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Growth and properties of InGaSb alloy semiconductor crystals grown under microgravity and 1G conditions

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Introduction

InGaSb, having tuneable lattice parameter and wavelength ranging 6.096 ～ 6.479 Å and 1.7 ～ 6.8 μm is a potential material for thermo photovoltaic and IR detector applications [1]. Since the high temperature solution growth process is affected by solute convection in 1G, it is important to understand the growth kinetics due to solute and heat transport at high temperature. μG is an ideal condition because of the suppression of convection [2]. In the present study, we have grown InGaSb crystals under μG condition in Japanese experimental module "KIBO" at the International Space Station as well as 1 G condition on earth.

Experimental method

The sandwiched GaSb(111)A/Te-doped InSb/GaSb(111)A structure was used to grow InGaSb crystals by vertical gradient freezing method (Fig. 1). The growth was processed under high vacuum at around 700 ˚C, just below the melting point of GaSb. Heat pulses were introduced to measure the growth rate and the interface shape [3]. During the growth process, InSb was completely melted at 525 ˚C and GaSb seed and feed crystals were dissolved in InSb melt. When supersaturation attained at the interface, InGaSb crystal started to grow from seed interface. Further growth of InGaSb was assisted by dissolution of GaSb feed crystal. The composition of grown InGaSb crystals was analysed by electron probe micro analysis. The crystals were etched with 1:3:1 ratio of HF:$KMnO_4$ (sat.):CH_3COOH under optimized conditions to observe the growth striations.

Results and discussion

The initial analysis revealed that the dissolution length of seed and feed crystals were smaller under μG than 1G condition. The result was consistent with the numerical simulation [4]. It indicated clearly that solutal convection affected the dissolution process. Fig. 2 and Fig. 3 indicate the growth striations marked with red lines for clear visibility. The growth interface of the μG sample was flat as shown in Fig. 2. On the other hand, the 1G sample indicated the highly concave towards solution as shown in Fig. 3. The respective initial Indium compositions for the 1G sample and the μG sample were 0.037 and 0.029 which were gradually decreased along growth direction. The growth rate of the μG sample (0.15 mm/h) was higher than that of the 1G sample (0.1 mm/h).

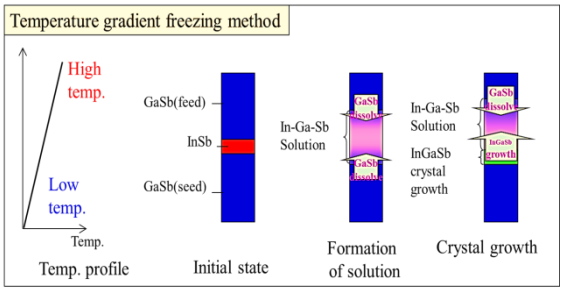

Fig. 1: Schematic of growth technique.

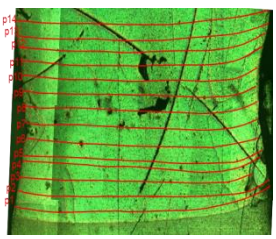

Fig. 2: Growth striations of the μG sample.

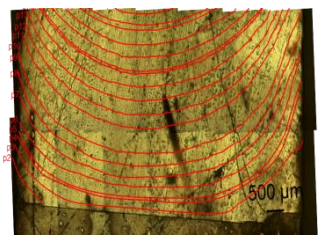

Fig. 3: Growth striations of the 1G sample.

Reference

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