Technology Opportunity

The CUNY Center for Advanced Technology In Photonics Applications (CUNY CAT)
Designated by NYSTAR, the New York State Foundation for Science, Technology and Innovation

High Efficiency Solar Cells

Novel multiple quantum well (MQW) based solar cells can improve photovoltaic conversion efficiency. The maximum energy conversion efficiency of a conventional solar cell is limited to ~33% because of a mismatch between the broad solar spectrum and the single band gap (E_{gap}) in a conventional solar cell. Solar photons with energy $E<E_{gap}$ are not absorbed, while photons with $E>E_{gap}$ generate electron-hole pairs, which lose all energy in excess of E_{gap}. Radiative and non-radiative carrier recombination contributes to further reduction in efficiency.

Theoretically, much higher conversion efficiency than that of conventional solar cells (~50% for two band gap cell) can be achieved using multiple band-gap solar cells that accommodate a greater portion of the solar spectrum. Multiple band-gap solar cells can be made from either a multi-junction cell or an MQW cell. The latter behaves as a two-band solar cell, in which wells act as narrow band cells and barriers act as a wide band cells. For several materials studied, the efficiency of MQW solar cells exceeds that of comparable single-band-gap cells made of the well or barrier material alone. The logical extension of this design is to combine several MQW structures with different band gaps in order to expand coverage of the solar spectrum.

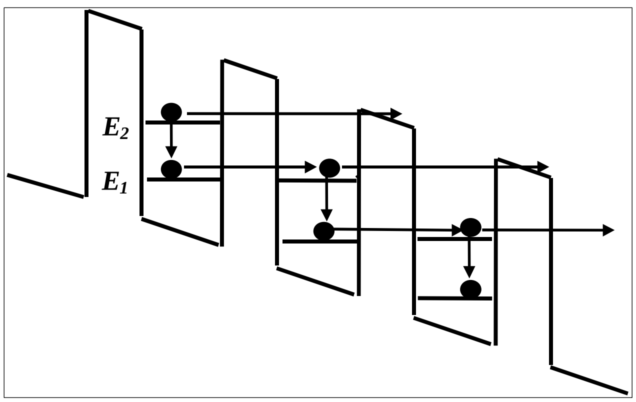

Fig. 1 Sequential resonant tunneling in MQW Structure

We have developed a novel approach to improve solar cell efficiency using specially designed III-V MQW-based structures with a sequential resonant tunneling geometry. Fig.1 shows such a structure, schematically. E_1 and E_2 are the ground and first excited electron sub-band energies inside the quantum well. Resonance occurs when the E_1 level in one well aligns itself with the E_2 level in an adjacent well.

Resonant tunneling can significantly speed up the collection rate of photoexcited carriers and thus increase output current and photovoltaic efficiency.

Our latest MQW solar cell, based on an InGaAsP/InP structure, showed an <u>11% increase</u> in photovoltaic efficiency over a control non-MQW cell. InP-based cells have an advantage over conventional Si-based cells because of their higher radiation resistance and more optimal bandgap.

MQW solar cells are fabricated using molecular beam epitaxy (MBE) or metal-organic vapor deposition (MOCVD). Currently, MQW solar cell production costs are higher than those of conventional cells. With further development of MBE, MOCVD and other growth techniques, costs will be reduced. High efficiency MQW-based solar cells have the potential for wide usage in compact computers, space power supplies, micro-scale motors, consumer products and ultra-small home electronics.

This technology opportunity sheet describes continuing efforts in this area. Several patents may have been issued or are pending and which may be available for licensing.

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