Chapter 4 Fabrication

The fabrication processes for sub-micro protein patterns are introduced in this chapter. The flowchart is illustrated in Figure 4.1.

4.1 Flow

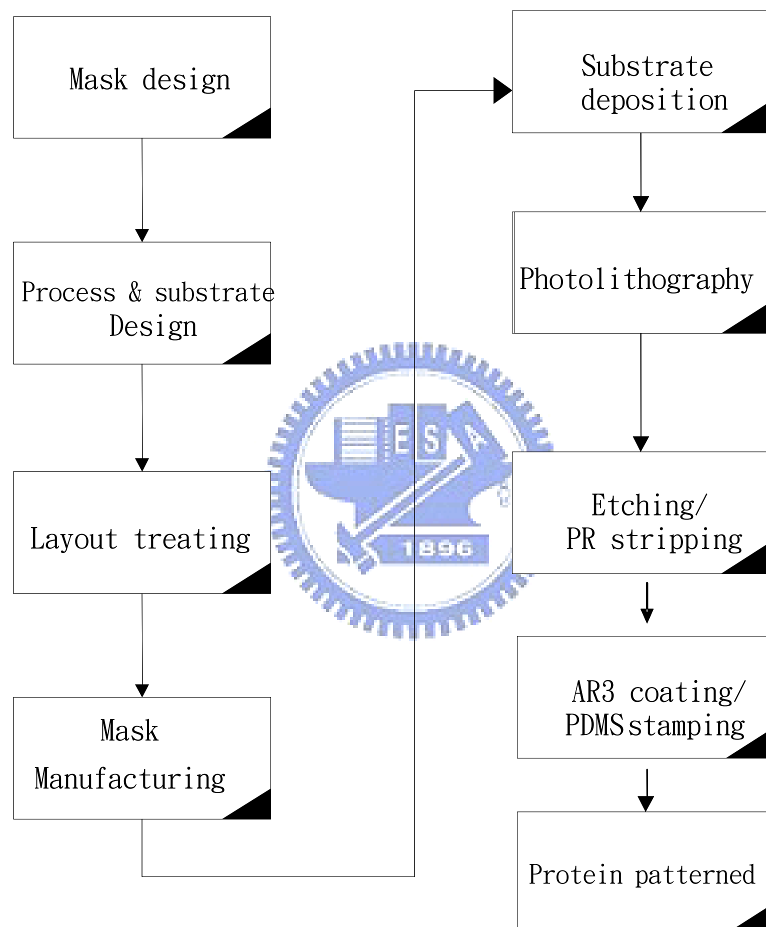


Figure 4.1 Flowchart of fabricating sub-micro protein patterns.

4.2 Mask manufacturing

In this thesis we choose the DUV lithography, some properties of mask for DUV must be concerned, such as blank material, flatness, defect size and CD controlling, etc.

The Mask is manufactured by TCE (Toppan Chunghwa Electronics) ,Mask Size is 6"
and material of blank are Quartz & Chrome.

4.3 Photolithography

In this process we use KrF(λ =248 nm) scanner for fabricating sub-micro patterns. Silicon or TEOS films (Silicon base) of wafers were primed with HMDS. The UV82 (Shipley) photoresist were spun to the thickness (0.6 um) and baked at 130C for 90 sec. The DUV scanner as shown in figure 4.2 is S206B (Nikon)and the illumination we choice is NA=0.82, σ =0.85 for exposure. After exposure, the samples were post-exposure-baked at 130C for 90 sec and developed by developer track ACT-8 (TEL) for 2 min. Then the photoresist masters were generated.

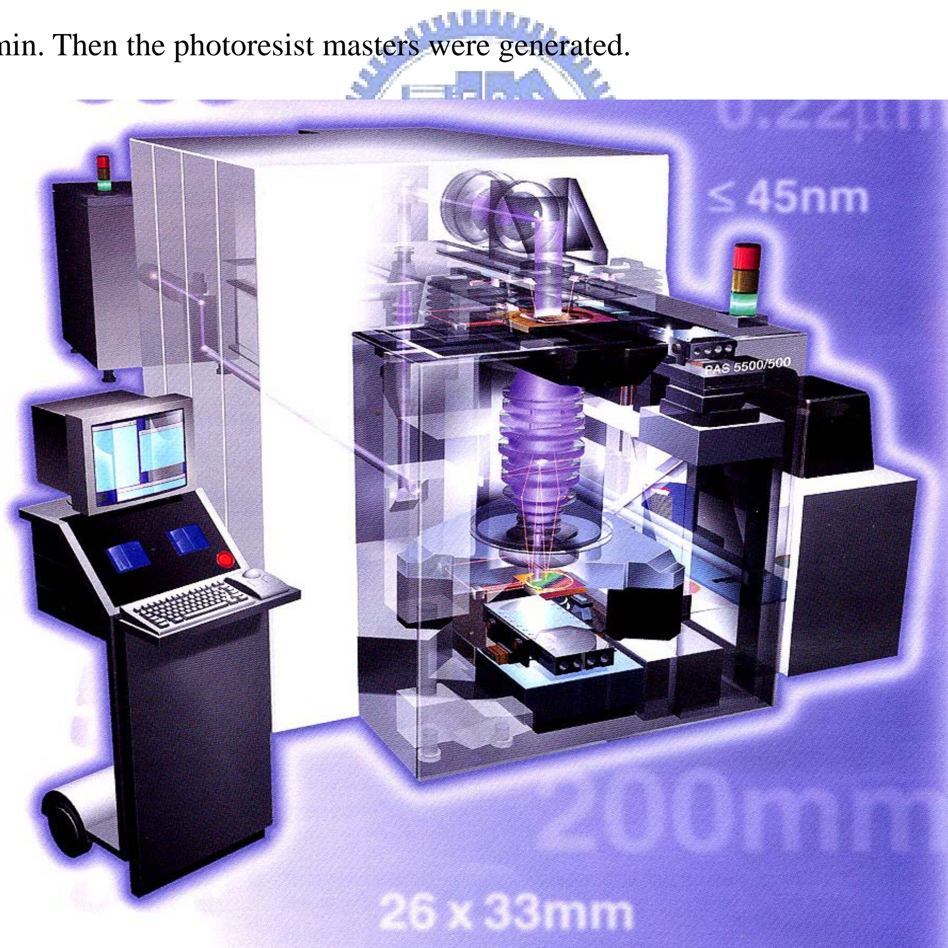


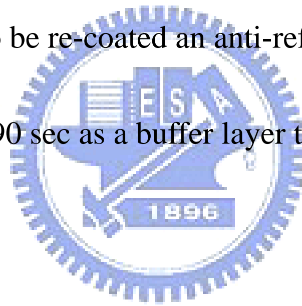
Figure 4.2 The picture of KrF (λ =248 nm) scanner

4.4 Hard mask and RIE etching

We deposited a TEOS film with 0.3 um thickness above the silicon structure of wafer. After photolithography, we use RIE etcher LAM 9400 (LAM) with recipe 10mT/350TCP/100BP/70Cl2/ 100HBr and transfer of the patterns into the TEOS film, then using RIE etcher again and the patterns have been successfully transfer into substrate of silicon.

4.5 Buffer layers coating

The samples then have to be re-coated an anti-reflection layer AR3 (Shipley) 700A and baking at 130°C for 90 sec as a buffer layer to avoid sticking issue between silicon and PDMS.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4.6 PDMS stamp

Then we prepared by casting the liquid prepolymer of PDMS against a master that has a patterned relief structure. After that, The PDMS stamp is treated in oxygen plasma cleaner (Diener electronic) evacuated with a mechanical roughing pump for 20 s at 100W prior to protein immobilization.

4.7 Protein micropatterns

Laminin solution (50 μg /ml in PBS) is dropped on the surface of the patterned

stamp for 4 hours at room temperature to allow for protein adsorption. The stamps were rinsed with diluted PBS and distilled water and then blown dry with a nitrogen blow-off gun. The stamp is placed in contact with 2.2 cm2 glass coverslip for 2 min. The coverslips are then immersed in sterile PBS before cell plating.

4.8 Measurement

For the wafer CD controlling, the measurement tool we use is SEM (Scanning Electron Microscope) S9220 (Hitachi) .For the control of pattern profile , we use JOEL 6700 for pattern cross-section.

Chapter 5 Results

Protein sub-micro patterns have successfully been generated by DUV lithography with micro contact printing method. Some principal results will be shown in this chapter. We will analyze and compare in both methods.

5.1 Photolithography

From figure 5.1,6 sets of patterns could be generated by lithography process. The exposure condition is NA=0.82, σ =0.85 (Nikon S206) with 6000A resist thickness(Shipley UV-82)

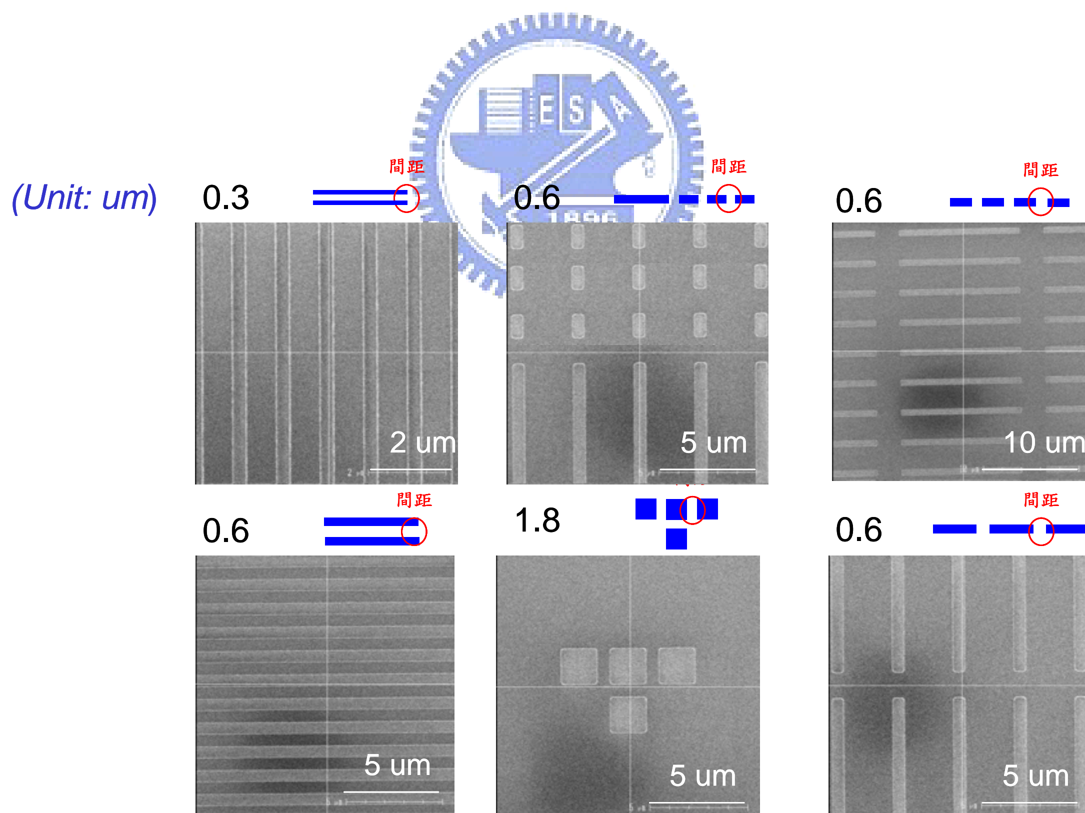

Figure 5.1 The top view pictures of 6 sets of resist patterns by lithography process

5.2 Silicon layers

In figure 5.2, 0.6 um dash line pattern (5B) could be generated in RIE etcher (LAM 9400). (a) shows the cross section in 5 degree tilt. (b) and (c) show the cross section with 15kvX15000 and 15kvX75000.The profile of oxide film is taper with 30 degree and sharp in silicon structure. The thickness of oxide film and silicon structure are 2400A and 4600 A.

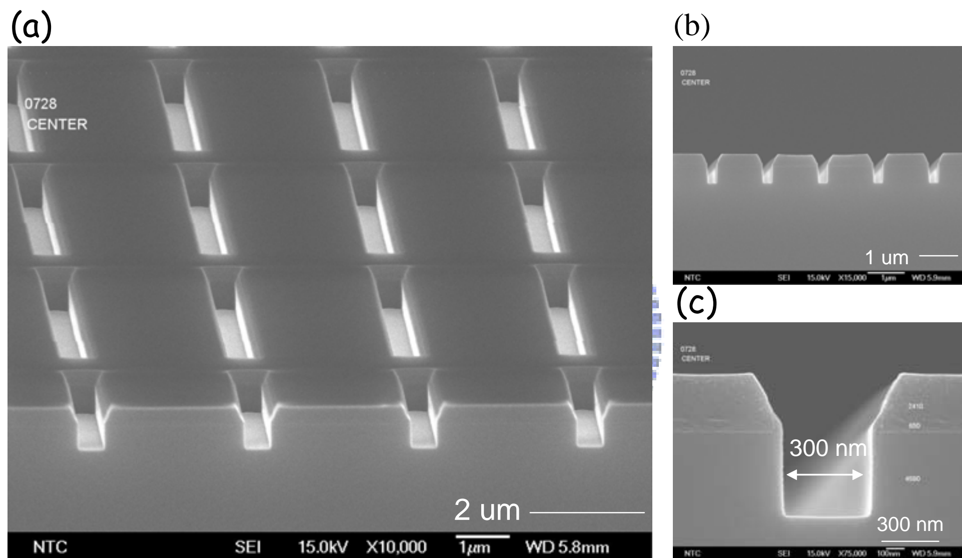

Figure 5.2 The cross sectional pictures of dash lines (5B) in Si patterns after RIE etching

5.3 PDMS layers

From figure 5.3, 6 sets of patterns could be generated by photoresist masters stamping. Figure 5.4 shows the cross section of short dash lines PDMS patterns.

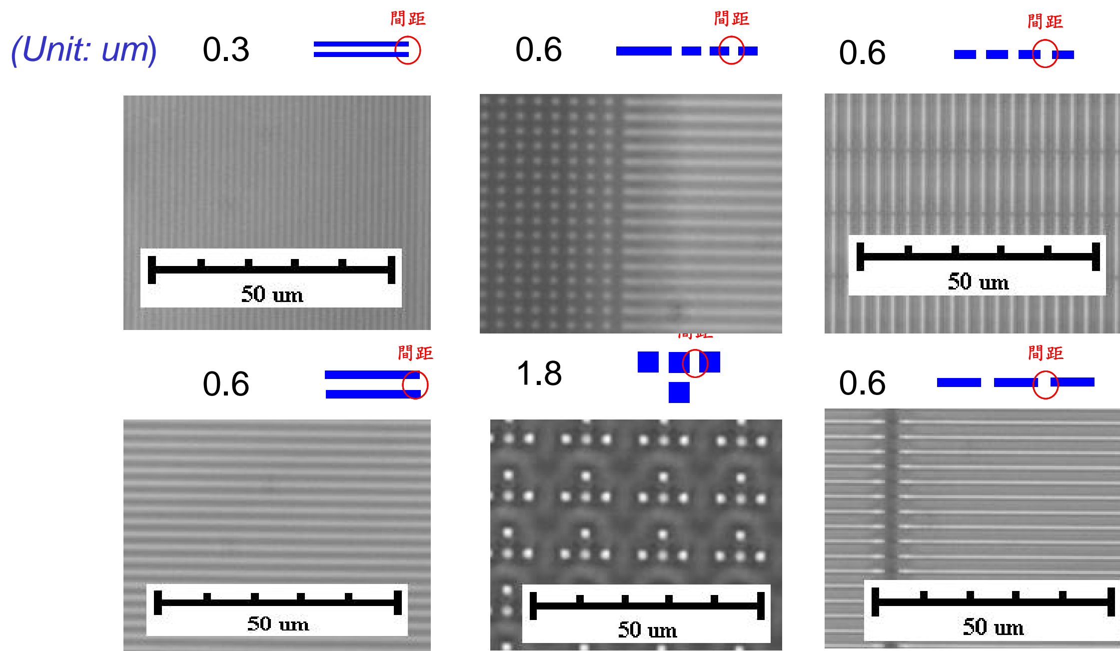

Figure 5.3 The top view pictures of 6 sets of PDMS patterns by silicon masters

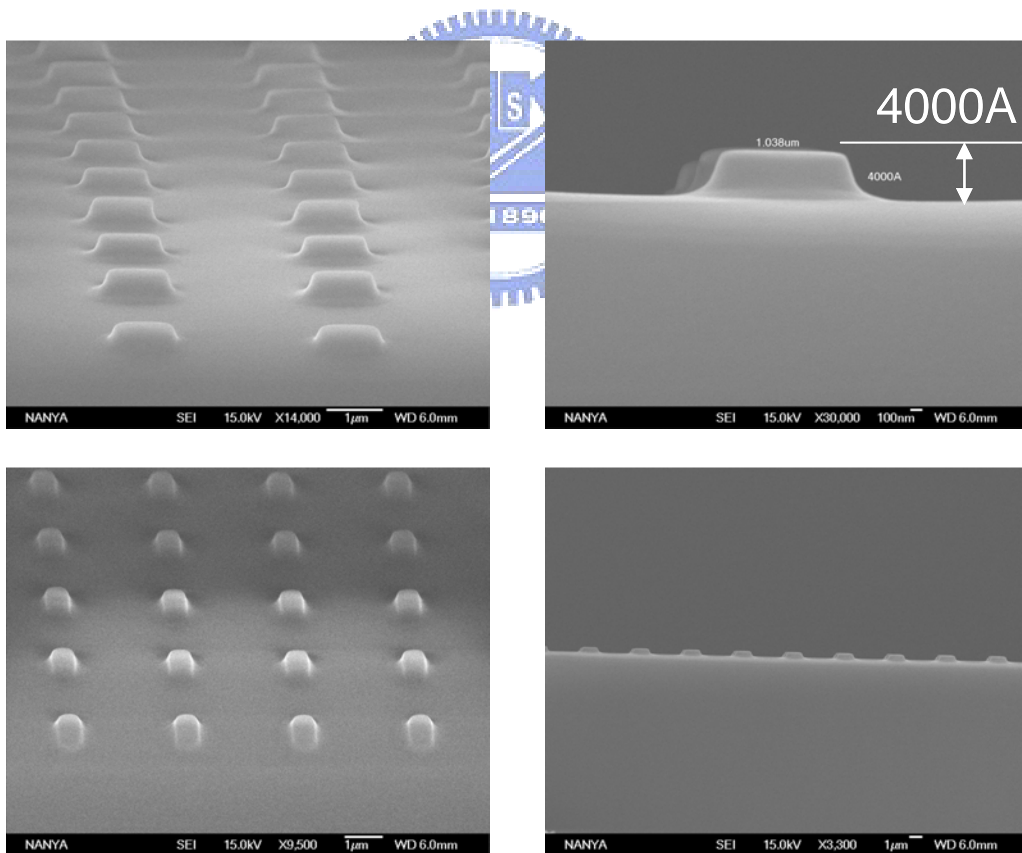

Figure 5.4 The cross section pictures of short dash lines PDMS patterns

5.4 Buffer Layers

The silicon base of masters have to be re-coated an anti-reflection layer AR3 (Shipley) 700A and baking at 130°C for 90 sec. AR3 is a conformal type of adhesion layers and covered along the surface topography of the substrates and formed a buffer layer to avoid sticking between silicon and PDMS. Figure 5.5 shows AR3 coating could be covered well on the surfaces of different types of sub-micro patterns, such as (a) T-shape, (b) short dash lines, (c) long dash lines and (d) solid lines.

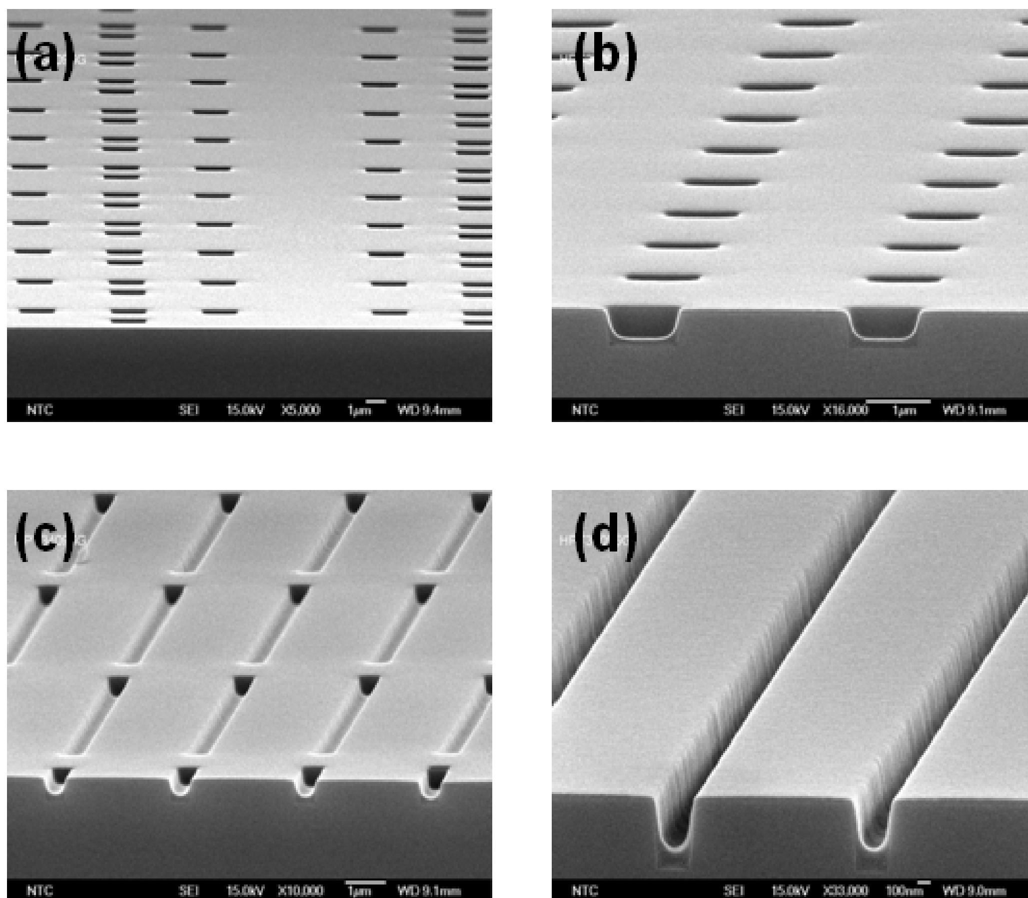

Figure 5.5 The pictures of AR3 coating and are covered on (a) T-shape, (b) short dash lines, (c) long dash lines and (d) solid lines sub-micro patterns.

5.5 Protein micropatterns

Figure 5.6 shows that 6 sets of protein patterns could be generated by PDMS stamping process. The 0.3 um patterns is poor (Up-Left) and the other 0.6 um patterns are good.

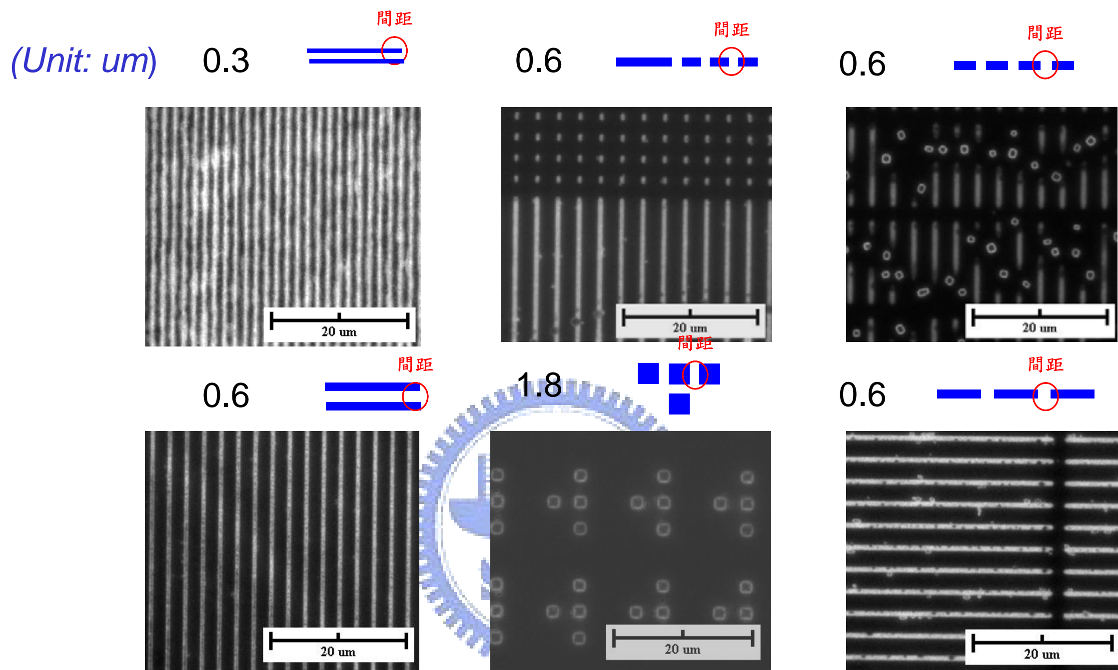

Figure 5.6 The top view pictures of 6 sets of protein patterns

5.6 Cell culture

In this work, the outgrowth of cells gave direct evidence for the functionality of the sub-micro protein patterns. All the six sets of protein patterns were able to be utilized for outgrowth of cells. Two protein micropatterns with 0.3 um line and T shape structures were investigated following the process we re-designed as illustrated in the figure 5.7 (a) and (b) ,respectively. The cells (Macrophages) were directly attached on

the positions that were marked by the arrows.

From the figure 5.7 (c) and (d), we could observe that the Macrophages have migrated and rotated on these positions by fluorescence microscope. The findings prove that the DUV photolithography combining micro contact printing could generated sub-micro protein patterns and be used in cell investigations.

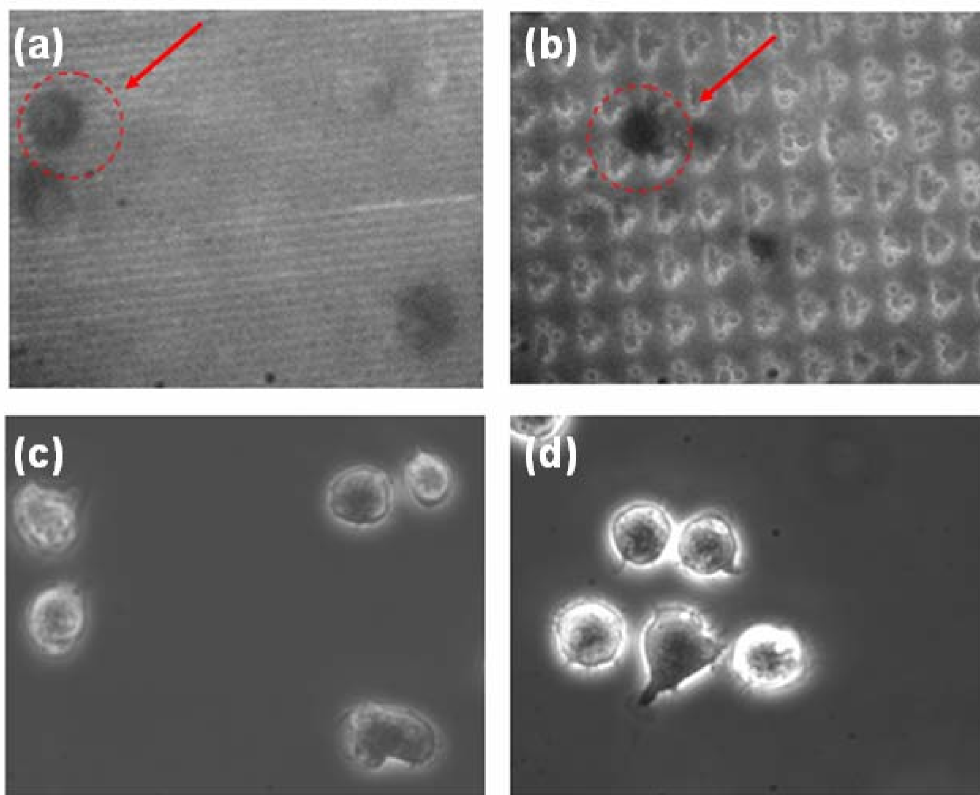

Figure 5.7 Macrophage cells were attached on the 0.3 um line of protein micropatterns (a) and T-shape of protein micropatterns (b) as marked by the arrows. The figure (c) and (d) shows the magnified pictures of Macrophage cells outgrowth on the positions marked by arrows in figure (a) and (b) (fluorescence image).