第16卷第2期 半 导 体 学 报 Vol. 16, No. 2
1995年2月 CHINESE JOURNAL OF SEMICONDUCTORS Feb., 1995

Band-Inhomogeneity in GaAs Single Crystal Grown in Space

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Abstract A band type inhomogeneity with 1.2—2.0 mm width in GaAs single crystal grown in space was revealed by using electrical plate technique. The striations have not been found in this area by anodic etching

PACC: 6150C, 6170

1 Introduction

It was commonly accepted that the striations do not appear on the most of space grown single crystals but only on the ground grown materials[1] and the electrial characteristics of GaAs single crystal was improved after growing in space[2]. It seems that a perfect crystal can be prepared under microgravity conditions due to the disappearance of buoyancy driven convection and of contamination from crucible which is avoided in space. This paper introduces a band type inhomogeneity in GaAs single crystal grown in sapce. This phenomenon was found in 1987 but it was never published.

2 Experiment and results

Figure 1 represents the ampoule before it was heated in space. The ampoule consists of quartz tube of diameter 1.7 cm and length 13 cm and contains a Te-doped single crystal GaAs ingot in it. The length and diameter of the ingot are 10 cm and 0.9 cm, respectively. The electron concentration of the ingot is $(2-5)\times10^{18}/cm^3$. There is additionally 18 mg As in the ampoule to supply an As pressure of one atmosphere during the period of crystal growth.

In space, a floating molten zone was formed (furnace temperature is ~1250℃) in the middle of the ingot, then single crystals were grown face to face from two ends of the melt when the temperature decreased slowly. The two crystals grown in space are in a shape of

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Received 5 May 1994

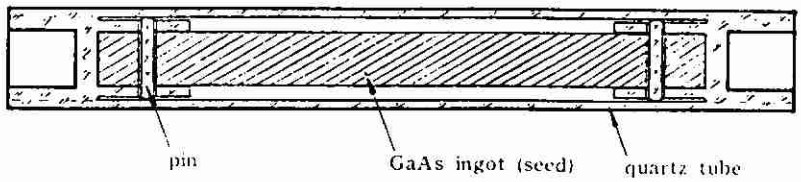

Fig. 1 Schematic diagram of the GaAs crystal growth ampoule

torch head of diameter 1 cm, and their lengths are 1 cm and 7 mm, respectively. The electric power could be supplied only for 90 minutes due to certain reasons. The temperature dropped rapidly when the electric supply was cut off. Arsenic escaped rapidly from melt and thus resulted in a break of the molten zone. The middle molten zone was drawn to the space-grown single crystal of length 7 mm, and formed polycrystal covering its surface.

After the anodic etching[3] of the crystal Ⅱ (surrounded by the polycrystal) cross section cut along the axis of the ingot, using an electrolyte of aqueous potassium hydroxide (KOH), the densely aligned parallel striations caused by thermal convection appear on the seed crystal, but not on the space-grown crystal. It is shown in Figure 2(a).

By chance, the band-inhomogeneity in GaAs single crystal grown in space was revealed by using electrical plate technique. The crystal Ⅱ (as cathode) and the stainless steel plate (as anode) were sunk into the solution consisting of KOH : H_2O=5 : 100 in weight. After plating for a few second under the condition of about 100—300 mA/cm^2, the band pattern was found on the cross section of space grown crystal as shown in figure 2(b). The contrast of this photo was increased to make the pattern clearer.

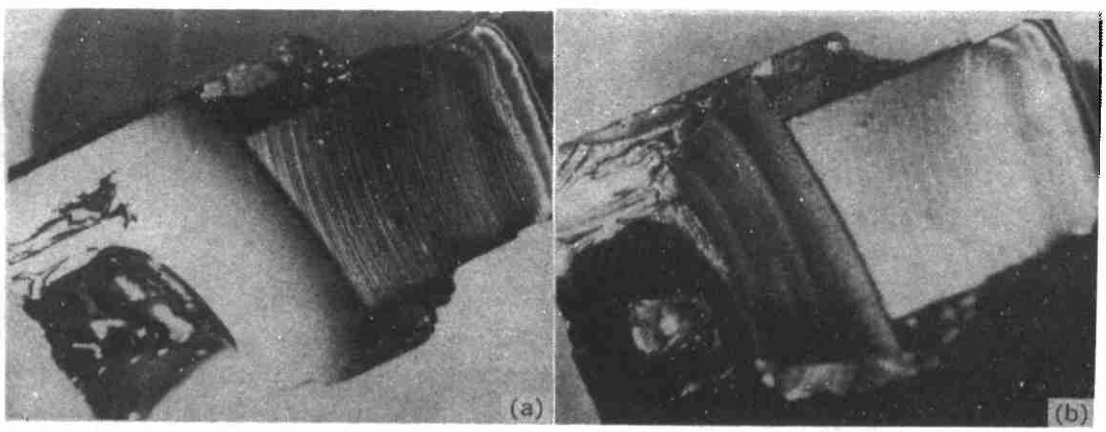

Fig. 2 The patterns of impurity striations on the seed crystal (a) and band-inhomogeneity on the space grown crystal Ⅱ (b)

3 Discussion

According to the band phenomenon, it is obvious that the GaAs single crystal grown in

space is not really homogeneous even though it is without striations. To explain the band-inhomogeneity is difficult, because the temperature drop was smooth. In this growth experiment, the first 45 minutes was for forming the molten zone and to stabilize the temperature, and the next 45 minutes was for growth.

The author estimated that the retrievable satellite traveled from south Atlantic Ocean, Africa and India Ocean to Asia. There were four areas and three changes between ocean and continent, the numbers for them are similar to the number of bands and their boundary. It is suggested that the band-inhomogeneity in GaAs single crystal may have been casued by the changes of different earth magnetic fields during growth processing.

Ackowledgement The author would like to acknowledge the help of this work by Prof. Lin Lanying, Prof. Wang Zhanguo and Mrs. Wang Fenglian.

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