Intermediate band quantum dot solar cells

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Currently there is a drive to investigate a new generation of improved efficiency photovoltaic (PV) devices that make a greater use of the solar spectrum than the conventional single junction solar cell. It is hoped that through this new "Third Generation PV" solar power can become more cost competitive to the more traditional sources of power such as fossil and nuclear fuels. New concepts will be needed to produce this 'third generation' of low-cost, high-performance PV devices. One of the largest losses associated with conventional single junction solar cells is that sub-bandgap energy photons do not contribute to the device current. The efficiency of ideal solar cells can be increased by using an intermediate band lying inside the forbidden energy gap of the semiconductor host material to absorb photons with energies below the semiconductor bandgap. The states within the intermediate band need to be partially filled to provide good photon absorption. This is so that an electron from the valence band can be excited to an unoccupied level in the intermediate band, from which it or another electron can then be excited to the conduction band. By this mechanism the absorption of two photons of low energy can result in an electron-hole pair of higher energy than the semiconductor host material bandgap. The electrons in the conduction band generated by this process add to those generated by the normal one step absorption process across the barrier semiconductor material bandgap thus adding to the current flow in the device. If the cell is properly contacted and carrier relaxation is slow enough, these extra electrons can be extracted at a high voltage, limited by the bandgap of the barrier material. This work deals with realizing the concept of an intermediate band solar cell by using quantum dot (QD) technology. It involves the design, growth, characterization, and theoretical calculation of the band structure and absorption properties of QD intermediate band solar cell device structures.