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1mm-long and 4µm-wide twin free single crystal Si stripe on glass fabricated by µ-CLBA method

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Abstract

Effect of SiO_2 capping layer thickness of Si film on rotation of crystal orientation in micro chevron laser beam annealing (µ-CLBA) method was investigated. Rotation was suppressed when capping layer thickness was larger than 300nm. As a results, a single crystal Si stripe with a length of as long as 1.1mm which is free of twin defects was formed successively.

1. Introduction

In recent years, a three dimensions virtual reality (3DVR) has been developed that enables users to enjoy virtual reality by using a small mobile terminal such as a smartphone and making the moving image displayed on the terminal a 3D large screen in front of his eyes. 3DVR has a problem that the definition is degraded and the image quality is degraded as compared with the actual moving image because the terminal is placed in front of the user and the screen is made large screen with the lens. In order to achieve high image quality, it is necessary to increase the speed of the thin film transistor (TFT) driving the display, and this requires single crystal Si having high mobility of 400 cm^2/ Vs or more. In order to meet this problem, we have proposed micro chevron laser beam annealing (µ-CLBA) method, in which single crystal Si stripe on glass substrate have been realized by scanning µ-CLB though Si film. The problem of this method is that crystal orientation rotated with lateral growing, so twin defects take place when the grain grow through undesirable crystal orientation. It is important to suppress rotation of crystal orientation in order to form a defect free and successive orientation controlled single crystal Si stripe. In this paper, we demonstrate suppression of orientation rotation by inducing capping layer on Si film.

2. Experiment research method

Figure 1 shows a schematic sectional structure of the sample. SiO_2 of 300 nm was deposited on a glass substrate, a-Si of 60 nm was deposited by CVD method, and SiO_2 was deposited as a caping layer by a sputtering method. The sample was dehydrogenated at 550°C for 30min. The scanning speed of µ-CLB was fixed at 45mm/s. The total power of µ-CLB was 0.25W – 0.35W. Here thickness of capping layer t_c was varied among 0nm to 500nm to investigate its effect on orientation rotation speed v. v was defined as following equation:

$$v = \frac{d\theta}{dx}$$

where θ is crystal angle displacement and x is displacement along lateral growth direction.

The crystal orientation of Si stripe was evaluated by Electron Back Scatter Diffraction (EBSD).

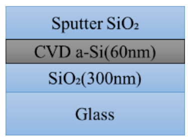

Fig.1 Sample cross section

3. Result and discussion

Figure 2 shows θ depending on x with different t_c. From the gradient, v can be defined and from which v depending on t_c was obtained, as shown in Fig.3. v was 0.5-0.6°/µm at t_c= 0, but decreased with increasing t_c, and became zero when t_c larger than 300nm. This results suggesting effectiveness of capping layer on suppressing v. Figure 4

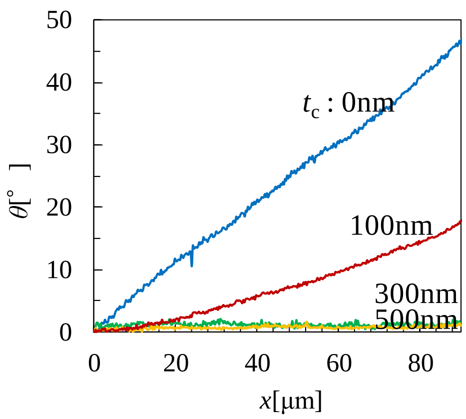

Fig.2 θ depending on x with different t_c.

shows EBSD map in both normal direction (ND) and scanning direction (SD) of Si stripe with t_c of 300nm. The length free of any any coincidence site lattice (CSL) boundary and random angle boundary was as long as 1.1 mm, and the width was 4µm. The stripe was (100) in ND (strictly, ~3° tilted from ND) with a tolerance within ±3°.

4. Conclusions

A single crystal Si stripe with a length of as long as 1.1mm which is free of twin defects was formed in µ-CLBA method. It was achieved by suppressing rotation of crystal orientation by means of using SiO_2 capping layer on Si film with the thickness larger than 300nm. This method provides selective formation of a single crystal Si stripe, which will be important for low cost fabrication of high performance c-Si TFTs for next generation ultra-high resolution flat panel displays.

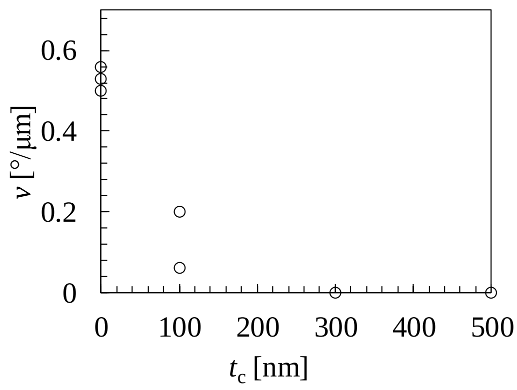

Fig. 3 t_c dependency of v

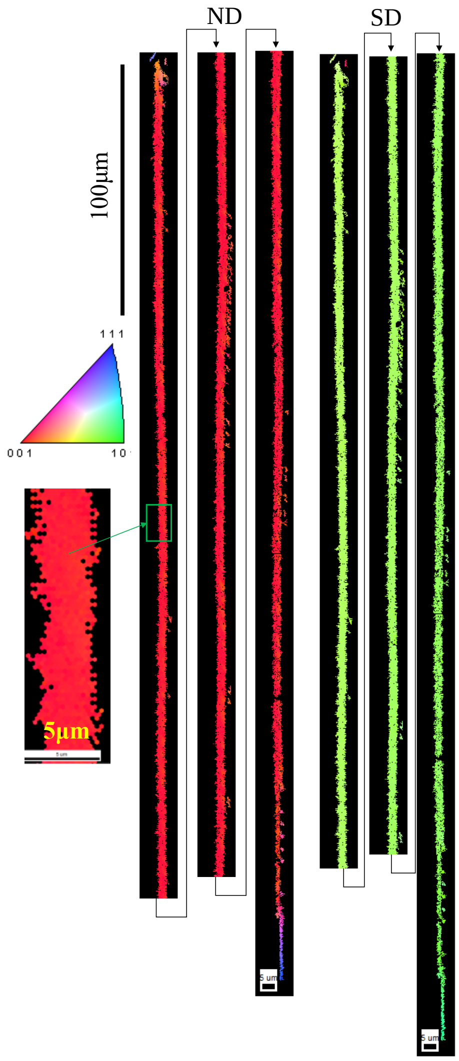

Fig.4 EBSD map in SD and ND of Si stripe with t_c = 300nm

5. Reference

[1] Wenchang Yeh, Proceedings of SPIE, 10349 (2017): 103490R.1- 103490R.7

[2] Wenchang Yeh, Satoki, Yamazaki, Akihisa Ishimoto and Shigekazu Morito, Applied Physics Express, 9 (2016) 025503.