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# Two-Step Photocurrent Generation in Droplet Epitaxy GaAs/AlGaAs QD-IBSCs

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The Intermediate Band Solar Cell (IBSC) has attracted considerable research attention since the concept was theoretically proposed in 1997 with the promise of overcoming the Shockley-Queisser conversion efficiency limit. Almost exclusively the research on quantum dot (QD) IBSCs has been carried out using InGaAs/GaAs QDs since their fabrication by Stranski-Krastanov growth mode is a well-established technique. However, complications arise due to accumulation of strain which originates from the lattice-mismatch between the two materials. In our group we have been studying solar cells with embedded GaAs/AlGaAs QDs grown by droplet epitaxy, therefore avoiding any strain-related issues in this lattice-matched material system. Here, we report the two-step photocurrent generation, which is the key operating principle of an IBSC, in GaAs/AlGaAs lattice-matched QD-IBSCs.

A p-i-n solar cell structure is grown on n-type GaAs (100) substrate by molecular beam epitaxy. Five QD layers separated by 20 nm barrier layers are embedded in the middle of a 600-nm-thick i-region sandwiched by n- and p-AlGaAs layers. To create deeply confined energy states from which thermal escape of carriers is limited at room temperature, we introduced a 2-nm-thick GaAs quantum well layer underneath each QD layer which increases the effective QD volume [1]. Si-doping is applied to the wetting layer underneath the QDs with a doping density of $2\times10^{11}$cm$^{-2}$, which is about four times the areal density of QDs ($4.6\times10^{10}$cm$^{-2}$) and is designed to sufficiently fill the QD energy states with electrons.

The current-voltage characteristics under 740 nm light illumination (Fig. 1) reveal that a large number of carriers cannot escape their confinement by thermal-assisted tunneling under forward bias condition and stay trapped in the QDs even at room temperature, which is a necessary precondition for IBSC operation. Some of these carries can be excited out of their confinement by additional 1.55 μm laser illumination which causes an increase in absolute photocurrent generation. This two-step photocurrent generation is strongly dependent on the applied voltage which will be discussed in ralation to carrier population in the QD energy states.

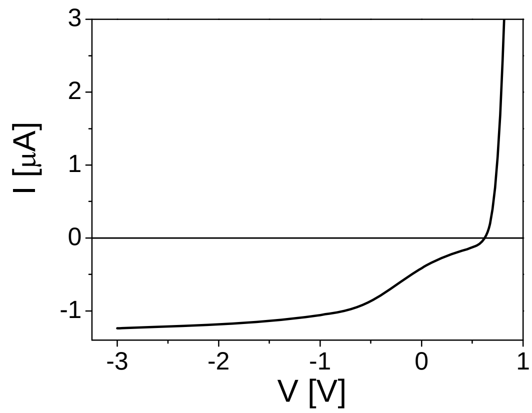


Fig. 1: IV dependence under 740 nm illumination at room temperature. The generated photocurrent decreases for V > -2 V which shows that part of the carries stay trapped in the QDs.

[1] M. Elborg, M. Jo, Y. Ding, T. Noda, T. Mano, and K. Sakoda, JJAP 51, 10ND14 (2012).