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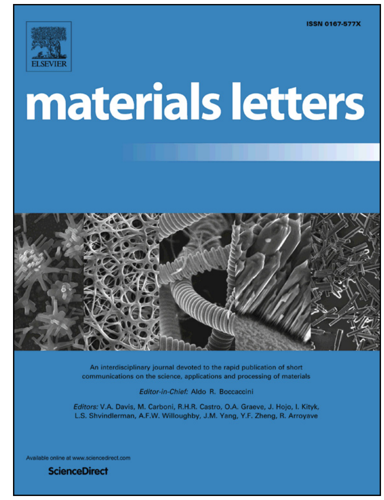

Use of ratchet band in a quantum dot embedded intermediate band solar cell to enrich the photo response

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Use of ratchet band in a quantum dot embedded intermediate band solar cell to enrich the photo response

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Abstract

Intermediate band (IB) solar cell has shown a significant amount of efficiency improvement. However IB cell suffers from demerits like high rate of recombination. A trade-off between efficiency and recombination is recently proposed by introducing a ratchet band just below the IB. In the present work, a single junction quantum dot (QD) IB cell is proposed by introducing a ratchet band (RB). The concept of carrier life time enhancement is also discussed by the help of RB. The validation of carrier life time enhancement is provided through the study of spectral response (SR), external quantum efficiency (EQE) and internal quantum efficiency (IQE) of the cell. The proposed model is simulated and the results are obtained using Silvaco ATLAS TCAD device simulator.

Key words: Ratchet band, Intermediate band, Quantum dot, Recombination.

I. Introduction

In these years solar scientists are in search of new ideas and techniques to overcome the fundamental thermodynamic efficiency barrier limit of 31.0% (at 1 sun) proposed by Shockley and Queisser [1]. Third generation intermediate band solar cells (IBSC) [2-3] has shown the pathway to cross the Shockley Queisser limit by additional photo current generation with the introduction of a new phenomenon called sub-band gap photon absorption or two photon absorption, which minimizes the thermalization losses. However thermodynamical modelling of IBSC shows that we can harvest a maximum efficiency of 46.8% under 1 sun and 63.2% under fully concentrated sunlight [4]. But in reality it is not true. According to the experimental reports of the last few years it has been seen that, the IBSC results significant amount of increment only in photo current [5-6].Whereas it is suffering from voltage losses which limits the conversion efficiency. The cause behind the voltage reduction in IBSC are a) short life time of carriers in the IB state, b) smaller occupation factor of IB, c) high recombination (both radiative and non-radiative) in IB region, d) absorption coefficient overlap, e) presence of deep levels and f) reduced thickness of QDs in absence of field damping layers.

To avoid the above threats of the IBSC module a quantum ratchet IBSC (QRIBSC) is proposed, where a InAs quantum layer is embedded along with GaSb IB. Besides these, how it helps in voltage preservation is also discussed. This model also provides a pathway to fully utilise the solar spectrum.

II. Operating principle of QRIBSC module

Before explaining the operation of QRIBSC we have to make some important considerations. a) Ratchet band (RB) should have a small energy interval ΔE less than that of IB, b) RB should be radiatively decoupled from valence band (VB), c) IB should be radiatively decoupled from conduction band (CB), and d) RB should be highly populated.

With the help of Fig. 1. It is very easy to understand the detail operation of QRIBSC. The photon that have energy equivalent or > E_G (i.e. for supra band gap illumination) the electron can directly jump from VB to CB. It is shown in Fig. 1 by transition (1).