GaAs リアヘテロ接合太陽電池: MOVPE 高速成長のタンデム PV 応用
GaAs rear-heterojunction solar cell: application of high-speed MOVPE to tandem PV cells

°ソダーバンル・ハッサネット[1], 生方映徳[2], 渡辺健太郎[1], 菅谷武芳[3], 中野義昭[4], 杉山正和[1]
° H. Sodabanlu[1], A. Ubukata[2], K. Watanabe[1], T. Sugaya[3], Y. Nakano[4], M. Sugiyama[1]
[1]東大先端研 RCAST, The Univ. of Tokyo, [2]大陽日酸(株) Taiyo Nippon Sanso Corp., [3]産総研 AIST, [4]東大院工 School of Engineering, The Univ. of Tokyo
°E-mail: sodabanlu@hotaka.t.u-tokyo.ac.jp

1 Introduction

We have reported the success in high speed MOVPE growth which 24.5 % conversion efficiency could be realized in a GaAs p-on-n solar cell grown at 120 µm/h [1]. However, it was found that GaAs n-on-p solar cells had lower open-circuit voltages (V_{oc}) and efficiencies than those of p-on-n devices grown with a similar growth rate of 120 µm/h [2]. The explanation is that the mobility of hole minority carrier (n-GaAs base) is more tolerant to an increasing of defect density than that of electron minority carrier (p-GaAs base) [3]. In this work, the influences of solar cell structures, including conventional n-on-p, inverted n-on-p and rear hetero (RHT) junction, on the cell performance will be investigated using the growth rate of thick base layer of 120 µm/h.

2 Experimental details, results and discussion

All of three device structures in this work were grown on p-GaAs substrates (5° misoritentation toward [110]) and contained 50-nm thick n-InGaP window and 100-nm thick p-InGaP BSF grown at 10 µm/h. The first structure was a conventional n-on-p solar cell comprising of 10-µm/h grown highly doped n-GaAs emitter (0.1-µm thick) and 120-µm/h grown lightly doped p-GaAs base (3.0-µm thick). The second device was an inverted n-on-p solar cell with 120-µm/h grown lightly doped n-GaAs emitter (3.0-µm thick) and 10-µm/h grown highly doped p-GaAs base (0.1-µm thick). The last structure was similar with the second one but the p-GaAs base layer was omitted, i.e. the RHT junction between n-GaAs and p-InGaP. The solar cell characteristics are shown in Fig. 1. The V_{oc} of inverted and RHT devices shown in Fig. 1(a) were obviously improved from the conventional one because of lower dark current density (J_{02}) in Fig. 1(c). This indicated that the non-radiative recombination in space charge region could be reduced when the thick active (absorber) layer was changed from p-GaAs to n-GaAs and the p-n junction was positioned at the rear interface. In addition, the RHT solar cell had a slightly better V_{oc} possibly due to a larger quasi Fermi splitting. The parasitic absorption in n-InGaP window reduced EQE in short wavelength range shown in Fig. 1(b). The decrease in short wavelength EQE from the conventional baseline in inverted and RHT cells was possibly due to poor carrier extraction (hole) from the vicinity of surface to the p-GaAs substrate. This behavior might relate to a decrease in fill-factor of inverted and RHT devices.

3 Summary

The RHT structure clearly exhibits a higher V_{oc} than the conventional n-on-p solar cell. In addition, its simple structure is favorable for high speed MOVPE growth which the number of interfaces is minimized. However, the issue of carrier extraction should be more thoroughly investigated. Nevertheless, this structure can be easily integrated into multijunction solar cells which would be the further research topic.

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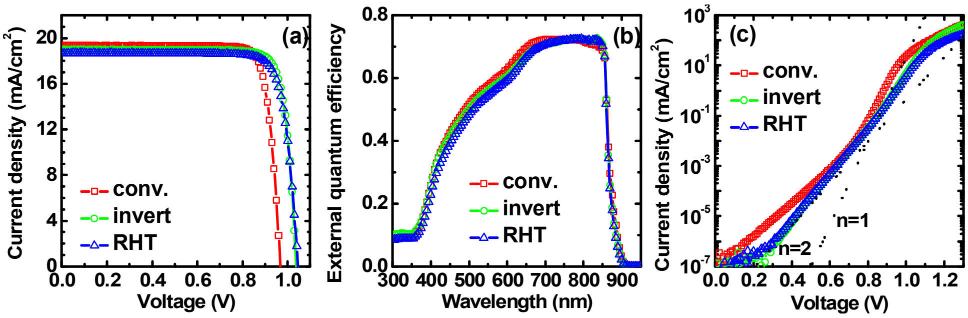

Fig. 1 (a) I-V characteristics, (b) EQE spectra and (c) dark I-V curves of high speed grown GaAs solar cells with various structures: conventional, inverted and rear hetero junction