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Twin Formation in One Dimensionally Grown Single Grain Si Stripe on Glass substrate

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Abstract

Appearance and twin boundaries in one dimensionally grown single grain Si stripe were investigated. From the crystallographic investigation of the Si stripe, twin boundaries were generally incoherent and V-shaped with its aperture toward crystal growth direction. These result shows the twin grains originated at solid-liquid interface but not formed after solidification.

1. Introduction

Micro-chevron laser beam scanning (μCLBS) method have been proposed to form single crystal stripe in thin film on glass substrate.[1] This method have been shown to be effective for both Si or Al films.[2,3] As for the Si film, crystal orientation of c-Si stripe rotates in a negative pitch direction, and the stripe contained Σ3 CSL twin boundaries within a grain. The crystal orientation rotation in negative pitch direction was explained by expansion rate difference be-tween top surface and bottom surface of Si film at solidification, and have been suppressed by forming ≥ 200 nm SiO_2 capping film on Si film. As a result, single crystal Si stripe with (100) and without twins in a length of about 3 mm have been realized.[2] Nonetheless, mechanism of twin generation in laser induced lateral growth is still not clear. In this paper, mechanism of twin generation in sc-Si stripe was investigated.

2. Experimental method

Borosilicate flexible glass with thickness of 0.14-0.17mm was used as substrate. After immersing the substrate in 40 ppm ozone water for 30 min for cleaning, 300nm-thick SiO_2 as passivation layer and 60nm-thick a-Si were deposited successively on the substrate by respectively reactive pulse-DC sputtering and DC sputtering at 400°C. Figure shows μCLBA system. The flexible sample was attached to surface of transparent hollow cylinder by vacuum chuck. The μCLB was focused on sample surface. The cylinder was rotating in a circumferential speed of 0.013 m/s. The sample after laser annealing was evaluated by scanning electron microscope (SEM) and electron backscattering diffraction (EBSD). The samples for OM observation were treated in Sirtl etch to visualize grain boundaries (GBs), while the samples for SEM and EBSD not.

3. Experimental results

Figure 2(a) and 2(b) respectively show optical photograph of Si film without and with Sirtl's etching, with an indication of scanning direction (SD), normal direction (ND), and transverse direction (TD). A 5-7μm-wide sc-Si stripe was formed at the center, with small lateral grains aside the sc-Si stripe. EBSD inverse pole figure (IPF) map of a sc-Si stripe in ND were shown in Fig.2(c), in which random angle GB, Σ3 CSL twin boundaries, and Σ9 CSL boundaries are indicated respectively by black line, red line, and green line. Figure 3 shows SEM image (70° oblique view) of sc-Si stripe. It can be divided into 4 regions from the appearance, respectively, a slightly convex but smooth region A, a wavy region B, a narrow wavy region C, and flat but finely textured region D. From comparing with Fig.2, a schematic diagram of these regions was estimated and was shown in Fig.4. Region A is corresponding to the c-Si stripe. This region was slightly convex. This is caused by agglomeration during melting, as was shown by white arrow in Fig. 4. Region C composed of very small lateral grains grew from outside region D toward melt. Region D was nanocrystalline Si caused by explosive crystallization.

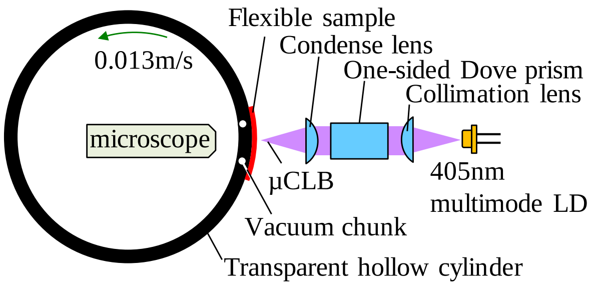

Fig.1 μCLBS system

In Fig.2(c), crystal orientation was rotating with lateral growth in a pitch direction, as have indicated before.[1] The Σ3 CSL boundaries (twin boundaries) were predominate boundaries in a stripe. All the twin boundaries are incoherent, and were typically V-shaped with aperture toward lateral growth direction. This indicate these twin grains were originated at solid-melt interface, and then grew with progressing of the solid-melt interface. Twin-mediated crystal growth which is common in crystal growth from melt with relatively weak supercooling temperature was not observed here.[45]

3. Conclusions

Appearance and twin boundaries in one dimensionally grown single grain Si stripe were shown. From the crystallographic investigation of the Si stripe, twin boundaries were generally incoherent and V-shaped with its aperture toward crystal growth direction. These result shows the twin grains originated at solid-liquid interface but not formed after solidification.

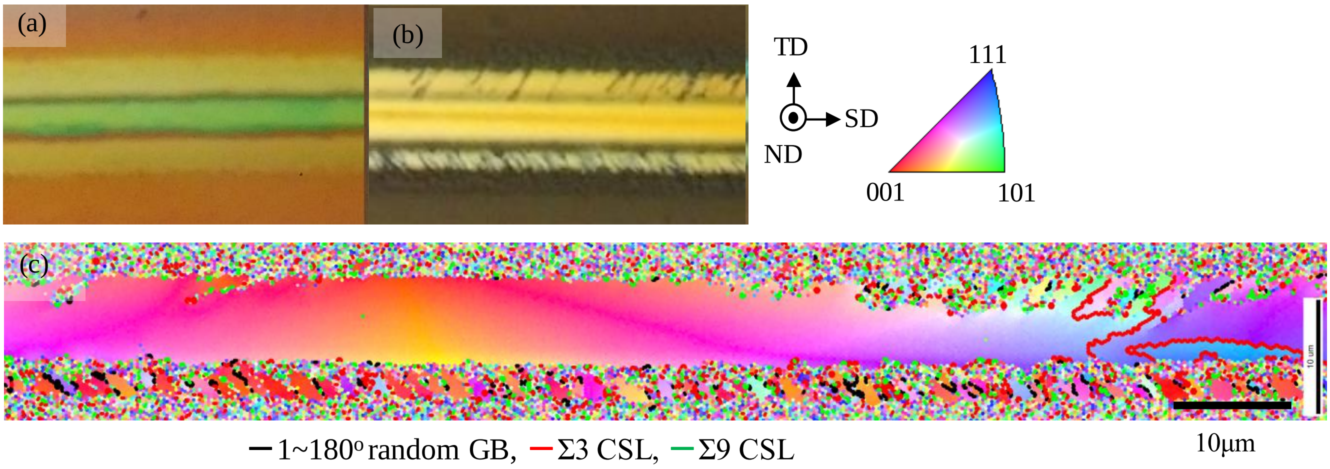

Fig.2 (a) and (b) respectively, optical photograph of Si film without and with Sirtl's etching, (c) EBSD inverse pole figure (IPF) map of a sc-Si stripe in ND, with an indication of SD, ND, and TD.

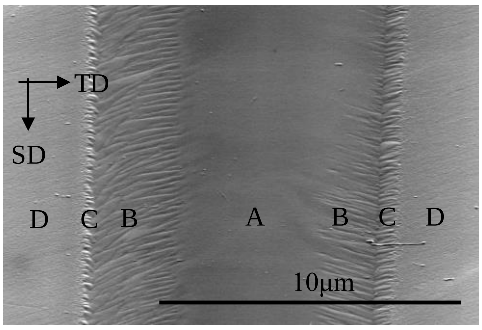

Fig.3 SEM image (70° oblique view) of c-Si stripe

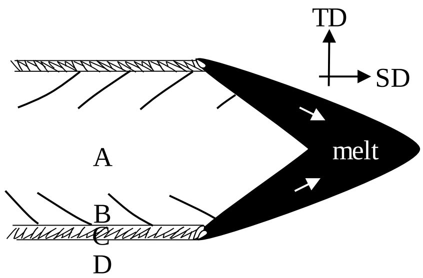

Fig. 4 Schematic diagram of grain growth in μCLBA

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