28p-G20-15

Relative strength of upconversion through Auger, thermal and two-step two-photon-absorption processes in InAs quantum structures

Institute for Chemical Research, Kyoto Univ.[1], JST-CREST[2], Toyota Technological Inst.[3] ○David M. Tex[1,2], Itaru Kamiya[3], and Yoshihiko Kanemitsu[1,2]

InAs quantum dots (QDs) have attracted much attention in the past decade for application in intermediate band (IB) solar cells [1]. The concept of IB solar cells is extended current by additional absorption and upconversion of carriers in intermediate states. Several InAs quantum structures may be applicable for design of the IB. The InAs QDs are usually a few nm in height. This induces deep confined states, which is favorable for increasing current by additional absorption. However, the realized upconversion efficiencies are low. We reported efficient photon upconversion from the IR to the visible through what we call InAs quantum well islands (QWIs), island-like structures of a few monolayer thick quantum well that are laterally extended by tens of nanometer [2]. Such structures have been known since the early stages of self assembled QD growth, however, have not attracted much attention. We have shown that the QWIs are very attractive candidates for IB solar cells because of their high upconversion efficiency [3].

IB solar cells based on InAs have been investigated, however, the concrete upconversion carrier dynamics in InAs have not been identified. For future device applications it is important to clarify the advantages of each of the different InAs structures. We measured the upconverted photocurrent (that is, the photocurrent generated by upconversion) of InAs/AlGaAs quantum structures to measure the intrinsic upconversion properties of the InAs QD and QWI. Combining two laser beam experiments and temperature dependence we identify the contribution of Auger, thermal and two-step two-photon-absorption (TS-TPA) upconversion in each quantum structure. The results indicate that the often anticipated TS-TPA process has a restricted efficiency due to the material properties of InAs. Instead the Auger process is found to be a more suited candidate for InAs based IBs.

The authors would like to thank T. Ihara for the help during the experiments. This work was supported by CREST, Japan Science and Technology Agency (JST) and by the Strategic Research Infrastructure Project, the Ministry of Education, Culture, Sports, Science and Technology, Japan.

References

[1] A. Luque and A. Martî, Phys. Rev. Lett. **78**, 5014 (1997).

[2] D. M. Tex and I. Kamiya, Phys. Rev. B **83**, 081309(R) (2011).

[3] D. M. Tex, I. Kamiya, and Y. Kanemitsu, 73rd Fall Meeting of the JSAP (2012).