Liquid-phase electroepitaxial growth of low band-gap p-InAsPSb/n-InAs heterostructures for thermo-photovoltaic device application

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Renewable energy technologies present an economically viable alternative to traditional energy sources today. Beside traditional solar cells, photovoltaic (PV) elements have found wide use in thermophotovoltaic (TPV) power converters recently. TPV power generation involves the conversion of solar or other thermal energy to electrical energy through the use of PV converters that respond to middle-wavelength infrared radiation. TPV energy conversion systems consist of a radiant heat source, a selective optical filter, and a TPV cell, which is a semiconductor p-n junction. Input power to the TPV cell is provided by a heat source, which has a high emitter temperature (1000°C-2000°C).

TPVs are low direct-band gap semiconductors, that can convert all photons with energies higher or equal to their band gap. The selective optical filter is used to reflect the radiation that cannot be absorbed by the TPV cell, back to the emitter to re-heat it. Unlike solar cells, the power density is significantly larger in TPV systems since the source is very close to the cell.

Most previous work on TPV devices has been concentrated on III-V semiconductors InGaAs on or InGaAsSb on GaSb. Miscibility gaps and lattice mismatch constraints limit the practical range of band-gaps in most of these systems. A recent theoretical study indicates, that for (1200 - 2500) K black body sources, optimum TPV cell band-gaps are in the range of (0.2 - 0.5) eV. Thus, there is a need for development in both new materials used for TPVs and in processing, to produce high performance TPV converters with very low band gaps. An alternative to InGaAs on InP, and InGaAsSb on GaSb substrate is epitaxial InAsP(Sb) structures on InAs substrates.

This report describes our efforts to fabricate InAsPSb/InAs epitaxial p-n heterostructures for TPV converter applications. For the growth of these TPV-structures the new version of liquid-phase electroepitaxy has been employed. The TPV structure consists of p-InAsPSb layer directly grown on a n-InAs (100) substrate. These structures have a mirror-like surface and a very flat interface. The dislocation density on the surface layer was no more than $N_D=10^5$ cm^{-2}. The I-V and C-V characteristics of n-InAs/p-InAsPSb heterostructures have been investigated. The maximum of photoresponse was observed near the wavelength of 3.3 μm, which corresponds to the optimum efficiency of TPV cell.

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