Development of maskless photolithography method with an LCD-projector for fabrication of micropatterned surfaces

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Statement of Purpose: Microfabrication techniques such as photolithography have been applied to micropatterning of polymers, biomolecules and cells. However, most of microfabrication techniques require specialized equipment and the preparation of photomasks, resulting in costly and time-consuming processes. We have developed an all-in-one device by utilizing a commercially available LCD projector for exposure of patterned images, which were generated on personal computer (PC), thorough the reduction lens. Secondly we developed a new device, which was equipped with XY positioning stages. Moreover, after the segmentation of a large mask image on PC, the images were repeatedly exposed with moving XY positioning stages and combined, resulting in the formation of micropatterns on large area. In our previous work, micropatterned cells with high resolution and microchannels on large area were fabricated. However, patterns of segmentalized boundary get out of shape for errors of XY stage, distortion of optical system, ununiformity of light intensity and so on. Therefore, in this study we designed a third-generation device equipped with a more precision XY-stage and developed a method to overcome the defect that patterns of divided edge with an XY stage get out of shape. By the method, patterns of segmentalized boundary were finely fabricated.

Methods: To overcome a defect that patterns of divided edge with an XY stage get out of shape, we invented a method to improve patterns of divided edge by multiphase exposure. In the method the divided images are showed in figure 1. When a pattern image size is 2000x1500 pixels and an image size of one-shot is 1000x750 pixels, the exposed images are usually divided four images (1000x750 pixels) like the upper of figure 1. However, in double phase exposure of the method the divided images (the upper of figure 1) are exposed for half time of normal exposure at first. Second the divided images (the lower of figure 1) are exposed for half time of normal exposure as overlapped with the first exposure. This multiphase exposure has an effect to disperse the divided boundaries.

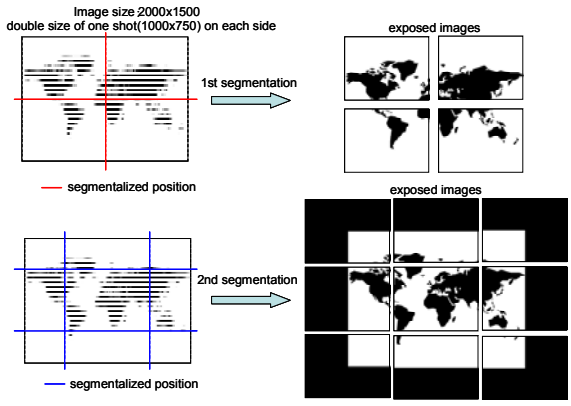

Figure 1 Multiphase exposure method

For evaluation of the method, we prepared test patterns. Each pattern size is 2000x1500 pixels. The patterns were exposed onto g-line positive photoresist spincoated on the coverslips. The fabrication of photoresist micropatterns was performed with a 3x objective lens to adjust the final resolution 2.5um/pixel. Since 1pixel size is 2.5um and the line width is 4 pixels on PC screen, the line width of photresist is almost 10um.

Results: Figure 2 shows SEM images of the resultant micropatterned photoresist surfaces in using the test patterns as a mask image displayed on PC. Figure 2(a) is the result of exposing without using the multiphase exposure method. In this case the segmentalized boundaries have a bit shifts. On the other hand, shifts are low in the result(Figure 2(b)) by double phase exposure method. Moreover, the pattern fabricated by fivefold phase exposure method has little shifts(Figure 2(c)). Totally, the line width of each patterns follow design. From the results, the multi-phase exposure method is extremely effective to finely fabricate patterns around segmentalized boundaries.

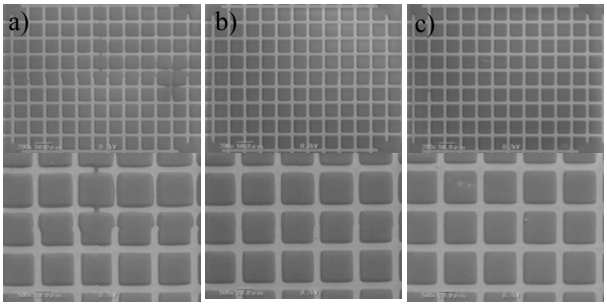

Figure 2 SEM images of positive photoresist on coverslips

Conclusions: We have developed a third generation maskless photolithography device. We also developed a method to improve a defect caused by the maskless system with an LCD projector. Using the new device and the method, we achieved fabrication of finer micropatterns of photoresist. This method can be also applied to maskless system with a DLP projector.

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