To date, the use of highly efficient III-V multijunction devices has been limited to space and high-concentration terrestrial systems owing to their extremely high manufacturing cost when industry-standard metal-organic vapor-phase epitaxy (MOVPE) techniques are employed. Hydride vapor phase epitaxy (H-VPE), in contrast to MOVPE, has a significantly higher growth rate of ~100 μm/h. In addition, H-VPE uses relatively cheaper group III metals, and the growth process typically involves a low group V overpressure of ~2, resulting in substantial cost reduction. Simon et al. previously demonstrated highly efficient GaAs solar cells grown with a high growth rate (60 μm/h) by vertical H-VPE. We recently reported that highly uniform GaAs solar cells can be obtained on 2-inch wafer using our custom-built H-VPE with horizontal flow at atmospheric pressure. In our continuous effort to increase the cell efficiency, we developed GaAs solar cells grown with In0.48Ga0.52P window layers.

H-VPE reactor tube was designed to have three chambers, namely, two growth chambers and a preparation chamber. After the just-oriented GaAs(001) substrate had been loaded into the reactor, it was thermally cleaned in an AsH3 flow in the preparation chamber. Then, GaAs solar cells were grown on it using the two growth chambers as shown in Fig. 1. The presence of the two growth chambers with different growth environments allowed for the continuous growth of multiple layers without interruption. The source and substrate regions were heated at 850 °C and 680 °C. Gaseous HCl was used to react with the liquid Ga and In contained in the quartz boats, resulting in the formation of GaCl and InCl as the group III precursors. PH3 and AsH3 were used as group V precursors, while DMZn and H2S were used as dopant gases. Growth rate for the GaAs and InGaP were 13 μm/h and 15 μm/h, respectively. V/III ratio was 5.0.

The effect of InGaP window layers on the cell performance was evaluated as shown in Fig. 2. In external quantum efficiency measurements (EQE), a significant improved EQE response in shorter wavelength region was obtained for the cell with the window layer, which was attributed to the passivation of surface recombination. In I-V characteristics, the Jsc, Voc, FF, and efficiency values were improved from 16.54 mA/cm², 0.909 V, 83.87%, and 16.54%, respectively, to 26.41 mA/cm², 0.925 V, 83.06%, and 20.29%, respectively, by the insertion of the window layer. The fact that FF for both cells was almost similar with high values suggests that high-quality InGaP/GaAs heterointerfaces can be formed in our low-cost H-VPE growth with a high growth rate. Thus, this study is a major step toward the development of highly efficient III-V solar cells grown by the low-cost H-VPE technique.

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