MOVPE による高速成長：InGaP 結晶成長の低コス PV 応用
High growth rate MOVPE: InGaP growth for low-cost PV application

◦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

During the last few years, the high-speed crystal growth by metalorganic vapor phase epitaxy (MOVPE) has become one of focus topics in III-V semiconductor as a promising technology to decrease the cost of III-V based solar cells. Our research group reported the growth of GaAs at a speed of 120 µm/h and the GaAs p-on-n solar cell with 24.5% efficiency [1]. As a further step approaching the growth of multijunction solar cells, ultrafast InGaP growth by MOVPE has been investigated in this work. Our preliminary study indicated that growth of InGaP at 10 µm/h using the standard condition; temperature of 650-680 °C and pressure of 6-10 kPa, resulted in poor InGaP qualities and solar cell performances. Therefore, influences of growth parameters including temperature and pressure on the InGaP quality should be thoroughly investigated and optimized.

2 Experimental details, results and discussion

The experiment was carried out using a narrow-channel horizontal MOVPE reactor with standard precursors. The growth of 1-µm thick InGaP on GaAs substrates was done with various reactor pressures of 6, 10, 15, 20, and 30 kPa and various temperatures of 580, 600, 620, 650, 680 and 720 °C. The flowrate of In precursor was maintained at 0.1 mmol/min while the flowrate of Ga precursor was varied according to growth conditions to obtain lattice-matched InGaP. The X-ray diffraction patterns indicated that the In composition in InGaP was in a range of 47.5-50.2%. Figure 1 shows 10×10 µm^2 AFM images of 1-µm-thick InGaP layers grown at 10 µm/h, 600 °C using a V/III ratio of 100 and various reactor pressures. With an increase in reactor pressure from 6 to 10 and 15 kPa, the surface morphologies were greatly improved. A further increase in reactor pressure did not clearly alter the surface morphology. The reasons can be related to the absolute pressure of P (group V atoms) and the migrations of In and Ga adatoms on the wafer surface. The experiments showed us that the roughness and morphology of InGaP were also improved with a decrease in growth temperature, especially at 580 °C. This can most likely be explained by the gas phase reactions and desorption of In from InGaP layer which depends on the reactor temperature. In addition, the Ga composition in InGaP seemed to increase with the increase in either reactor pressure or temperature.

3 Summary

A lower growth temperature and a higher pressure are beneficial for the MOVPE growth of InGaP with a fast growth rate. These optimized parameters are much different from those of GaAs growth in the same reactor. This experiment opened up the way to the fabrication of InGaP solar cells as well as III-V multijunction solar cells using the high-speed MOVPE for low cost PV application.

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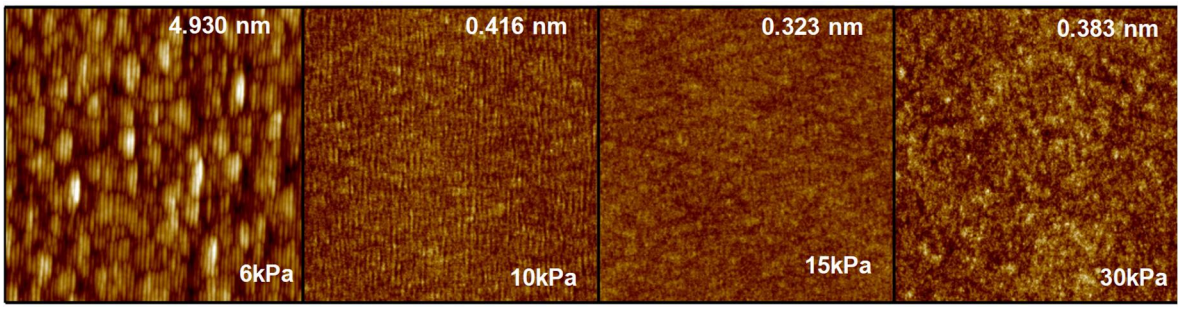

Fig. 1 10x10 µm^2 AFM images of 1-µm-thick InGaP grown at 10 µm/h, 600 °C using a V/III ratio of 100 at various reactor pressures