Inverted wide band gap heterojunction solar cells for III-V/Si tandem

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Silicon single-junction solar cell is a mature technology that is fundamentally limited to a 29.4 % conversion efficiency under AM1.5G illumination. This limit can be overcome by stacking a wide band gap solar cell on top of the Si cell in a tandem architecture, which improves light harvesting and reduces thermalization losses. Wide band gap solar cells based on III-V semiconductors such as AlGaAs and GaInP can offer high efficiency and stability. Especially, AlGaAs/GaInP heterojunction solar cells with a 1.73 eV band gap and a 18.7 % efficiency have been demonstrated [1] and further improved up to 19.05 % efficiency [2]. These heterojunctions are thin semi-transparent devices (≈2 µm) that can be coupled with Si solar cells in a 2-terminals or 4-terminals configuration for high efficiency tandems.

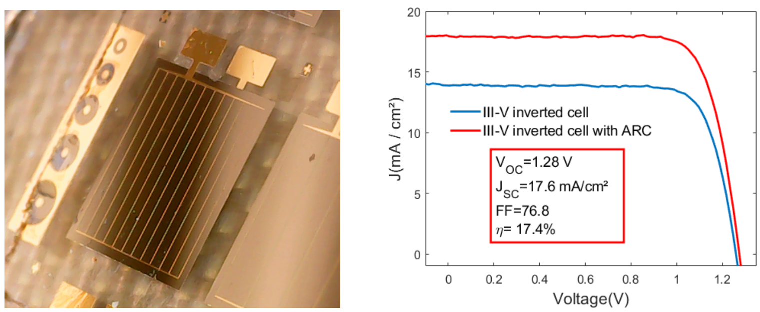

FIGURE 1. Left : picture of the inverted 0.25 cm^2 III-V cell on Glass, Right : IV curves before and after ARC.

In this work, AlGaAs-based solar cells (bandgap 1.75 eV) were grown in an inverted configuration using molecular beam epitaxy (MBE). After backside metallization through photolithography, the samples were transferred onto glass, and the GaAs substrate was chemically removed. Photolithography was then used again to define both the metal grid (aligned with the back contact to enhance transmittance) and the cell mesa (Figure 1-Left). A two-layer anti-reflection coating (ARC), consisting of TiO_2 and MgF_2, was finally deposited on top of the inverted cells. The processed samples were characterized using I-V and EQE measurement (Figure 1-Right and blue curve in Figure 2) techniques, showing performances comparable to upright-grown heterojunctions, with efficiencies reaching up to 17.4 %. Additionally, the infrared transmittance of the inverted cells was used to estimate the Jsc (red curve in Figure 2) of an Si cell located below, highlighting the potential of tandem configurations. The quantum efficiency of the Si cell is estimated by multiplying the EQE of a reference Si cell by the optical transmission of the inverted upper cell (dashed yellow curve).

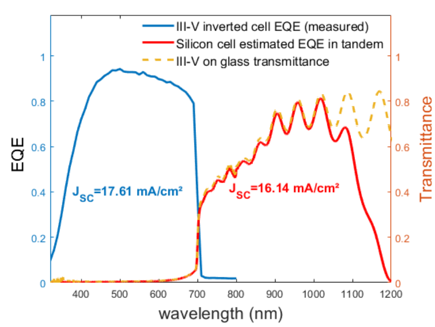

FIGURE 2. Experimental (blue) and estimated (red) EQEs of the III-V on Si 4T tandem cell.

[1] A. Ben Slimane et al., 1.73 eV AlGaAs/InGaP heterojunction solar cell grown by MBE with 18.7% efficiency. Prog Photovolt Res Appl (2020).

[2] O. V. Bilousov et al. Large band gap AlGaAs/InGaP Heterojunction Solar Cells : towards 20% efficiency and beyond. JNPV (2021).