

# Monolithic Integration of II/VI and III/V Materials for Multi-junction Solar Cells

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Multi-junction photovoltaic solar cells are attracting increasing attention in the research of renewable energy resources for their relatively high conversion efficiency. GaInP/GaAs/InGaAs 3-junction solar cells currently hold the record for energy conversion efficiency, at 30.6% under 1 sun AM0 and 33.8% under 1 sun AM1.5G [1]. Using this approach, a further increase in efficiency is hindered by the lack of high-quality materials for additional junctions lattice matched to GaAs or Ge substrates. Dilute nitride materials, such as GaInNAs, have been examined, however their short minority-carrier lifetime or diffusion length greatly reduces the working current [2]. Although some promising results on dilute nitride solar cells have been published, materials with both large short circuit current and open circuit voltage are still unavailable at the optimum bandgap energy [3][4]. It is therefore necessary to explore a different approach to substantially improve solar cell efficiency.

A 4-junction solar cell is proposed using monolithically integrated II/VI (ZnCdSeTe) and III/V (AlGaAsSb) materials, both of which have zinc blend crystalline structure with similar coefficients of thermal expansion. These materials can be grown lattice matched to GaSb substrates with bandgap energies that cover the entire solar spectrum. Consequently, this solar cell design can be optimized by varying both the bandgap energy and the layer thickness of each subcell, offering the prospect of ultra-high conversion efficiency. Simulations of all the designs are carried out using the commercial software package Silvaco. Losses due to the Shockley-Read-Hall, radiative, and Auger recombination are included in the model. The input material parameters such as absorption coefficients, effective masses, recombination coefficients, and carrier mobilities are obtained from linearly interpolated published values [5][6]. These simulations use the 2-D finite-element method, a 2-D

drift-diffusion model for carrier transport, and take into account the position-dependent carrier generation and recombination. Simulation results show that the achievable AM0 energy conversion efficiency of a practical four-junction solar cell design is 38% under 1 sun and 46% under 2000 suns compared with 49% and 60% from Henry's model.

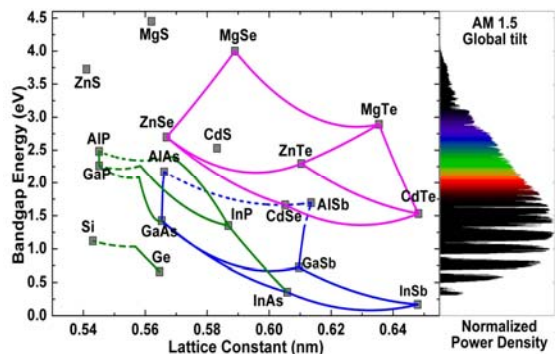


Fig 1. The calculated bandgaps of various II/VI and III/V alloys versus lattice constant. The solar AM0 spectrum is plotted on the right [7].

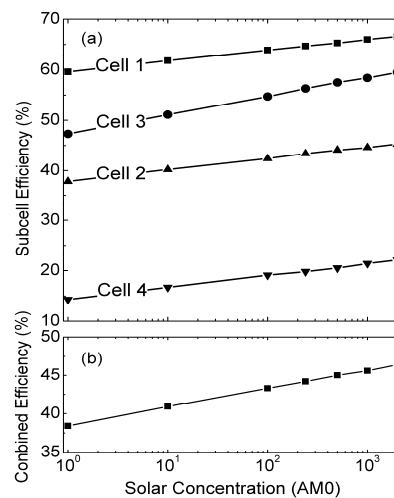


FIG. 2 Achievable energy conversion efficiencies of 4-junction solar cell design under various sun concentrations from 1 to 2000 suns.

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