CHARACTERIZATION OF GaSB QUANTUM DOT SOLAR CELLS BY CAPACITANCE MEASUREMENTS

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The intermediate band solar cell (IBSC) concept is attractive because of a potential for high efficiency exceeding the Shockley-Queisser limit [1]. The key operation principle is photocurrent (PC) generation due to absorption of two photons via an IB or intermediate states (ISs), known as two-step PC generation. Quantum dots (QDs) are widely utilized for the formation of an ISs and the two-step PC generation in QD solar cells is intensively studied. In our previous work, we worked on QDs with a type-II band alignment, which might be suitable to reduce recombination due to spatial separation of electrons and holes, and studied their optical properties for application to solar cells [2].

In this work we study charge accumulation in GaSb QD solar cells and dynamical properties of holes trapped in QDs by capacitance measurements. We show an increase in capacitance due to illumination, and discuss the result in relation to holes trapped in GaSb QDs.

Samples were grown on n-type (100) GaAs substrates by molecular beam epitaxy. Ten periods of GaSb QD layers are embedded in a 600-nm thick i-layer, sandwiched by n- and p-type GaAs (AlGaAs) layers. The QDs were fabricated using Stranski-Krastanov growth mode. The details of the sample structure are reported in Ref. 2. Wafers were processed into a mesa-shaped diode with an area of \(6.6 \times 10^{-5}\ \text{m}^2\). Capacitance was measured as a function of frequency, \(f\), of the ac signal using a Keithley 4200 SCS at room temperature. The measurement was done at short circuit condition.

Figure 1 shows a change of capacitance, \(\Delta C\), due to illumination of a 940-nm monochromatic light. Positive \(\Delta C\) means an increase in capacitance, which is seen in both samples. This is explained by the presence of photogenerated carriers in QDs. Another feature in Fig. 1 is that \(\Delta C\) depends on \(f\) and the barrier material for GaSb QDs. In GaSb/GaAs QD sample, it peaked at 30 kHz with a value of about 5 pf, while in GaSb/AlGaAs QD sample it exhibited a monotonic increase with decreasing \(f\). The difference in \(\Delta C-f\) characteristics is due to the difference in escape time of holes trapped in QDs. We point out that the electrons are likely to be expelled from GaSb QDs because of a type-II band alignment [2].

In summary, we have studied charge accumulation and dynamical properties in GaSb QD solar cells. We have shown that an increase in capacitance due to illumination depends on the frequency of the ac signal and the barrier material for GaSb QDs. This result is explained by dynamical properties of holes trapped in QDs.

References

![Figure 1: \(\Delta C-f\) characteristics in GaSb quantum dot solar cells.](image-url)