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High-Efficiency III-V Multijunction Solar Cells

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9.1 INTRODUCTION

The large-scale use of photovoltaics is slowly becoming a reality. Small scale ($\sim$10–20 kW) power systems using Si solar cells now compete with fossil-fueled electric generators for remote applications, where "remote" in the United States means less than one kilometer from the electrical grid. The total worldwide solar cell production in the year 2000 was 0.3 GW, mostly in the form of flat-plate Si solar cells. Compared to the PV production capacity 20 years ago, this represents remarkable progress. Silicon solar cells have reached efficiencies exceeding 20%, and the cost has been reduced to under $10/W. However, in the context of world energy consumption, 0.3 GW is a miniscule number. The problem is related to the diffuse nature of solar radiation. For example, to generate 1 GW of electrical power using Si solar cells requires an aperture area on the order of 10^7 m^2. The main problem is not the land area, but the daunting task of producing 10^7 m^2 of what has been termed *solar-grade silicon*, which in reality is virtually indistinguishable from semiconductor-grade silicon. One solution to this problem is to use "concentrator technology." Here, lenses or mirrors focus the sunlight (usually the direct portion) on a smaller solar cell. The concentration ratio can be as large as 200X to 300X for Si and 1000X to 2000X for a GaAs solar cell. At these concentration ratios, the cost of the cell becomes less important than its efficiency. For example, a GaInP/GaAs/Ge tandem cell with an efficiency of 34% at 1000X and a cost of \$10/cm^2 may be more cost-effective than a Si concentrator cell with an efficiency of 28% at 200X and a cost of \$0.50/cm^2. The trade-offs are complex and currently not well quantified, but it seems clear that concentrator photovoltaics must be a dominant player if photovoltaics have to supply a significant fraction of the world's energy needs.

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