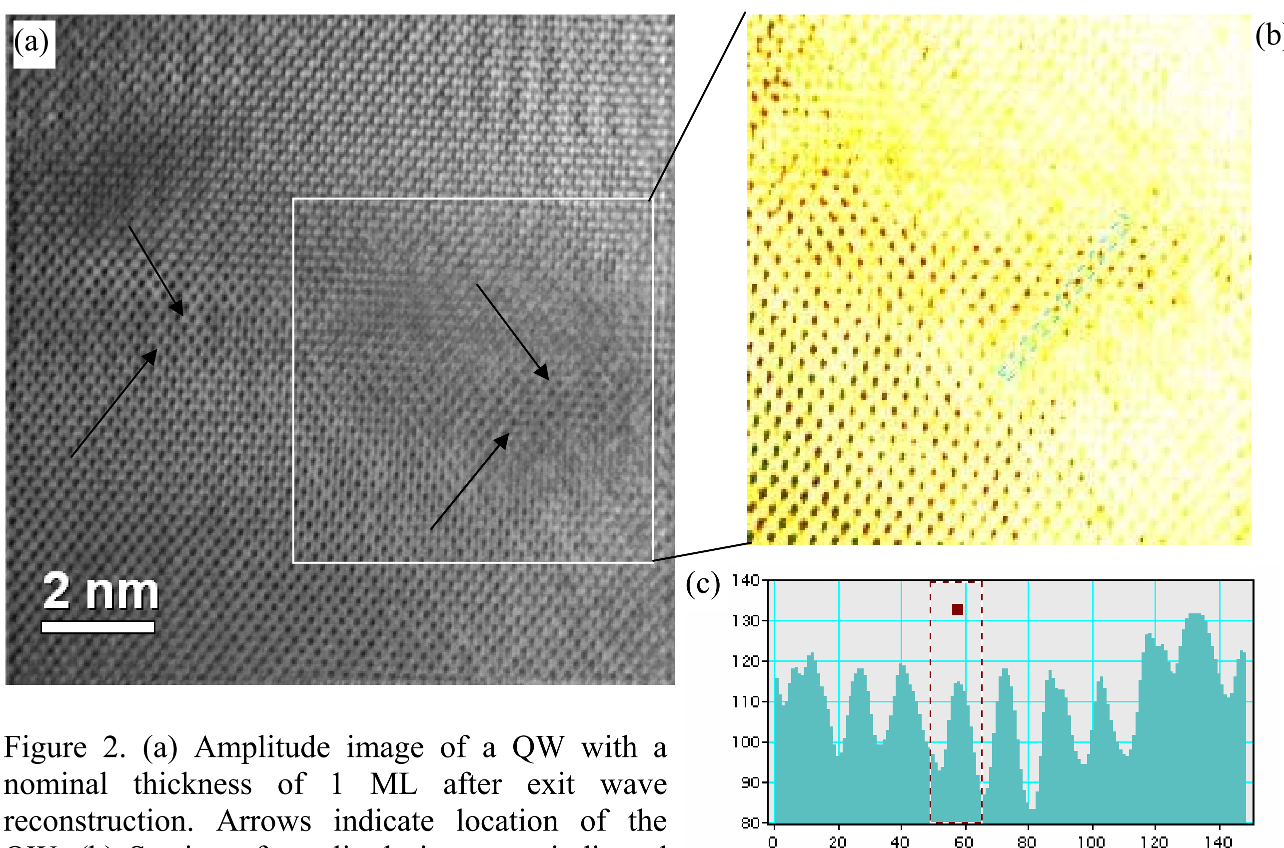

Figure 2. (a) Amplitude image of a QW with a nominal thickness of 1 ML after exit wave reconstruction. Arrows indicate location of the QW. (b) Section of amplitude image as indicated by parallelogram in (a), different colors have been used. (c) Intensity profile from rectangle in (b) showing variation of lattice dimensions.

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