Intermediate Band Solar Cells

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Intermediate band solar cells (IBSCs) are photovoltaic devices conceived to exploit the energy of below band gap energy photons [1]. The intermediate band (IB) is an electronic band located within the semiconductor band gap, separated from the conduction and the valence band by a null density of states. In this device, below band gap energy photons are absorbed through transitions from the valence band to the IB and from the IB to the conduction band (Figure 1). On the other hand, by sandwiching the material containing the IB in-between two high bandgap semiconductors [2], it can be shown that the output voltage of the cell is still limited by the total bandgap E_G. This relies also on the assumption that carrier relaxation beetwen bands is a much faster process than carrier relaxation within bands so that each band has got associated its own quasi-Fermi level. The interested reader can consult in adition, for example, Refs. [3, 4, 5, 6] for more detailed information about aspects such as equivalent circuit of the cell, impact in the efficiency of the absorption coefficient overlap and thermodynamic consistency. As a result, the limiting efficiency of an IBSC is almost the same one than the limiting efficiency of a triple junction solar cell (63.2 % under maximum concentrated light). The concept boosts the number of potential materials and systems that can be exploited. In this respect, the following are been researched in practice:

- Quantum dots [7]. Under this approach, the IB arises from the energy level related to the electrons confined in the dots. This approach has allowed demonstrating the principles of operation of the IBSC [8, 9]. Several groups worldwide have by now already investigated further this approach [10, 11, 12] mostly on the basis of an InAs/GaAs like QD material system.

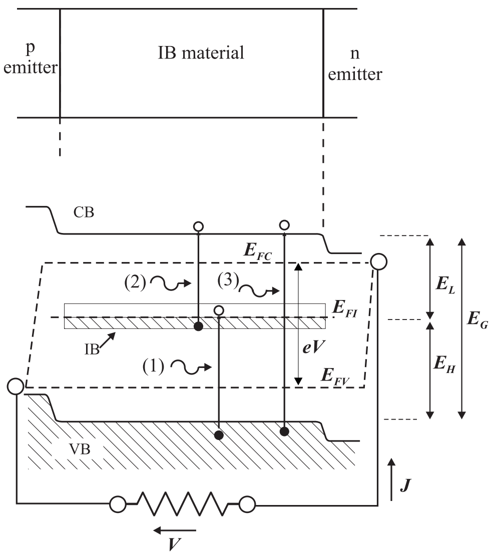

Figure 1: Basic structure of an IBSC showing the absorption of below bandgap energy photons and how the output voltage eV, determined by the split between electron and hole quasi-Fermi levels is limited by the total bandgap E_G.

- Insertion of transition metals such us Mn in InGaN [13, 14]. This approach builds on the assumption that the IB can arise from deep centres if the associated impurity can be incorporated into the semiconductor host at a sufficiently high density [15] (beyond the Mott's transition). Experimental evidence of the formation if the IB according to this principle has been recently be found by inserting Ti at high dose in silicon [16].

- Thin film materials [17, 18]. This approach pursues the implementation of the concept in low cost hosts.

– Insertion of transition metals in III-V compounds [19].

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