Optimized material for intermediate band solar cells: type-II CdTe quantum dots in a ZnCdSe matrix

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Intermediate band solar cells (IBSCs) based on quantum dots (QDs) have the potential to overcome the Schockly-Quisser limit for single junction soar cells. By forming an intermediate band (IB) within a host material with a larger band gap, QDs can ultimately increase light absorption of the solar spectrum without compromising the open circuit voltage of the device. This is achieved by a two-step photon process that occurs from the valence band (VB) to the IB and from IB to the conduction band (CB), while the conventional band to band transitions from the VB to CB of the host material is still allowed.

Type-II ZnCdSe/Zn(Cd)Te submonolayer QDs have been explored by our group for their promising properties as IBSCs. However, it was recently shown that at the interface between the ZnCdSe host material and the QDs an unintentional highly strained interfacial layer (IF) is formed comprised of ZnSe[1]. The presence of this layer can affect the band structure of the device and result in accumulation of strain, which can lead to the formation of defects, reducing the device performance. Here we pursue a new material system: sub-monolayer CdTe QDs embedded in the ZnCdSe host material. Besides providing a platform in which the ZnSe IF layer is highly suppressed, this system has several advantages over the ZnCdTe QD system previously studied. Two main advantages are: 1) the binary composition of the QDs which makes them more easily controlled and more uniform, and 2) its larger valence band offset with the matrix material (ZnCdSe) which allows for better device bandstructure engineering.

The ZnCdSe/CdTe QD superlattice (SL) is grown by a combination of conventional molecular beam epitaxy (MBE) and migration enhanced epitaxy (MEE). A spacer region of ~3nm was grown made of ZnCdSe nearly lattice matched to InP. The formation of CdTe QDs was achieved by using a shutter sequence of alternating Cd and Te fluxes with short wait times between them. A triple cycle of this alternating shutter sequence was used, and the spacer and QD layers were repeated 100 times. High resolution XRD data illustrates the high quality of the IB absorption material and shows that the superlattice (SL) structure is under high compressive strain due to the CdTe QDs and indicates no evidence of a ZnSe IF layer. Calculations indicate that only submonlayer quantities of CdTe are required for the observed SL mismatch. Both IB absorption layers and full solar cell device structures will be discussed.

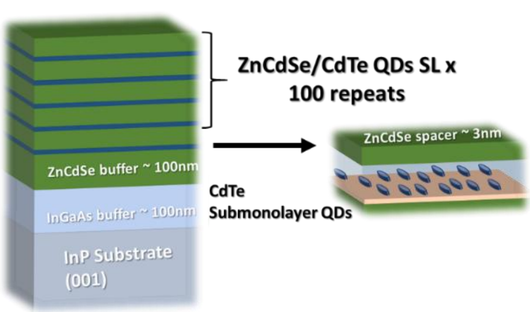

Figure1. Schematic of IB material studied.

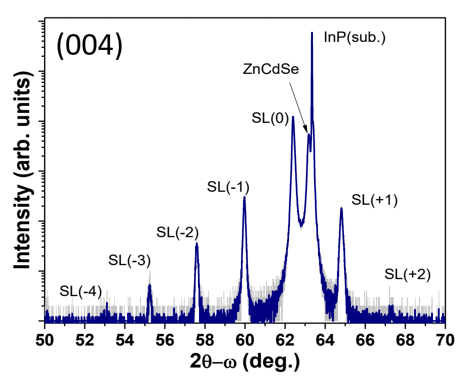

Figure 2. HR-XRD (004) symmetric scan of ZnCdSe/CdTe SL.

[1] V. Deligiannakis, et al. *J. of Crystal Growth*, Vol.12, 15 April 2019, 203-207

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