傾斜温度成長に基づく$Al_{0.35}GaAs$ / InGaP ヘテロ接合太陽電池

$Al_{0.35}GaAs$ /InGaP Heterojunction Solar Cell Based on Temperature Graded Growth

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InGaP is regarded a competent material for the top cell in III-V multi-junction solar cells due to its adequate bandgap and lattice-matched growth on GaAs substate. However, the performance of cells suffers from the low minority carrier mobility, especially in p-type InGaP[1)], which leads to insufficient carrier collection and brings down current density. Meanwhile, the scarcity of Indium may limit the massive application of this material.

Above problems can be solved by introducing p-$Al_{0.35}GaAs$ to replace the p-InGaP base[2)]. Due to the closed bandgap and lattice constant, $Al_{0.35}GaAs$ offers higher carrier mobility without changing the bandgap of solar cell. The use of Indium is also greatly reduced since only a thin n-InGaP emitter is required in this structure. However, a crucial challenge emerges in building high-quality p-$Al_{0.35}GaAs$/n-InGaP heterojuction, that is, the two alloys prefer different growth temperatures[3,4)] in metal-organic vapor phase epitaxy (MOVPE). The inevitable temperature ramping process between the growth of these layers exposes the $Al_{0.35}GaAs$ surface for several minutes and thereby introduces oxygen contamination. These undesired defects would behave as Schockley-Read-Hall (SRH) recombination centers[5)] and would degrade the cell performance gravely.

In this report, a temperature graded layer of $Al_{0.35}GaAs$ was employed to avoid surface exposure in reactor as shown in the following schematics. The oxygen contamination is successfully suppressed with an observed improvement in open-circuit voltage according to the J-V curve of cell samples, indicating lower SRH recombination rate. A measured external radiative efficiency based on electroluminescence suggests the same conclusion as well. However, the graded growth also brought about a reduced fill factor with a poor field-aided collection[6)]. Simulation via SCAPS-1D reveals that a layer with higher Al composition might be formed near the junction and hence an energy barrier prohibits the electrons transportation. Overall, based on the newly proposed temperature graded growth method, this study improved the quality of AlGaAs/InGaP heterostructure grown by MOVPE, indicating a promising approach for AlGaAs/InGaP hetero-emitter solar cells with high performance.

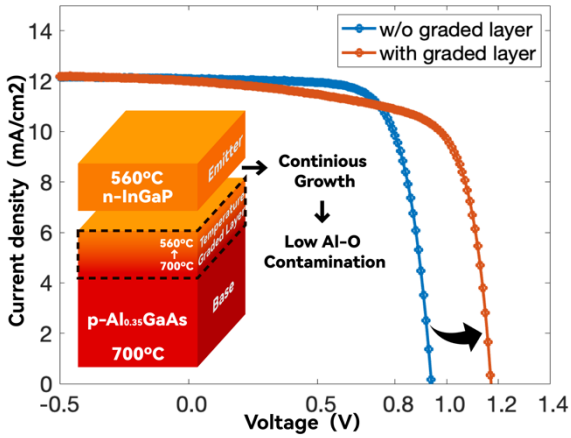

Fig.1 Schematic of graded layer and J-V curve of solar cells.

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