Extended Abstracts of the 2007 International Conference on Solid State Devices and Materials, Tsukuba, 2007, pp. 596-597

P-8-19L

Large Grain Poly-crystalline Si Films by Carbon Dioxide Laser Assisted SLG Method

Hiroshi Tsunazawa[1], Yoshihiro Taniguchi[1], Shinya Okazaki[1], Masanori Seki[1], Yasuhito Otsuka[1], Hiroaki Takeuchi[1], Masaya Okamoto[1] and Junichiro Nakayama[2]

[1] Production Technology Development Group, SHARP Corporation
2613-1, Ichinomoto-cho, Tenri, Nara 632-8567, Japan
Phone: +81-743-65-4950 E-mail: tsunazawa.hiroshi@sharp.co.jp
[2] International Business Group, SHARP Laboratories of America Inc.
5750 NW PACIFIC RIM BLVD., CAMAS, WA 98607, USA

1. Introduction

Super lateral growth (SLG) method of Si films is very attractive due to its high mobility, because it can make large grain poly-Si films [1], [2].

In this paper, we introduce the newly developed carbon dioxide laser (CDL) assisted SLG crystallization to obtain higher mobility based on larger grain than the conventional SLG.

2. Concept of CDL assisted SLG crystallization

The scheme of CDL assisted SLG crystallization is shown in Figure 1. A CDL (a wavelength of 10.6um) module is added on to the XeCl excimer laser anneal system for SLG.

The excimer laser is absorbed by an a-Si film; meanwhile, the CDL penetrates the a-Si film and is absorbed by a base coat layer. The base coat layer is heated with the CDL irradiation. On this heated condition, SLG crystallization, that is the excimer laser irradiation through a mask slit, is occurred. Then the heat flow by the excimer laser irradiation to the substrate is prevented; thereby, the SLG crystal length is expanded compared with the conventional SLG crystallization.

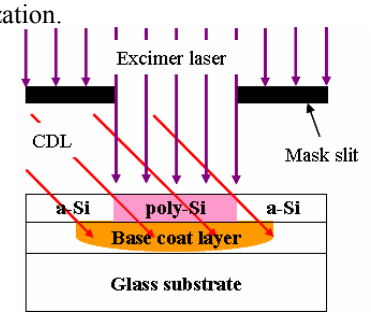


Fig. 1 CDL assisted SLG crystallization.

3. CDL assisted SLG crystallization (Single shot)

The effect of the crystal length expansion by CDL assistance was investigated. Sample structure was an a-Si film of 50nm thickness / a base coat layer of 100nm thickness/ a glass substrate.

CDL assisted SLG crystallization by single shot irradiation of both excimer laser and CDL was demonstrated. Figure 2 shows the relationship between CDL energy and a lateral growth length (LGL). LGL becomes longer with increasing CDL energy and a crystal grain of about 6μm length was observed.

Figure 3 shows a SEM image of a 6μm length grain after Secco-etching. Crystals have grown laterally from the both ends of a 12μm width slit, and they collide at the center of the slit and form a "ridge".

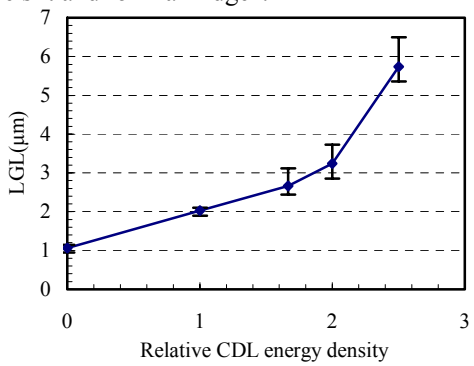


Fig. 2 Relationship between CDL energy and LGL.

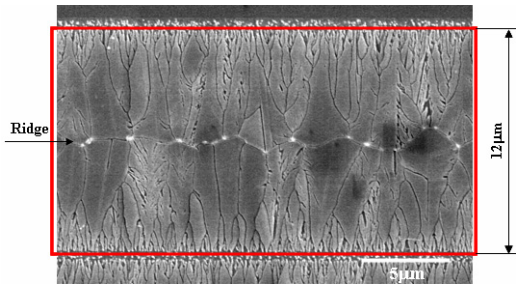


Fig. 3 SEM image of CDL assisted SLG crystallized sample.

4. Application to Sequential Lateral Solidification (SLS)

The grain by CDL assisted SLG can be expanded by the Sequential Lateral Solidification (SLS) technique as a multi shot crystallization [3].

Figure 4 schematically illustrates the process of sequential growth by the SLS technique. The SLG grain by the first shot is succeeded in the second shot shifted from the first shot, and the crystal length is expanded by repeating this operation sequentially [4]. The ridge formed at the previous shot is eliminated at the following shot, as a result, only the last shot ridge remains and the region between two ridges is one unit of SLS crystal. The SLS length (L) (=ridge distance) is expressed in

$$L = SP \times (N-1) + SW - OL \qquad (1)$$

where, SP is a scan pitch (shift distance in each shot), N is the number of SLS shots, SW is a slit width and OL is a overlap with neighboring crystals. SW and SP is set as SW<2LGL and SP<LGL for LGL. Based on these viewpoints, we can set up a larger SW and a longer SP in CDL assistance because of the longer LGL as described previously.

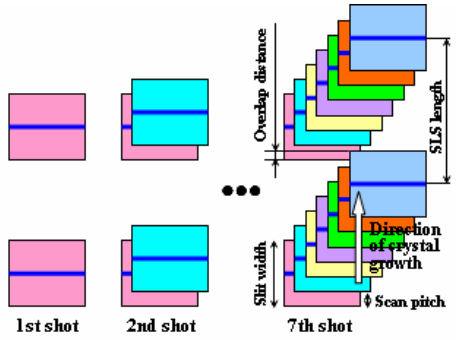


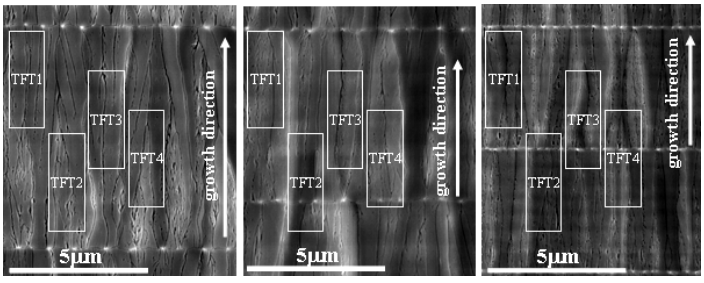
Fig. 4 Schematical drawings of the SLS method.

By using SLS technique, three types of SLS crystal samples were fabricated as shown in Table I. In sample C without the CDL assistance, a SLS length is 4.5μm. In sample A and B with the CDL assistance, a SLS length is 8.3μm and 6.4μm respectively with enlargement of SW and SP. In sample B, OL is enlarged compared with sample A.

Table I Fabricating conditions of SLS samples

Sample #	CDL	Slit width	Scan pitch	Overlap	SLS length
A	○	4.0μm	0.9μm	1.1μm	8.3μm
B	○	4.0μm	0.9μm	3.0μm	6.4μm
C	x	2.0μm	0.5μm	0.5μm	4.5μm

Figure 5 shows SEM images of those SLS samples. In sample A, the SLS length is the longest among sample A to C and its crystal grain width has spread along with the crystal growth direction corresponding to long growth. In sample B with enlargement of OL, the small grain near the initial growth point can be eliminated, thus, the high homogeneous crystal is obtained.



Sample A Sample B Sample C

Fig. 5 SEM images of SLS samples.

5. Fabrication of TFT and characteristics

The thin-film transistors (TFTs) were fabricated with the above SLS samples A to C.

80 pieces of n-channel transistors and those of p-channel transistors were formed on a substrate measuring 730mm x 920mm, separately for sample A to C. The channel length was 3.5μm, and the channel direction was set as parallel to the direction of crystal growth.

Figure 6 shows the relation between the SLS length and the mobility. Figure 6(a) is the result from the n-channel transistors and (b) is the result from the p-channel transistors. The uniformity of the mobility indicates as a coefficient variation (CV) at each sample. The average mobility and its uniformity improve with increasing SLS length by CDL assistance for both n-channel and p-channel transistors. The average mobility of n-channel transistors in sample A is the highest in this experiment and it was about 300cm^2/Vs. It is considered that the frequency of channels crossing the ridge decrease with a large SLS length as shown in Figure 5. The mobility and uniformity of sample A with a long SLS length are higher than those of sample B with a homogeneous grain width. It is considered that the contribution of the SLS length is more significant than the homogeneity of grain widths for mobility.

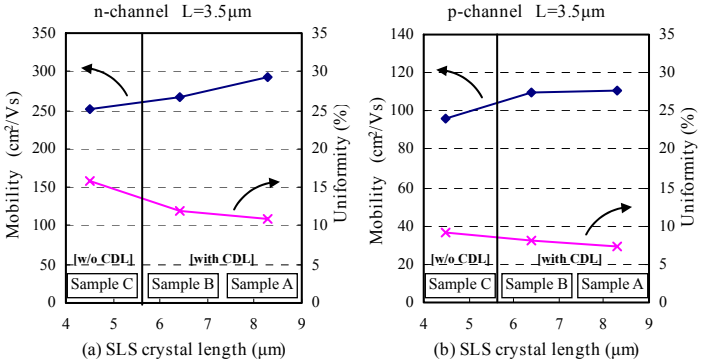


Fig. 6 TFT characteristics of SLS samples.

6. Conclusions

The following knowledge was acquired as a result of investigating the CDL assisted SLG method.

(1) About a 6μm LGL was obtained even with a single shot crystallization.

(2) The crystal grain by CDL assisted SLG could be expanded by the SLS technique. The SLS length with CDL assistance was longer than without CDL assistance. As a result, the mobility and the uniformity of TFTs were improved; the mobility of about 300cm^2/Vs was obtained in n-channel transistors.

References

[1] J. S. Im and H. J. Kim, Appl. Phys. Lett. **64** (1994) 2303.

[2] K. Ishikawa, M. Ozawa, C-H. Oh and M. Matsumura, Jpn. J. Appl. Phys. **37** (1998) 731.

[3] R. S. Sposili and J. S. Im, Appl. Phys. Lett. **69** (1996) 2864.

[4] A. T. Voutsas, A. Limanov and J. S. Im, J. Appl. Phys. **94** (2003) 7445.