Solid Epitaxial Lift-off (ELO) of GaAs Solar Cell on Silicon Substrate

Univ. of Tokyo[1], ○ (M2) Ziqi Zhang[1], Kentaroh Watanabe[1], Hassanet Sodabanlu[1], Yoshiaki Nakano[1], and Masakazu Sugiyama[1]

E-mail: zhang@enesys.rcast.u-tokyo.ac.jp

Epitaxial lift-off (ELO) is a method to separate the photovoltaic layer from the substrate by selective etching of the release layer, where the separated substrate can be recycled and reused to grow another PV layer in order to reduce overall cost of expensive III-V solar cell devices (about 1/3 of the cost of such devices come from substrate cost [1]). Most of the previous research focused on ELO process of single junction GaAs solar cell on an external flexible polymer substrate to induce bending on the device to accelerate the etch process [2]. However, if we apply ELO to III-V//Si multijunction solar cell bonded by Surface Activated Bonding (SAB), this conventional method becomes challenging because silicon is rigid and difficult to bend, unlike the case of polymer substrate. A new approach, we call it Solid ELO, that uses thin silicon wafer to bend the sample, is under investigation. Since slight bending of silicon is possible, ELO process using silicon support may be feasible. Therefore, new approach (Solid ELO) can possibly serve as a method of ELO process for III-V//Si multijunction solar cell.

In this study, we prepare 2-inch GaAs solar cell sample using MOVPE method. 15nm thick-AlAs release layer is inserted between PV layer and substrate that can be selectively etched by HF solution. The GaAs solar cell is then bonded on a 4-inch silicon wafer by SAB method and cut to several small sized (5×5 mm and 5×7 mm) samples for further experiment. The GaAs solar cell on Si substrate structure is demonstrated in Fig.1. Small samples are bonded on another 4-inch silicon wafer by black wax and put into 11.5% HF solution with induced bending of silicon wafer. In the experiment, the bending radius of silicon wafer is controlled to be about 500 mm at all times, which is safely larger than the minimum bending radius (350 mm) allowed for brittle silicon wafer to withstand without failure, according to our stress analysis simulation result. The small samples come to a full separation after putting in 50 °C 11.5% HF solution in 24 hours. The cross-sectional SEM image of separated sample is shown in Fig. 2, where Si substrate and GaAs PV layer can be identified, while GaAs substrate is separated from the device. Then the GaAs PV//Si substrate samples are fabricated into solar cells for PV characterization. The obtained characterization results confirmed that the separated sample functions as a solar cell, with V_{oc} of 0.81V, and I_{sc} of 12.47mA/cm^2. In the presentation, detailed PV performance of the fabricated devices will be presented.

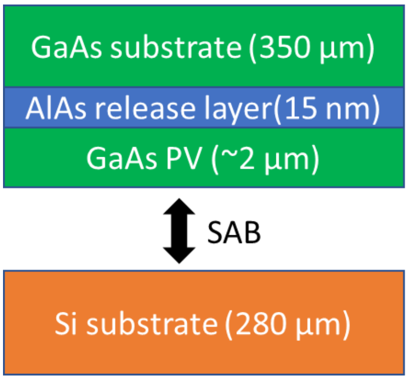

Figure 1: Structure of GaAs solar cell on Si substrate.

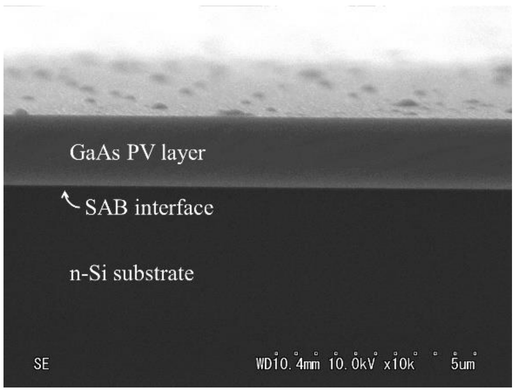

Figure 2: Cross-sectional SEM image of separated sample.

Reference

[1] Horowitz, K., Remo, T., Smith B. & Ptak, A. "A Techno-Economic Analysis and Cost Reduction Roadmap for III-V Solar Cells.", National Renewable Energy Laboratory, 2018

[2] Bauhuis, G. J., Mulder, P., Haverkamp, E. J., Huijben, J. C. C. M. & Schermer, J. J. 26.1% thin-film GaAs solar cell using epitaxial lift-off, *Solar Energy Materials Solar Cells* **93**, 1488–1491 (2009)