THE EFFECTS OF DEFOCUS ON THE PULSED-LASER-INDUCED CRYSTALLIZATION OF SI FILM IN OPTICS-BASED C-SLG METHOD WITH NUMERICAL ANALYSIS

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1. Introduction

Optics-based C-SLG (controlled super lateral growth [1]) method for pulsed-laser-induced crystallization of Si film is a promising concept to grow large poly-Si grains for high performance TFTs. In optics-based C-SLG method such as SLS (sequential lateral solidification [2]), defocus strongly influences the spatial intensity profile of the patterned laser beamlet and has a noticeable effect on the final microstructure of crystallization.

2. Numerical Analysis

The spatial intensity profiles of the patterned(7 μm) laser beamlet are simulated with various defocus conditions and then the crystallization of Si film is simulated with those spatial intensity profiles and various energy density conditions. The system is 800Å Si film on 3000Å silicon oxide layer and glass substrate.

3. Results and Discussion

The spatial intensity profile of laser is shown in figure1. As defocus increases, the spatial intensity profile of laser has a maximum intensity at central area and the value of maximum intensity becomes higher, but it is remarkable that FWHM of profile becomes narrower because the total energy sum of each profile must be all the same. In case that defocus is larger than theoretical DOF (depth of focus, 10 μm) the shape and the size of beamlet are not defined definitely due to the smooth intensity gradient. Energy is redistributed by the effect of defocus.

The width of complete-molten region is shown in figure 2. For in-focus condition, complete-molten region appears at energy density of 500mJ/cm^2, but the width is larger than those of the other defocus conditions due to wider FWHM of profile. For defocus of 40 μm and of 50 μm, complete-molten region appears in the narrow central area at lower energy density of 450mJ/cm^2 due to the energy concentration on the central area. For all defocus conditions, the width of complete-molten region becomes larger as energy density increases, but the increase of width is limited to a certain value because FWHM of profile is restricted itself and higher energy generally leads to agglomeration due to a surface tension gradient [3]. As defocus increases, agglomeration happens easily at lower energy density due to the energy concentration on the narrow central region and ultimately reduces the upper bound of energy density, i.e., the process window. In this study, agglomeration is not simulated, so we plot the results over the same range of energy density which is reasonable for all defocus conditions.

Lateral growth starts from both edges of the complete-molten region. Lateral growth fronts collide with each other in the center or collide with the nucleation region which is filled with small poly-Si grains. Lateral growth distance is shown in figure 3 and the final microstructure is shown in figure 4. As defocus increases, lateral growth distance becomes longer at the same energy density because the incubation time for nucleation is prolonged by the energy concentration on the narrower complete-molten region. The incubation time for nucleation is shown in figure 5. However, the final lateral growth distance depends on the width of complete-molten region. Therefore, the final lateral growth distance of in-focus condition is expected to reach nearly 7.0 μm which is the size of original beamlet, whereas that of defocus of 50 μm is limited to about 5.5 μm.

4. Conclusions

In conclusion, it is important that the deviation of focus should be maintained within DOF in order to have a wide process range without agglomeration and in order to get the microstructure of large poly-Si grains which has the size of original beamlet in optics-based C-SLG method.

5. Reference

[1] J.S.Im, et al., Phys. Stat. Sol. A166, 1998, p603
[2] R.S.Sposili, et al., Appl. Phys. Lett. Vol.69, No.19, 1996, pp2864-2866
[3] T.R.Anthony, et al., J.Appl. Phys. 48, 1977, p3888

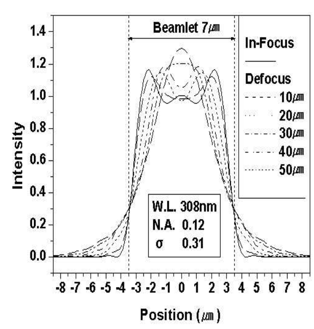


Fig. 1. Spatial intensity profile of laser

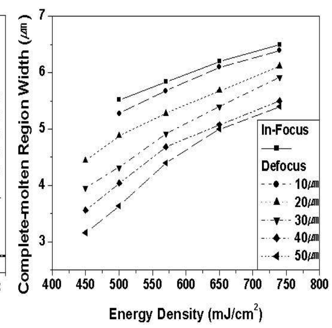


Fig. 2. Width of Complete molten region

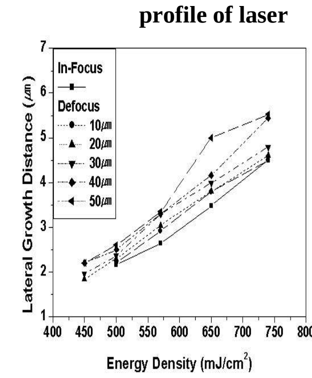


Fig. 3. Lateral growth distance

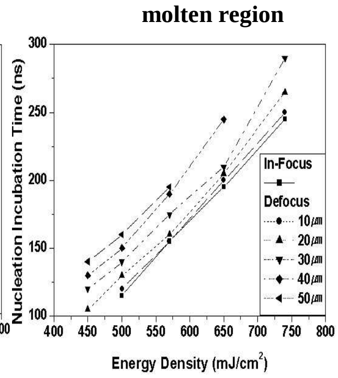


Fig. 5. Incubation time for Nucleation

E/D mJ/cm^2

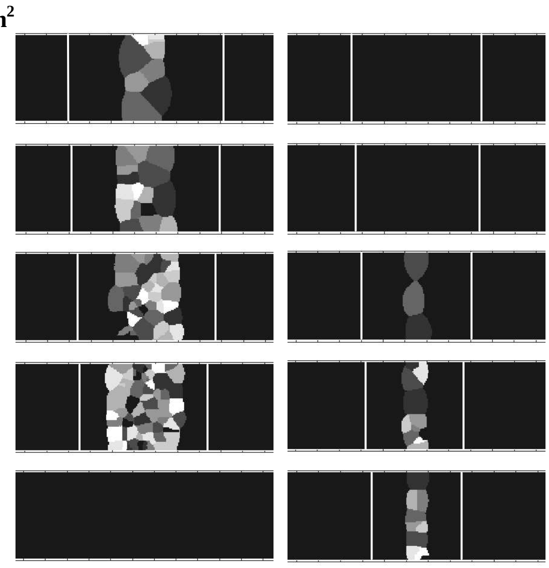
740

650

570

500

450



(a)in-focus **(b)defocus of 50 μm**

Fig. 4. Final microstructures with energy density (E/D) for (a)in-focus and (b)defocus of 50 μm