Interface Modification in Type-II ZnCdSe/Zn(Cd)Te QDs

V.Deligiannakis[1,3+], S. Dhomkar[1], M. S. Claro[1], I. L. Kuskovsky[2,3], M. C. Tamargo[1,3]

[1] City College of CUNY, New York, New York 10031, USA
[2] Queens College of CUNY, Flushing, New York 11367, USA
[3] The Graduate Center of the City University of New York, New York, New York 10016, USA

Intermediate band solar cells (IBSCs) have been proposed as a possible solution to overcoming the Shockley-Queisser limit [1] for solar cell quantum efficiencies. In these, a mid-gap energy band is formed, for instance, by quantum dots within a large bandgap semiconductor matrix. Type-II ZnCdSe/Zn(Cd)Te submonolayer (QDs) have been explored by our group for their promising properties as IBSCs [2, 3]. The ZnCdSe host material when latticed matched to InP has an energy bandgap of ~ 2.1 eV in which the Zn(Cd)Te QDs can form an intermediate band with an energy between 0.5 - 0.7 eV [3]. The similarity of these parameters with those required for an optimal IBSC makes this material system an outstanding candidate. However, challenges arise during the growth of these materials due to the lack of a common anion, resulting in formation of an unintentional ZnSe interfacial layer (IL) between the ZnCdSe spacer and the QDs, causing high tensile strain in the structure. Here we report the results of several modified growth sequences that modify and suppress the IL, allowing for the host material and QDs to be both simultaneously lattice matched.

Samples were grown by a combination of MBE and migration enhanced epitaxy (MEE) in which sub-monolayer dot formation was achieved by exposure of the sample surface to alternating Zn, Cd and Te fluxes. By incorporating a modified shutter sequence (Fig 1b inset) with a Cd-only exposure between the growth of the spacer layer and the MEE cycles, significant suppression of the ZnSe tensile layer was achieved. The HR-XRD (Fig 1a) of two samples with different shutter sequences shows that the sample with the modified shutter sequence (sample A) has nearly lattice matched ZnCdSe spacers, as well as the zero-order peak of the QD superlattice [SL(0)], while the previously adopted shutter sequence required a strain compensated ZnCdSe spacer (sample B). The type II nature of the band structure for sample A is confirmed by the intensity dependent blue shift of the PL peak (Fig 1b). Further adjustments to the band structure were obtained by modifying the QD composition.

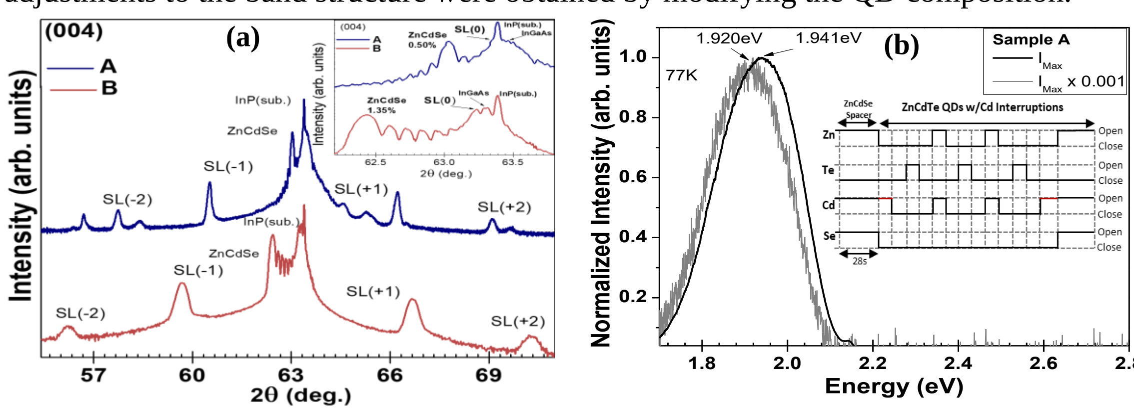

Fig. 1(a) HR-XRD for samples A and B, grown with two different shutter sequences. In sample A nearly lattice matched ZnCdSe spacers and SL(0) peaks were obtained **(b)** low temperature PL for samples A confirming type II behavior **(inset)** shutter sequence used in the growth of sample A.

[1]A. Luque and A. Marti, Phys. *Rev. Lett.*, **78,** 5014 - 5017 (1997).
[2]S.Dhomkar, et al. *Solar Energy Materials and Solar Cells,* 117, 604 (2013)
[3] M. Imperato, e al. *Journal of Electronic Materials* (2018). 10.1007/s11664-018-6241-6
+Author for correspondence: vdeligia@gmail.com