**Area: 6** Advanced Concepts and New Emerging Materials for Future PV

# EFFICIENT TWO-STEP PHOTOCURRENT IN INTERMEDIATE BAND SOLAR CELLS USING HIGHLY HOMOGENEOUS INAS/GAAS QUANTUM-DOT SUPERLATTICE

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Quantum-dot intermediate-band solar-cells (QD-IBSCs) have attracted strong attention, because an extremely high conversion efficiency above 60 % is expected [1]. Such high conversion efficiency can be achieved by two-step photon absorption (TSPA) via the intermediate states of QDs designed in the bandgap of the host semiconductor. However, carrier recombination in QDs suppresses TSPA and reduces the conversion efficiency. We have succeeded in fabricating QD superlattice (QDSL) structures comprises closely stacked InAs/GaAs QDs with a thin spacer layer[2, 3]. Recently, we demonstrated that photoexcited electron and hole are spatially separated in the QDSL minibands and suppress their recombination [2]. Thus, the stronger electronic coupling of closely stacked QDs improves the TSPA efficiency. In this work, we investigated enhanced TSPA of QDSL-IBSCs with improving the homogeneity of the QDSL energy states.

Two kinds of QDSL-IBSCs including 9-stacked InAs/GaAs QDs were fabricated by molecular beam epitaxy. The first InAs QD layer was deposited at 480 °C. Then, the following GaAs spacer layers and InAs QD layers were deposited at 430 °C or 480 °C. External quantum efficiency (EQE) measurements were performed at 10 K under an additional infrared light (1550 nm) irradiation. The difference between the photocurrent with and without IR-irradiation was normalized by the incident photon number, which is defined as ΔEQE. The ΔEQE and photoluminescence (PL) spectra for (a) 430 °C-cap and (b) 480 °C-cap QDSL-IBSCs are shown in Fig 1. The absorption edge indicated by an arrow in the ΔEQE spectrum for the 430 °C-cap coincides with the fundamental-state emission wavelength. This suggests that the second excitation from the IB to the conduction band is enhanced by carrier separation in the QDSL miniband of the fundamental state. Conversely, the edge in the ΔEQE spectra for the 480 °C-cap appears at the excited-state emission wavelength, as the fundamental state does not form the miniband owing to a relatively large inhomogeneity. Moreover, the fundamental state of QDSLs at 430 °C redshifts as compared with that at 480 °C. Thus, the TSPA response wavelength region succeeded in extending drastically with forming QDSLs operating at the longer wavelength side.

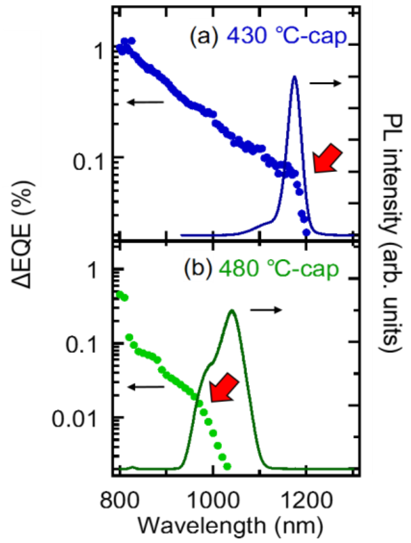

Figure 1: ΔEQE and PL spectra of (a) the 430 °C-cap and (b) the 480 °C-cap QDSL-IBSC.

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