Large band gap AlGaAs/InGaP Heterojunction Solar Cells: towards 20% efficiency and beyond

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GaAs-based solar cells have received significant attention for high-efficiency multi-junction photovoltaics.[1] Currently, commercially available photovoltaic systems are dominated by silicon solar cells, which are reliable but limited by their single junction design. To use III-V architectures for terrestrial PV, III-V/Si multi-junction solar cells are a promising way to achieve module efficiencies over 30%, while still mitigating the cost and benefiting from well-established Si cell production lines. In particular, AlGaAs and InGaP alloys show great promises for the realization of solar cells with direct bandgaps near 1.73 eV, suitable for the top cell with Si-based tandem devices. In the previous work, AlGaAs-based heterojunction solar cells were grown by solid source molecular beam epitaxy (MBE) resulting in a certified efficiency of 18.7% at a bandgap of 1.73 eV.[2] This heterojunction design has additional advantages of a tunable AlGaAs absorber bandgap and a low consumption of In. Furthermore, a certified power conversion efficiency of 19.05% was also obtained for AlGaAs/InGaP heterojunction solar cell. However, even higher efficiencies are required to obtain full benefits of tandem devices with Si.

In this work, we demonstrate working directions and results on the increase of the AlGaAs-based heterojunction solar cells efficiency, with targets beyond 20%. We mainly focus on the following routes: a) Optimization of III-V stack in terms of quality improvement of specific III-V layers and fine tuning of doping levels and composition to avoid possible barriers, b) Implementation and optimization of double-layer SiO_2/TiO_2 for large band gap AlGaAs absorber, c) Top contact grid design and process improvements, which involves tests of different grid designs and their impact on Jsc and FF (Figure 1).

Overall, quality of our MBE-grown AlGaAs alloys is comparable to the performances of MOCVD-grown layers based on AlGaAs/InGaP heterostructure quality and cell efficiency[2] and is promising for further integration into tandem devices with Si.

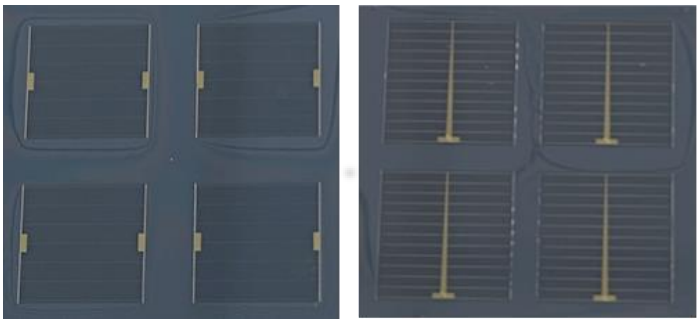

Figure 1. Examples of grid design which makes influence on the performance of heterojunction cells (cell area is 0.25 cm^2).

References:

[1] R. C. Whitehead et al., Optimization of four terminal rear heterojunction GaAs on Si interdigitated back contact tandem solar cells, *Appl. Phys. Lett.* 118, 183902 (2021).

[2] A. Ben Slimane et al., 1.73 eV AlGaAs/InGaP heterojunction solar cell grown by MBE with 18.7% efficiency. *Prog Photovolt Res Appl*. 28: 393– 402. (2020).