Extended Abstracts of the 15th Conference on Solid State Devices and Materials, Tokyo, 1983, pp. 27-30

A-2-2

Crystallinity of Recrystallized Si on SiO_2 by Zone Melting Method

Kohei Higuchi, Shuichi Saitoh and Hidekazu Okabayashi

Microelectronics Research Labs., NEC Corporation

Miyazaki, Miyamae-ku, Kawasaki 213, Japan

Si films recrystallization on SiO_2 was performed using the zone melting technique. The recrystallized Si films crystallinity was found to be dependent on the width of SOI islands surrounded by a seeding area, based on electron channeling pattern observations.

§1. Introduction

Si films recrystallization on SiO_2, using the zone melting method, has been reported by many authors[1-5]. This technique was characterized in preparation of large area SOI films. However, such SOI films typically contained about 50 μm wide and several hundred μm long grains or subgrains. Perfect single crystalline SOI films were not obtained yet.

The authors investigated the SOI film crystallinity dependence, for films formed by strip heater recrystallization, on the width of SOI islands surrounded by a seeding area, based on ECP (Electron Channeling Pattern) observatins.

§2. Experimental and Discussion

Si films recrystallization on SiO_2 was carried out using a strip heater annealer. Figure 1 shows a diagram a strip heater annealer, which has a fixed graphite heater with SiC coating for heating substrates up to about 1300 °C and a movable tungsten rod heater. The top tungsten rod heater is 2mm in diameter and 200 mm in length. It can be moved at 0.2 to 2.5 mm/s speeds over about 1.5 mm from the sample surface.

For investigating the seeding effects, two kinds of samples were prepared. One sample has variously sized rectangular SOI islands, enclosed by a 5 μm wide seeding area, patterned on a (100) Si substrate, as shown in Fig. 2(a). The other sample has the seeding area formed on one side of the (100) Si substrate, as shown in Fig. 2(b). Figure 2(c) shows a cross sectional view of the sample, in which 0.8 μm thick SiO_2 was thermally formed by LOCOS method and 0.5 or 1.0 μm thick poly-Si films were deposited by LPCVD. 1.0 ~ 2.0 μm thick SiO_2 films were used as a cap film. All samples were pre-annealed at 1000 °C in N_2 gas for 20 minutes.

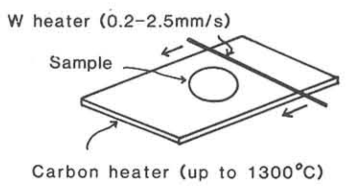


Fig. 1. Strip heater annealer diagram.

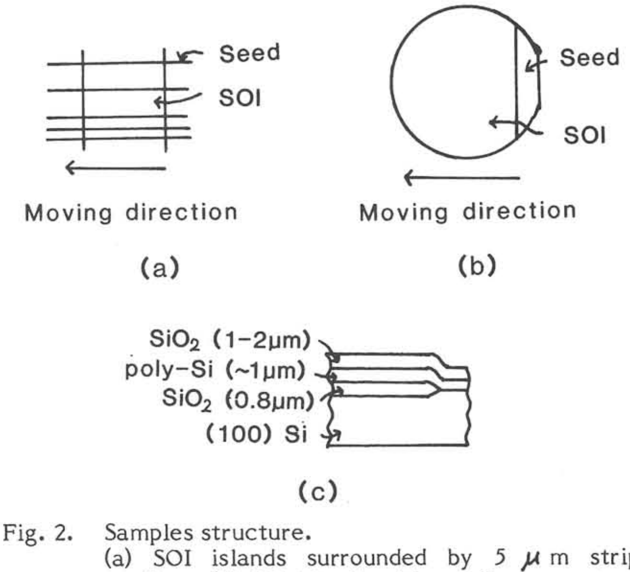


Fig. 2. Samples structure.
(a) SOI islands surrounded by 5 μm stripe seeding. (b) SOI island with seeding area at one side. (c) A cross sectional view.

1. SOI islands surrounded by a seeding area.

With the top heater moving in parallel to the stripe seeding area, as shown in Fig. 2(a), SOI islands less than about 200 μm wide were successfully recrystallized into single crystalline islands. Figure 3(a) shows an optical micrograph of a part of 100 μm wide and 3 mm long recrystallized SOI islands after Secco etching, under the condition v=0.2mm/s and $T_S \approx 1200\,^\circ C$, in which v is top heater movement speed and Ts is substrate temperature. Figure 3(b) shows ECP for the regions in Fig. 3(a). From ECP observations, (100) single crystals were found to be laterally grown. In this manner, SOI islands with small width were rather easily recrystallized into simple crystals.

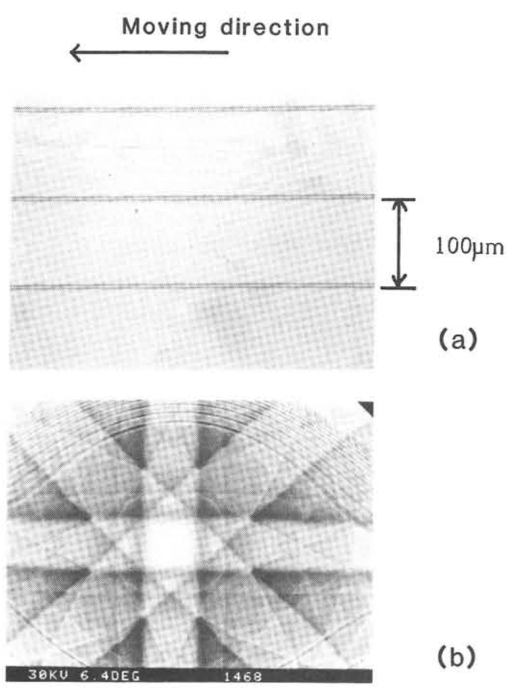


Fig. 3. (a) Optical micrograph for a part of 100 m wide and 3 mm long recrystallized SOI islands after Secco etching. (b) ECP at the regions in Fig. 3(a).

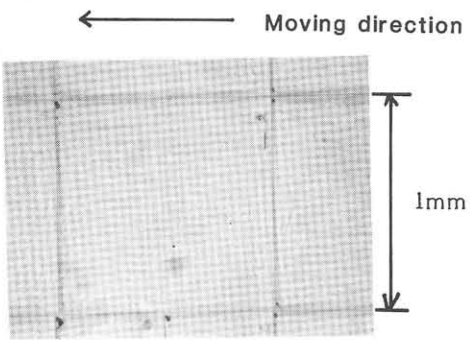


Fig. 4. A 1 mm square recrystallized SOI island after Secco etching optical micrograph.

In the case of 0.5 to a few mm wide SOI islands, SOI recrystallization into single crystals became difficult. Figure 4 shows an optical micrograph of a recrystallized 1 mm square SOI islands after Secco etching under the condition where v is 2.5 mm/s and Ts is about 1200 °C. Subgrain boundaries were observed. From ECP observations, the orientation of subgrains was nearly (100) direction.

2. SOI islands with seeding area at one side.

When a top heater was set in parallel and moved perpendicularly to the seed-SOI boundary, as shown in Fig. 2(b) for one side seeding case, which corresponds to SOI islands with infinite width, seeded single recrystallization grew laterally over an area only about 100μm long from the seed-SOI boundary, as shown in region (A) in Fig. 5(a). Figures 6(a) and 6(b) show ECPs for a seed area and region (A) which are enclosed by an open circle in Fig. 5(a). From Figs. 6(a) and 6(b), this SOI area near the seed-SOI boundary was laterally grown into single crystals. This lateral epitaxial region stopped at small grains concentrated region (B) in Fig. 5(a). In this region, no ECP was observed. After these small grains were concentrated in region (B), recrystallized SOI films (region (C)), which had dendritic grain boundaries, were observed. Figure 5(b) shows an SEM micrograph of region (C) about 5mm from the seed-SOI boundary. Figures 7(a) and 7(b) show ECPs for mutually adjacent subgrains in

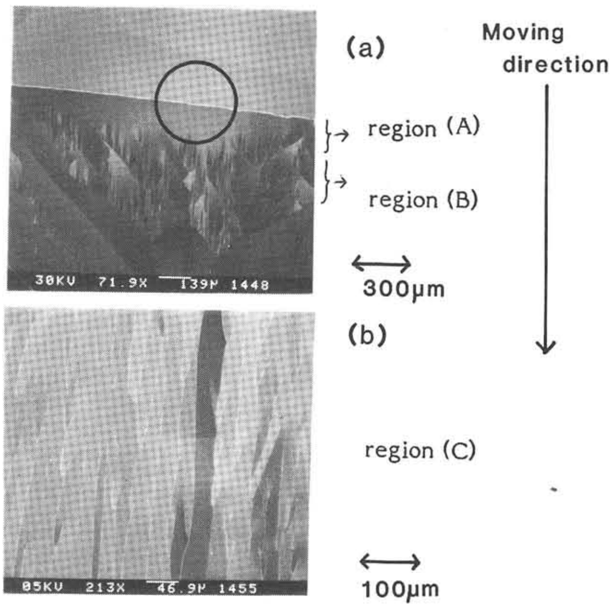
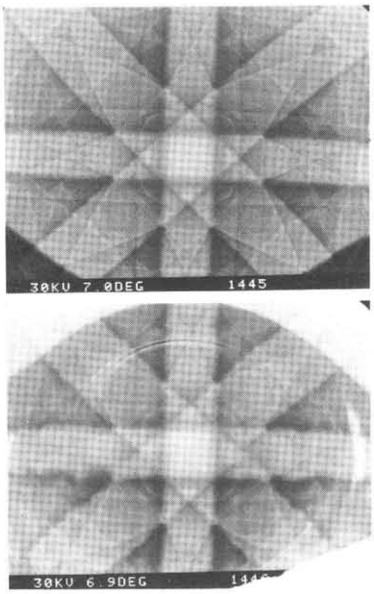


Fig. 5. SEM micrographs (a) near the seed-SOI boundary (b)about 5 mm from the seed-SOI boundary.



(a)

(b)

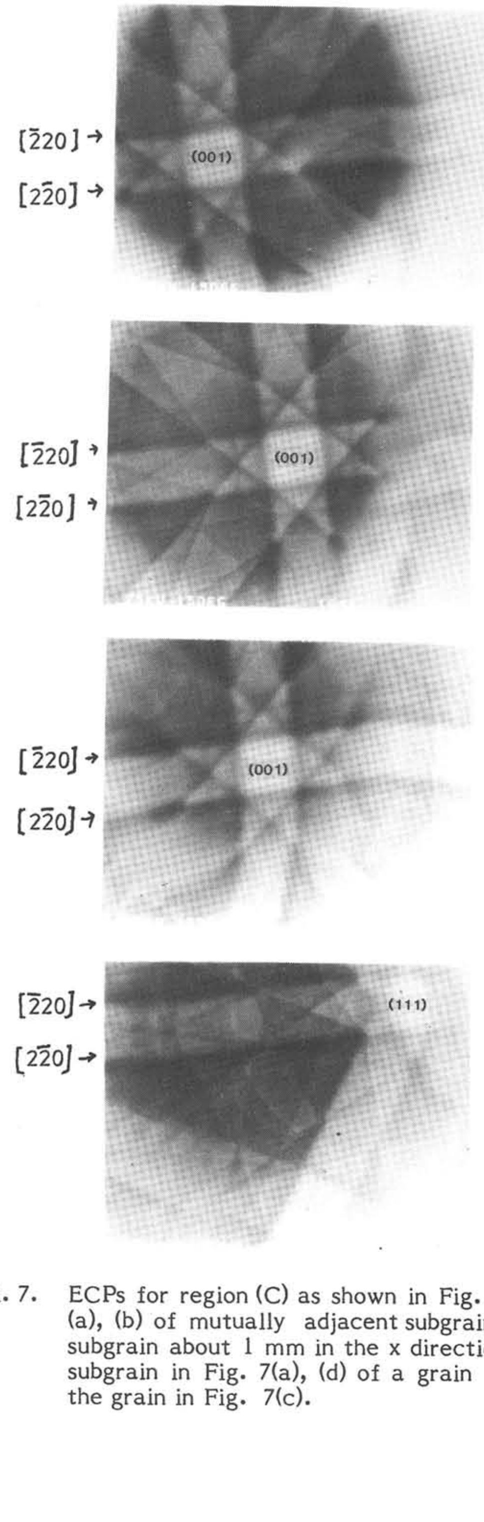
Fig. 6. ECPs (a) of a seed area (b) of an SOI area enclosed by an open circle in Fig. 5(a).

region (C). Figure 7(c) shows an ECP for a subgrain about 1 mm in the x direction from the subgrain in Fig. 7(a). A similar ECP was observed for a subgrain about 1 mm in the y direction from the subgrain in Fig. 7(a). From the translation and the rotation in ECP in Figs. 7(a)-7(c), overall variation in the orientation between these subgrains is less than 0.5 ° in the film plane and less than 5 ° in the direction normal to the substrate. The size of this subgrains region is a few mm square. Figure 7(d) shows an ECP for a grain adjacent to a grain in Fig. 7(c). The orientation of this grain is nearly (111) direction. However, no [$\bar{2}$20] or [2$\bar{2}$0] plane rotation was observed.

§3. Summary

Recrystallized Si films crystallinity on SiO_2 was found to be dependent on the width of SOI islands surrounded by a seedng area.

1. SOI islands, less than 200 μm wide, were recrystallized into single crystalline islands.
2. In 0.5 to a few mm wide SOI islands, subgrains were formed.
3. For one side seedng case, which corresponds to SOI islands with infinite width, an only 100 μm long single crystal grew laterally from the seed-SOI boundary. In the major part of an SOI film, large angle grains and subgrains growth were observed.



(a)

(b)

(c)

(d)

Fgi. 7. ECPs for region (C) as shown in Fig. 5(b). ECPs (a), (b) of mutually adjacent subgrains, (c) of a subgrain about 1 mm in the x direction from the subgrain in Fig. 7(a), (d) of a grain adjacent to the grain in Fig. 7(c).

Acknowledgement

The authors gratefully thank Y. Okuto for his encouragement and helpfull discussions and C. Takekawa and K. Yamada for samples fabrications.

This work was performed under the management of the R & D Association for Future Electron Devices as a part of the R & D Project of Basic Technology for Future Industries sponsored by Agency of Industrial Science and Technology, MITI.

References

1) J.C.C. Fan, M.W. Geis and B.Y. Tsaur: Appl. Phys. Lett. 38 (1981) 365.

2) M.W. Geis, H.I. Smith, B.Y. Tsaur, J.C.C. Fan, D.J. Silversmith and R.W. Mountain: J. Electrochem. Soc. 129 (1982) 2812.

3) H.J. Leamy, C.C. Chang, H. Baumgart, R.A. Lemons and J. Chang: Materials Lett. 1 (1982) 33.

4) R.F. Pinizzotto, H.W. Lam and B.L. Vaandrager: Appl. Phys. Lett. 40 (1982) 388.

5) H.W. Lam, R.F. Pinizotto, S.D.S. Malhi and B.L. Vaandrager: Appl. Phys. Lett. 41 (1982) 1083.