Microlens-enhanced Flexible Gallium Arsenide Microcell Array for Low-cost, Roof-top Photovoltaics for Automobiles

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High-efficiency GaAs solar cells are good candidates for roof-top photovoltaics for automobiles but, they are very expensive and inflexible. If GaAs photovoltaics can be made as microcells and if microconcentrators are used to concentrate light on individual microcells, a high power output could be achieved along with reduced material cost. The costs can be reduced further if GaAs microcells are made on inexpensive metal substrates (cost $8/m^2) instead of GaAs wafers (cost $11,000/m^2). The purpose of this work was to investigate if low-cost polydimethylsiloxane (PDMS) microlenses can be used as microconcentrators for GaAs microcell arrays on flexible substrates and compare their effectiveness with complex conventional concentrator optics. Individual and series-connected GaAs microcells of 250–1250 μm diameter were fabricated on metal substrates using photolithography. The photovoltaic parameters of the cells were determined from current-voltage characteristics at 1 sun with and without PDMS microlens as well as at 13 suns with conventional concentrator optics. PDMS microlenses functioned well as microconcentrators resulting in ~12 times more power from the smaller GaAs microcells at 1 sun, comparable with the power output at 13 suns using complex concentrator optics. The open circuit voltage of flexible GaAs microcells at 1 sun and 13 suns increased steadily with increasing number of series-connected microcells resulting in correspondingly higher power output. GaAs microcell arrays using PDMS microconcentrators offer the combination of flexibility, lower cost and higher power output that can make roof-top photovoltaics for automobiles feasible and extend the range of electric cars by as much as 50 miles.

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