

Hot-Carrier Cooling Dynamics in InAs/GaAs Quantum Dot Superlattices

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Recently, we have proposed a high-conversion-efficiency solar cell utilizing the hot carrier (HC) population in quantum dot superlattices (QDSLs) [1]. High HC temperature and long HC cooling time are essential for achieving the high-conversion-efficiency HC solar cells. In this work, we studied the HC cooling dynamics in InAs/GaAs QDSLs.

InAs/GaAs QDSLs were grown on a semi-insulating GaAs(001) substrate by solid-source molecular beam epitaxy [1, 2]. We have demonstrated the one-dimensional translational motion of exciton in the InAs/GaAs QDSLs according to the $T^{1/2}$ dependence of the radiative recombination lifetime [2]. Photoluminescence (PL) measurements were performed at 3 K by using a mode-locked Ti:sapphire pulse laser with a wavelength of 800 nm. The PL signal was detected by a near-infrared streak camera system with a temporal resolution of 20 ps. The HC temperature was estimated using the PL spectrum by taking into account the Boltzmann factor, the one-dimensional density of states, and the homogeneous and inhomogeneous broadening of the QDSLs.

Figure 1 summarizes the HC cooling curves in the InAs/GaAs QDSLs. The HC temperature monotonically increases with the excitation photon density. The high HC temperature in the InAs/GaAs QDSLs results from the one-dimensional density of states because that in the InAs/GaAs quantum wells (QWs) is less than one order of magnitude. Dashed lines are calculated results taking into account the energy loss rate (ELR) [3]. The ELR reduction factor in the InAs/GaAs QDSLs is almost independent of the excitation photon density in this study, and is more than one order of magnitude larger than that in the QWs reported in Ref. 3.

[1] D. Watanabe *et al.*, Appl. Phys. Lett. **105**, 171904 (2014).

[2] A. Takahashi *et al.*, Phys. Rev. B **87**, 235323 (2013).

[3] K. Leo *et al.*, Phys. Rev. B **37**, 7121 (1988).

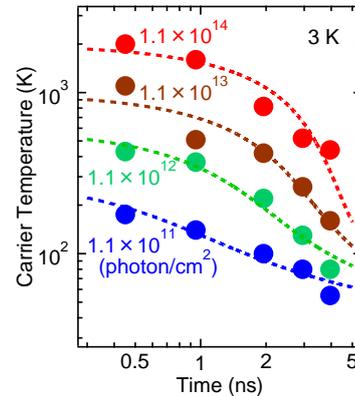


Figure 1- HC cooling curves in the InAs/GaAs QDSLs at 3 K.