Relative strength of upconversion through Auger, thermal and two-step
two-photon-absorption processes in InAs quantum structures
Institute for Chemical Research, Kyoto Univ.\textsuperscript{1}, JST-CREST\textsuperscript{2}, Toyota
Technological Inst.\textsuperscript{3}  David M. Tex\textsuperscript{1,2}, Itaru Kamiya\textsuperscript{3}, and Yoshihiko Kanemitsu\textsuperscript{1,2}

InAs quantum dots (QDs) have attracted much attention in the past decade for application
in intermediate band (IB) solar cells \cite{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 ab-
sorption. 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),
島状の構造として、数モノーラー厚の量子井戸を後方にずれた
島状の構造として、数モノーラー厚の量子井戸を後方にずれた
island-like structures of a few monolayer thick quantum well that are laterally extended by tens
of nanometer \cite{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 \cite{3}.

IB solar cells based on InAs have been investigated, however, the concrete upconversion car-
rier 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. Combin-
ing 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 effi-
ciency 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 Strate-
gic Research Infrastructure Project, the Ministry of Education, Culture, Sports, Science and
Technology, Japan.

References

\begin{thebibliography}{99}
  \bibitem{3} D. M. Tex, I. Kamiya, and Y. Kanemitsu, 73rd Fall Meeting of the JSAP (2012).
\end{thebibliography}