Interface and material studies regarding InP-based high efficiency solar cells

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III-V multi-junction solar cells currently represent the most efficient photovoltaic devices. Only with III-V semiconductors all the relevant band gaps can be realized for building optimized, highly efficient, thin film multi-junction solar cells. Regarding 3-junction cells, e.g. the monolithic Ge/GaAs/InGaP world record solar cell, and considering the thermodynamic limit of efficiencies there is a lack of an appropriate material with a band gap in the range of 1eV on the lattice constant of Ge and GaAs respectively. Absorber materials in the band gap range of about 1eV, i.e. low band gap cells, can be grown epitaxially from III-V semiconductors only when based on the lattice constant of InP.

A type of an InP-based 3-junction cell is introduced that involves all the appropriate III-V compounds to achieve highest efficiency. Therefore, new solar cell materials have been developed and grown with MOCVD on the lattice constant of InP like GaAsSb ($E_{bandgap}$ = 0.75eV), InAlGaAs ($E_{bandgap}$ = 1.15eV) and were compared to more established materials like InGaAs (0.75eV) und InGaAsP (1.15eV). In an InP reference cell an improvement of the internal quantum efficiency has been achieved compared to the currently most efficient InP solar cell using alternative precursors like tertiary butyl phosphine (TBP) instead of PH_3. Critical issues of individual solar cell components like the InP - GaAsSb interface were analyzed in detail with surface science tools with regard to the reconstruction of an abrupt interface. It is shown on the example of an InP - GaAsSb resonant tunnelling diodes that careful interface preparation is crucial with regard to the performance of those devices.