Quantum dot solar cells (QDSCs) have been studied extensively to increase power conversion efficiency [1]. In development of intermediate-band QDSCs with high performance, ultrahigh-density QDs must be prepared, and effective photo-excitation and transport of carriers must be derived in the pin-junction [2]. Recently, we demonstrated highly dense InAs QDs with $0.5 \times 1.0 \times 10^{12} \text{cm}^{-2}$ by Sb-mediated growth [3,4]. In this conference, we will present a fabrication of ultrahigh density InAs QDs on GaAsSb/GaAs(001), which has a type-II heterointerface. From their photoluminescence (PL) and solar cell properties, we will discuss the carrier dynamics in this type-II structure.

Figure 1 shows a sample structure and an AFM image of highly dense InAs QDs on GaAsSb/GaAs buffer layer, which were grown through a Stranski-Krastanov mode by MBE. The QD density was $5 \times 10^{11} \text{cm}^{-2}$. The segregated Sb atoms from the GaAsSb buffer layer enhanced the 3-dimensional InAs nucleation and suppressed the formation of giant dots due to the coalescence. Since the separation distance between the QDs is narrower than about 6 nm, electrons in their QDs can laterally transport by a tunneling effect. Thereby, electrons in their ground state (GS) gradually occupied from lower state of larger QDs to upper state of smaller QDs [5]. Figure 2 shows PL spectra (a) and PL decay time (b) of highly dense InAs QDs/GaAsSb for two different excitation wavelengths of 785 nm (blue) and 860 nm (red). For 785-nm and 860-nm excitations, PL peaks were observed at 1060 nm and 990 nm, respectively. Both PLs showed a long decay time of 5 – 8 ns because of the carrier separation in the type-II structure of InAs QD/GaAsSb. Therefore, the 1060-nm peak for 785-nm excitation is originated from the type-II transition between the electrons in the QD GS and the holes in the GaAsSb valence band (VB). The 990-nm peak for 860-nm excitation is due to the type-II transition between the QD excited state (ES) and the GaAsSb VB. Figure 3 shows PL excitation (PLE) spectra of highly dense InAs QDs/GaAsSb and low density InAs QDs/GaAs. In a case of highly dense InAs QDs/GaAsSb, the strong PLE intensity based on the QD ES transition (990 nm) was maintained at a wavelength region of 830 nm to 950 nm. It corresponds to a region of the absorption wavelength at the InAs QD (above 3rd ES), WL, and the GaAsSb layer. Therefore, the electrons excited at their layers are transferred to the QD ES, and it is expected that these electrons having a long lifetime are effectively excited to the conduction band by infra-red light.