

超高速 MOVPE 成長 GaAs の結晶品質における V/III 比の影響

Effects of V/III ratio on the quality of GaAs grown by MOVPE with extremely-high growth rate

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1 Introduction

At present, the cost of III-V solar cells is relatively high compared to Si PV cells, which limits their use to high-concentration and space applications. Much effort has been devoted recently to reduce the cost of GaAs based solar cells including the epitaxy cost, generally by metalorganic vapor phase epitaxy (MOVPE). This can be achieved by either increasing the growth rate (decrease machine overhead time) or improving material (source) utilization. Our previous study showed GaAs PV cells deposited at 90 $\mu\text{m}/\text{h}$ by MOVPE using a V/III ratio of 40 without significant degradation of cell efficiency [1]. As a further step to reduce the material cost, effects of V/III ratio on the quality of GaAs grown at an extremely high growth rate will be thoroughly investigated in this work.

2 Experimental details, results and discussion

The experiment was carried out using a horizontal MOVPE reactor with standard precursors. The growth of GaAs was done under reactor pressure, temperature and growth rate of 6 kPa, 680 $^{\circ}\text{C}$ and 90 $\mu\text{m}/\text{h}$, respectively. First, unintentionally doped 4- μm -thick GaAs layers were deposited on (100) GaAs vicinal substrates, 2° -off toward (110), with various V/III ratios of 5, 10, 20 and 40, corresponding to $2 \times 2 \mu\text{m}^2$ AFM images in Figs. 1(a), 1(b), 1(c) and 1(d), respectively. All samples exhibited step bunching, aligning along [001] direction owing to vicinal GaAs substrates. The RMS roughness of GaAs seemed to be independent on the supplied V/III ratio. The electrochemical capacitance-voltage (ECV) measurement revealed that the background hole

concentration, most likely due to carbon atoms, increased with lowering V/III ratio. In the previous study [1], GaAs p-n solar cells comprising n-GaAs base layer were studied. Accordingly, in this report, influences of V/III ratio on minority hole lifetime in the n-GaAs layer grown at 90 $\mu\text{m}/\text{h}$ have been studied by AlGaAs/GaAs/AlGaAs doublehetero structure. Time-resolved PL under 780-nm excitation in Fig. 2 shows the decay characteristics of the n-GaAs grown at 90 $\mu\text{m}/\text{h}$ with various V/III ratios. The sample with V/III ratio of 5 shows the remarkably longest decay time. The ECV measurement indicated that the electron concentration in the n-GaAs layer grown at a V/III ratio of 5 was about one half of the values in the other samples. The impact of V/III ratio on the non-radiative carrier lifetime, which is related to crystal quality, is not clear possibly because radiative recombination process is dominant in the GaAs layers with a doping level of $2 \times 10^{17} - 4 \times 10^{17} \text{ cm}^{-3}$.

3 Summary

Effects of V/III ratio on the crystal quality of 90- $\mu\text{m}/\text{h}$ grown GaAs layers have been investigated. The results have not evidenced a significant change in quality as a function of V/III ratio. Further studies would focus on the influence of low V/III ratio on the performance of GaAs solar cells grown at 90 $\mu\text{m}/\text{h}$.

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[1] H. Sodabanlu et al. presented at PVSC-44, Washington DC, 2017

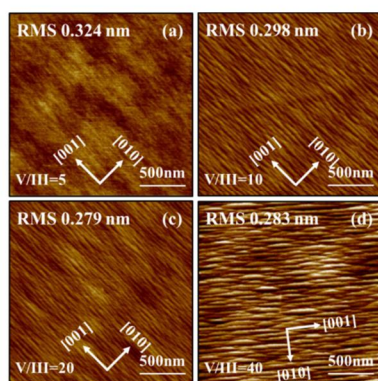


Fig. 1 $2 \times 2 \mu\text{m}^2$ AFM images of 4- μm -thick GaAs grown at 90 $\mu\text{m}/\text{h}$ with various V/III ratios

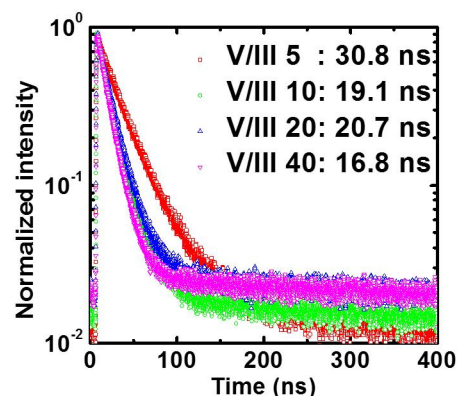


Fig. 2 TRPL spectra of GaAs doublehetero grown at 90 $\mu\text{m}/\text{h}$ with various V/III ratios