Strain-Balanced Quantum Well Solar Cells

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GaInP/GaAs tandem cells currently represent the highest efficiency monolithic solar cells and are in commercial production for space applications [1]. As the cells are connected in series, the same current must be photogenerated in each cell and traditionally the absorbing thickness of the junctions are varied to adjust the photocurrents [2]. However it has been suggested that quantum well structures could provide a more optimal III-V monolithic tandem cell [3].

The quantum well solar cell structure is typically a p-i-n device with the quantum wells located in the intrinsic region. The quantum well layers are composed of a lower band-gap material than the p-i-n host material and serve to extend the absorption of the p-i-n structure, resulting in an increased short-circuit current. The GaInP/GaAs tandem cell can therefore be enhanced by incorporating quantum wells into the GaAs junction, providing nearly optimal current matching.

Achieving high quality quantum wells in a GaAs p-i-n host structure is complicated by there being no high quality, lattice matched material with a lower band-gap to GaAs, requiring strained materials to be used. Recently a strain-balance approach has lead to an unprecedented performance for the quantum well solar cell [9] and is projected to yield current densities of 18mA/cm^{-2} in a GaInP/QW p-i-n tandem configuration [10].

The behaviour of the open-circuit voltage is complex and not fully understood at present. Some theoretical models suggest mechanisms by which a fundamental efficiency advantage over bulk

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materials could be achieved [4–6] whereas others suggest that quantum well cells are governed by the same efficiency limits as bulk semiconductor cells [7]. However, none of these theories fully describe the experimental observations [8]. Some very recent measurements on electroluminescence from quantum well structures under illuminated conditions, offer a further insight into the operation of the quantum well solar cell.

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