To enlarge the lateral grain growth length we introduce a heat reservoir layer to increase the grain growth time. Figure 3.12 is the fabrication procedure. The steps are similar to figure 3.9 and the only difference is that a 3500Å capping SiO_2 layer was deposited on the α-Si film before the laser irradiation and the heat reservoir layer was removed by the diluted HF in 15 minutes after laser irradiation.

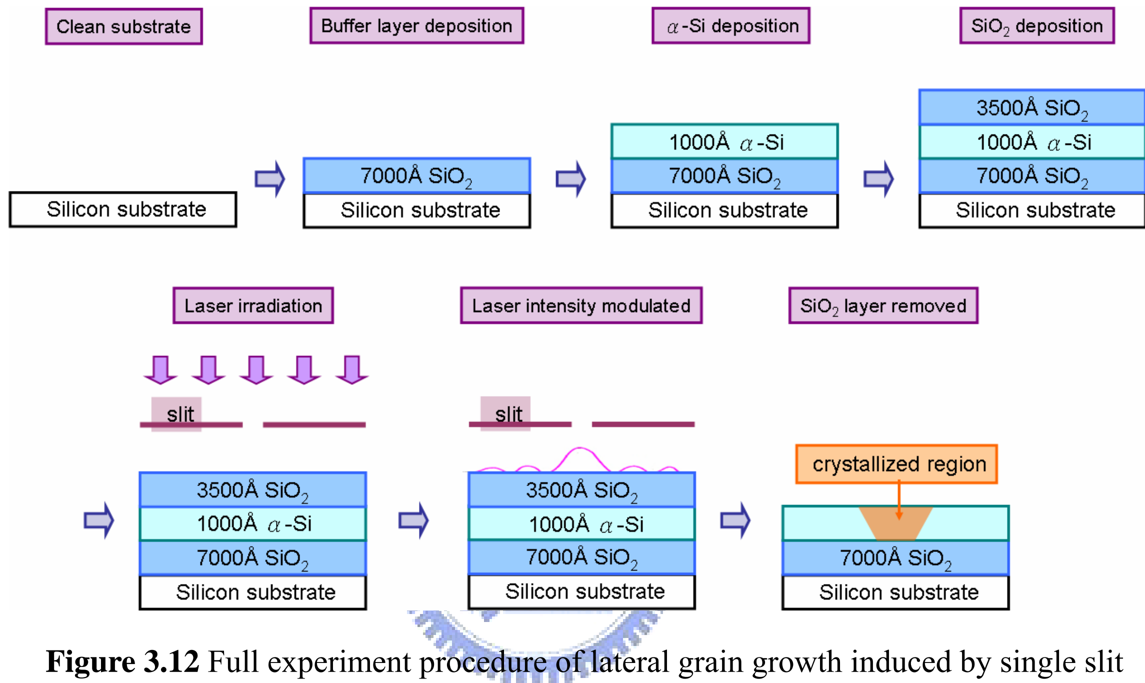


Figure 3.12 Full experiment procedure of lateral grain growth induced by single slit diffraction with capping oxide layer (including the sample preparation and laser irradiation).

The SEM images of the single slit diffraction with the heat reservoir layer are shown in figure 3.13(a) and (b). The reservoir layer could absorb the exceeding thermal energy transferred from the Si film. When the temperature of the Si film became lower than that of SiO_2 the thermal energy stored in the capping layer would release and transfer back to the Si layer. The film thickness of the heat reservoir layer is a critical parameter. The thinner film couldn't store enough thermal energy such that the effect of the reservoir layer would be limited. The thicker SiO_2 film wouldn't be a heat reservoir layer any more but the heat sink due to great amount of thermal energy transferred to the capping oxide. The heat transferred to the SiO_2 layer would increase the temperature of SiO_2 but the temperature was not high enough to heat the Si layer again as the temperature of the Si layer decreased. As our

expectation the lateral grain size increases to 2μm. It's 1.5 times that without the capping SiO_2. It's similar to the result which was presented by Masakiyo Matsumura in 2002[16] shown in figure 3.14. The lateral grain growth length increased from 4μm to 7μm.

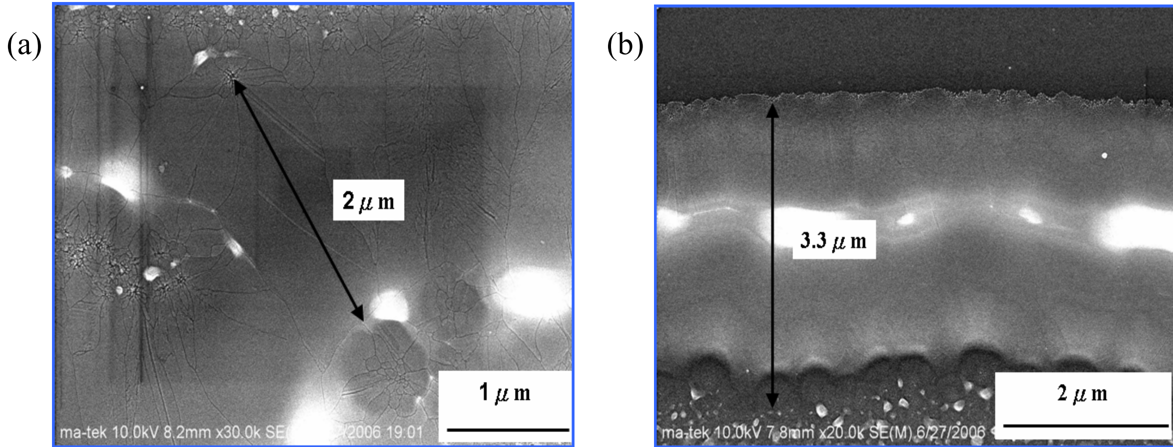


Figure 3.13 The SEM images for the lateral grain growth region with a capping SiO_2 layer. (a) L = 4.124mm, the lateral grain growth length = 2μm. (b) The lateral grain growth length = 3μm with a single grain boundary in it.

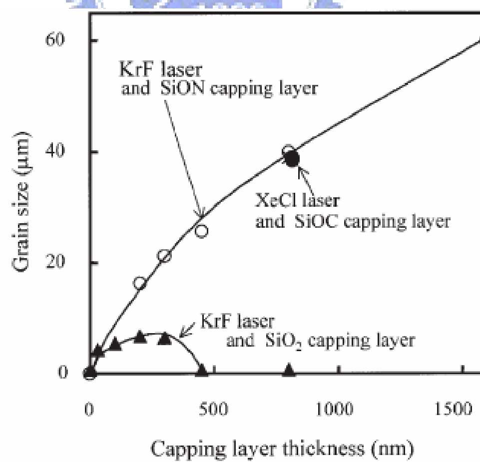


Figure 3.14 The effect of capping layer in PMELC. The initial grain size is 4.5μm without capping layer. The optimum SiO_2 film thickness is 370nm and the grain size is 7μm which is about 1.56 times the former.

In the lateral crystallization induced by the single slit diffraction, the lateral crystallization position and the grain length could be principally controlled by the laser energy

and laser intensity profile which depends on the “L/a” separately. Furthermore, the grain size could be enlarged by depositing the heat reservoir layer SiO_2 which could reserve the exceeding heat stored in it during the crystallization process. In figure 3.15, we compare the heat flux at 25ns (just after irradiation) and 200ns. At 25ns the laser energy was only absorbed by the Si layer and the heat flux indicates that the thermal energy tends to transfer to the SiO_2 layer At time = 140ns, the temperature of the Si layer was lower than that of the capping layer such that the heat stored in the capping SiO_2 transfer to the Si layer to increasing the melting time of the Si layer. The longer melting time would increase the grain growth time.

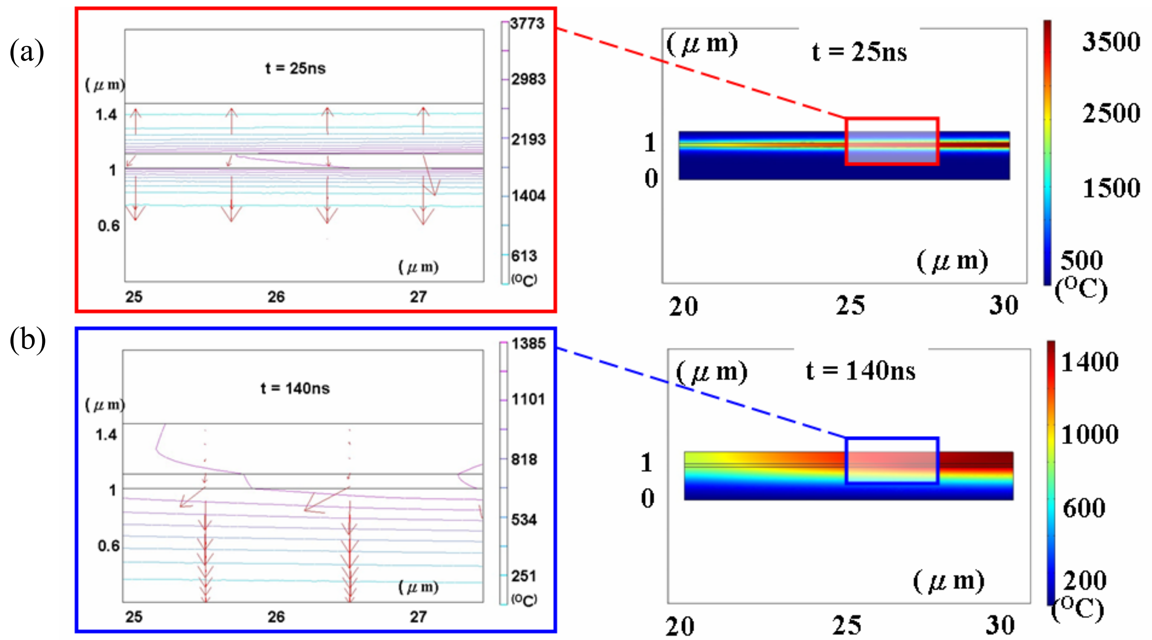


Figure 3.15 Heat flux at (a) time = 25ns and (b) time = 140ns.

When the α-Si film thickness increases to 2000Å the lateral grain growth would be enlarged. The curves of lateral grain growth length versus L with and without the capping reservoir layer is shown in Figure 3.16. We found that the lateral grain length of the poly Si with the capping SiO_2 is 1.2 times that without capping layer because the 3500Å SiO_2 might not be enough for the 2000Å Si thickness. If we would like to enlarge the grain size more, a thicker SiO_2 film is necessary.

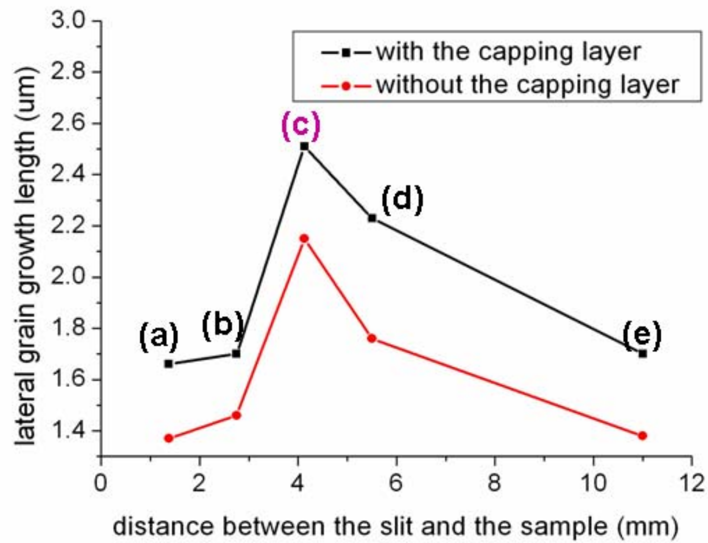
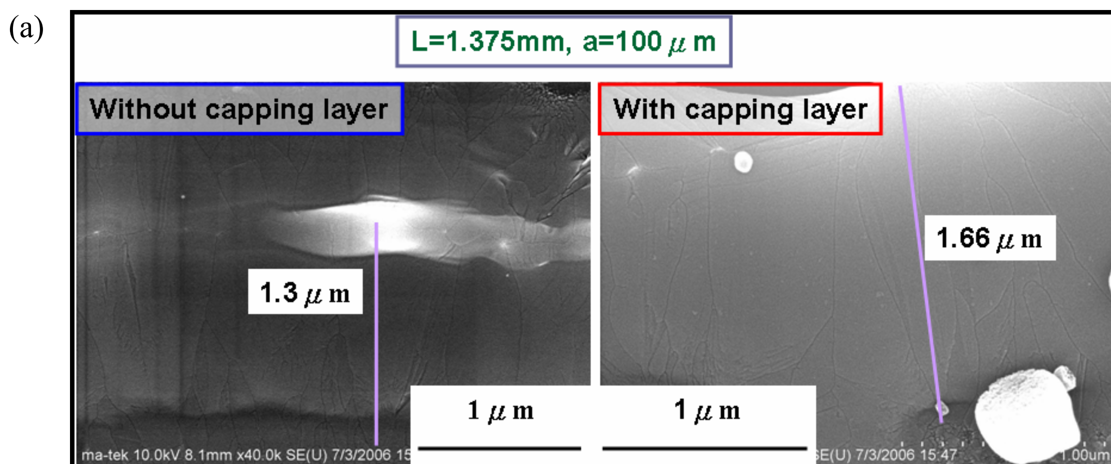


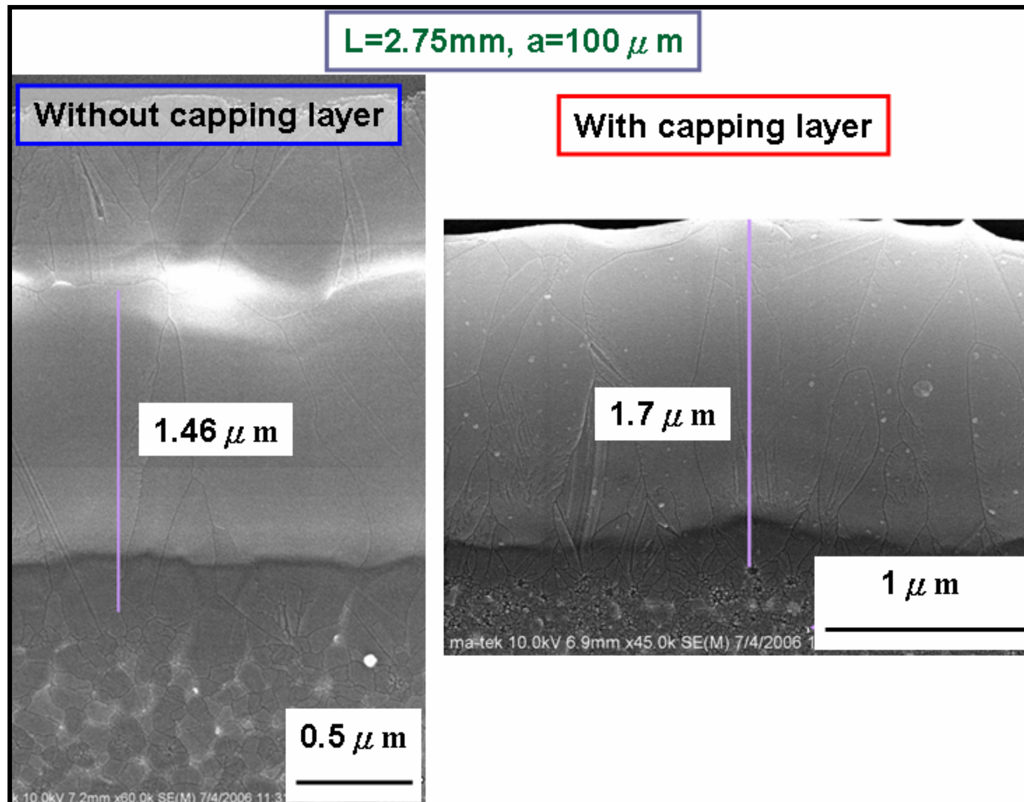
Figure 3.16 Lateral grain size versus the distance between slit and sample with and without the capping layer.

The fine view of the SEM images for the lateral grain growth region is shown in figure 3.17, the laser energy is about 650mJ/cm^2. L and a are labeled on it. The left figures are the sample without the reservoir film, and the right ones are that with the capping SiO_2.

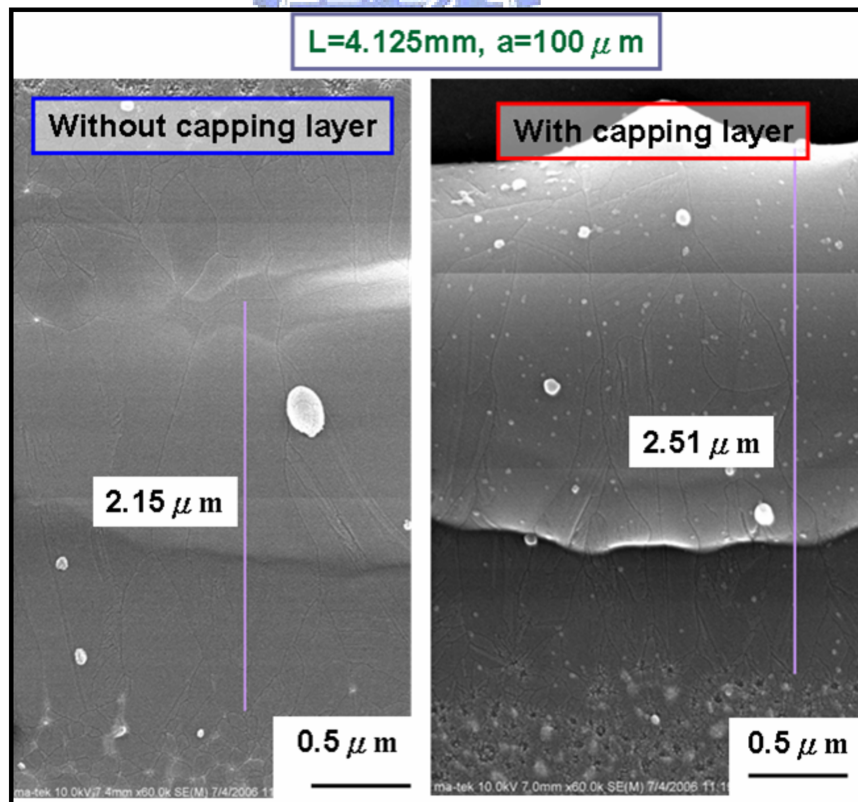
(a)



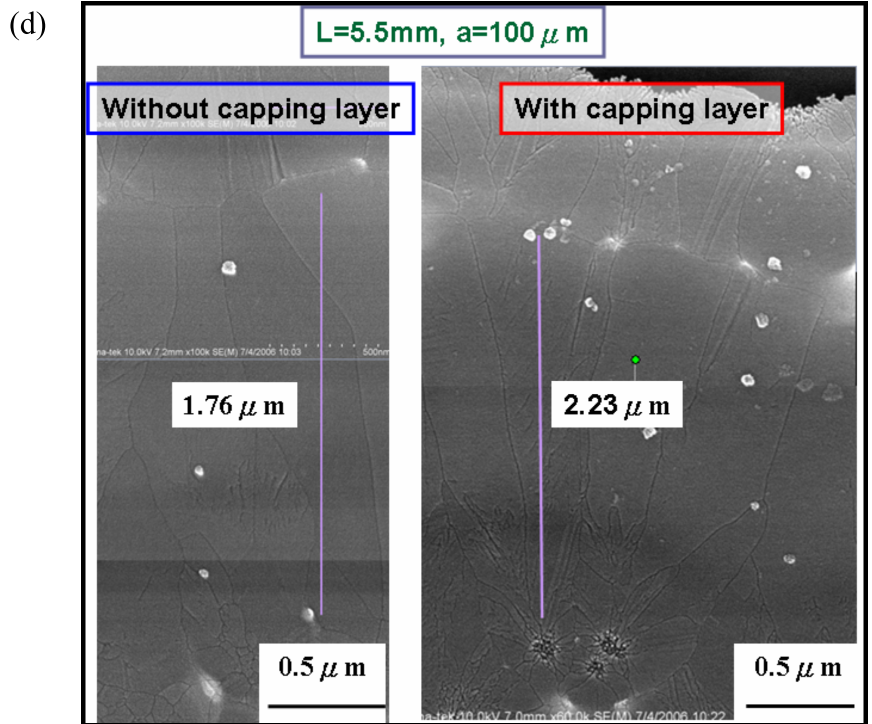
(b)



(c)



(d)



(e)

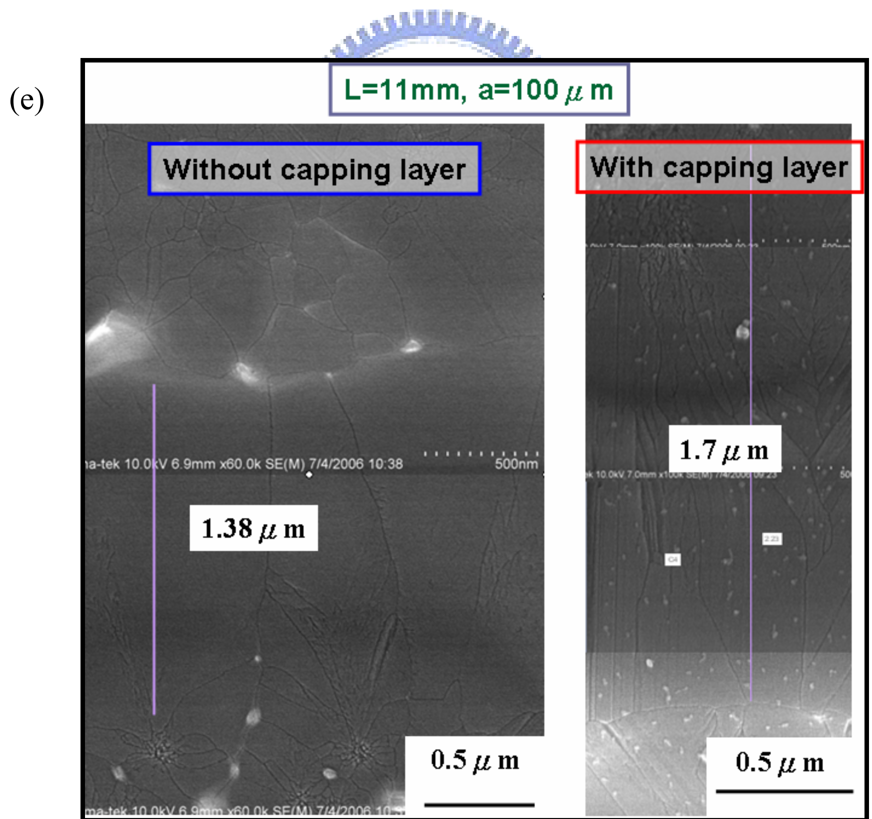


Figure 3.17 The fine view of the SEM image for the lateral grain growth region. The α-Si film thickness = 2000Å, laser intensity = 650mJ/cm^2 , a = 100μm, L = (a)1.375mm, (b)2.7mm, (c)4.125mm, (d)5.5mm, (e)11mm respectively.

Chapter 4 Conclusion and future work

In our simulation, we didn't consider the condition that the value of thermal conductivity and the heat specific would change with the temperature. The simulation would be completed until this term is combined in it. In the metal reflection method, the grain growth length and grain growth direction could be controlled well. We found that lateral grain length increasing with the laser energy density increasing as shown in figure 3.4 (f). However, the ablation of metal Cr film would occur at the laser intensity larger than 300mJ/cm^2. There are fine grains exiting in region near the edge of metal patterns due to the random nucleation induced by the rapid temperature decreasing. Nuclei couldn't be controlled at the expected position precisely. For the nano-hole structure, the average grain size modulated by the value of L and a, the grain size is equal to (L-a)/2. The nucleation position was controlled at the edge of holes. In single slit diffraction method, the lateral crystallization mainly depends on the laser intensity distribution slope. In figure 3.11(f), when the slope is not large enough the lateral grain growth phenomenon would not be obvious. With a reservoir 3500Å SiO_2 film, the average grain size increase to 2μm which is about 1.5 times that without capping SiO_2 layer.

Compare the three method we tried to approach the lateral grain growth in table 4.1. We could find that the largest lateral grain length is induced by the single slit methods, the lateral growth direction control is induced by the metal reflection layer and the nuclei position control is induced by the nano-hole structure. For metal reflection layer, a new metal material which could endure the higher laser energy is necessary to enlarge the lateral grain growth size. For the nano-structure, a proper value of L (the distance between each hole) and D (the size of the nano-holes) could approach a largest grain size as possible. For the single slit diffraction method, the subsequence and larger lateral grains could be obtained by tuning the laser intensity distribution and the laser energy and the effect of the heat reservoir layer could also enhanced by change the film thickness and the material. The distance between the slit

and the sample should be controlled with a movable stage such that the intensity distribution could be more easily and precisely. Furthermore, the design of the slit size and shape would be useful way to approach 2D grain growth control. Combining the laser intensity modulation and the structure method is a useful way to create a single grain in the TFT channel and these methods would take into the device fabrication in future.

Table 4.1 Comparison of three crystallization methods.

	Average lateral grain length	Nuclei position control	Grain growth direction control
Metal reflection layer	0.7 μm	normal	great
Nano-hole structure	0.4 μm	great	good
Single-slit diffraction (with capping layer)	1.3 μm (2 μm)	normal	good

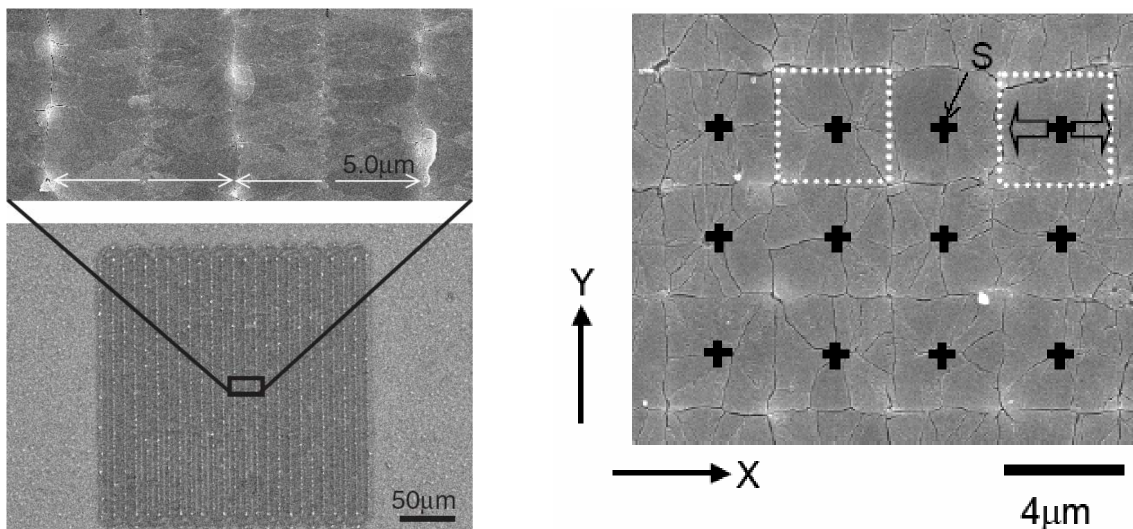


Figure 4.1 The subsequence lateral grain growth region induced by tuning the laser intensity well[26] and 2D grain growth control.

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