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Physics and modeling of quantum dot solar cells

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The idea of using quantum dots (QD) to extend the spectral sensitivity and improve the efficiency of solar cells was first put forward by Aroutiounian *et al.* (*J. Appl. Phys.* 89, 2268, 2001). QDs indeed provide several useful knobs in photovoltaics, such as tuning the bandgap for a certain spectrum and concentration, realizing current-matched multiple junction cells, and improving radiation hardness in space. On the other hand, the expectation of overcoming the Shockley-Queisser limit of single-gap cells with QD solar cells is yet unfulfilled. For this to happen, it is necessary to engineer the nanostructures to suppress phonon assisted coupling between extended and quantum-confined states, and within intraband confined states too. In this way, one could realize by means of QDs the intermediate band (IB) solar cell (Luque *et al.*, *Phys. Rev. Lett.*, 78, 26, 1997), which has a theoretical efficiency about 50% higher than its single-gap counterpart under unconcentrated light. Three decades of extensive research, mostly on self-assembled III-V QDs, has led to observe the fundamental mechanisms of the IB solar cell at cryogenic temperatures but the demonstration of a high efficiency IB cell is yet to come. Recently, new materials have emerged, such as strain-free III-V QDs and colloidal QDs into perovskite absorbers, with promising features for IB operation at room temperature. In this talk, I will revisit the physics and limits of QD solar cells, considering optical and transport simulations and discuss possible ways forward for their development, both in the perspective of single-gap and IB operation.

Type of presence

Presence online

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