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Quantum wells in the ternary system $Zn_{1-X}Cd_XSe$ by high resolution 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. On the other hand, 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] and appear as 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].

Transmission electron microcopy is used to characterize diverse samples in these systems, both transmission and scanning transmission are used in high resolution modes. Results of two samples are shown here. The crystallographic structure is similar in ZnSe and CdSe as shown in Fig. 1, however the specific atomic distribution makes the zone axis parallel to [101] particularly attractive to image these QWs. High resolution shows dumbbells in this orientation with intensities that depend on composition giving an inverse intensity relationship when Zn is substituted by Cd or viceversa, see arrows. Fig. 2 shows images of the three QWs in a sample with three 15 ML QWs, both in low and high resolution in Cs corrected STEM mode. The dumbbells are clearly seen in Fig. 2b as well as the distinctive Z contrast. The width of the quantum wells is around 3 nm as expected from the unit cell dimensions. Figure 3 shows results obtained in an image Cs corrected microscope for a sample with thirty 3 ML QWs. Some of these QWs in low and high resolution are shown in Figs. 3a-c. Additionally to the dumbbell configuration, strain contrast is also depicted, as expected. The QW becomes more difficult to image as the magnification is increased. Additionally to single images, focal series have also been recorded and will be described in the presentation. Fig. 3d shows a phase image after reconstruction with TrueImage (FEI ®). The intensity asymmetry within the dumbbell in the QW as a function of composition is indicated in the intensity profile shown in Fig 3e (see arrows). In these samples a strong strain contrast is normally found together with generation of dislocations that release partially some of the strain produced by the lattice misfit between CdSe and ZnSe. These defects have also been imaged in the [101] orientation axis in TEM-HREM.

References

[1] I. Hernandez-Calderon, Advanced Summer School in Physics 2005, Am. Inst. Physics. CP809 (2006) 343.

[2] Financial support from IPN (COFAA-SIP) and CONACYT (Grants 45887 and 50133) are gratefully acknowledged. INMETRO (Brazil) and FEI (The Netherlands) are acknowledged for allowing the use of Cs probe and Cs image corrected Titan microscopes, respectively.

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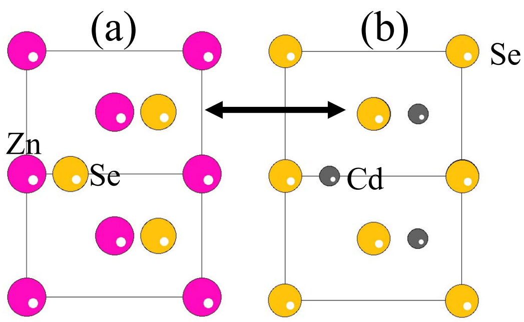


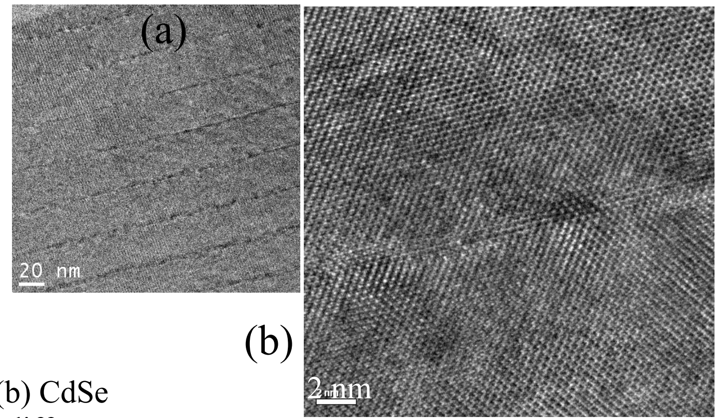
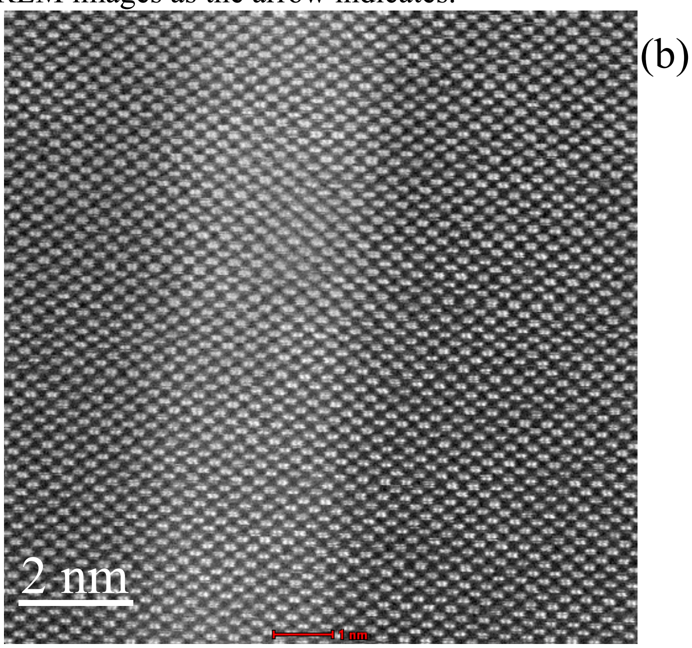
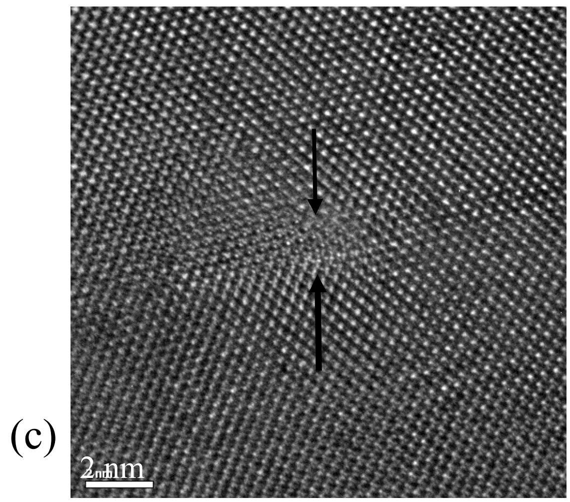
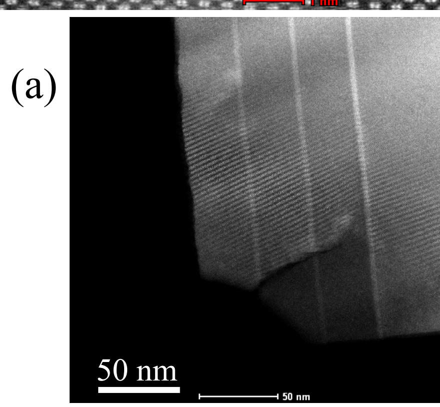


Fig. 1 Structural projections of (a) ZnSe and (b) CdSe along [101]. The dumbbell formation and the different scattering factors produce an intensity reversal in HREM images as the arrow indicates.







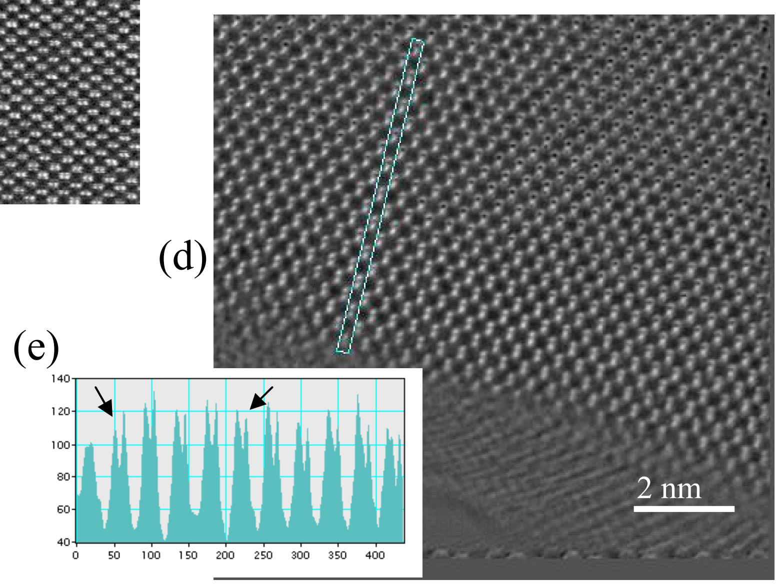


Fig. 2. Sample containing 15 monolayer QWs, STEM images in a probe Cs corrected microscope (a) Low resolution, (b) High resolution Z contrast image.

Fig. 3. Sample with 3 ML QWs, (a)TEM, (low resolution), b-c high resolution in a Cs image corrected microscope. (d) Phase image (e) Intensity profile from area in d.

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