Shape-Compensation of 3-D Structure Fabrication by X-ray Lithography

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The distorted shapes of microstructures have been observed after the fabrication of PMMA microstructure using X-ray lithography with PCT technique [1]. The shape-correction theory for X-ray mask design in this work confirmed the successfully predictable microstructures resulting from X-ray lithography and PCT technique.

Due to the relationship between the absorption X-ray energy and the absorber on X-ray mask, without the conscientious mask design, the deformed shapes of sloped side-wall on the exposed structures were observed. However, base on the measurement of errors occurred between the 2-D shape of mask pattern and the resulting wall of fabricated 3-D structure, various factors were investigated [2] e.g., the inclination of exposure stage, distortion of X-ray mask, resist stability and heat stress in the developing solution, emission of SR light, X-ray scattering and effect of Dose-depth non-linear curve. In this work, the Dose-Depth nonlinear parameter was selected to be the main factor causing deformation of the resulting structures.

The study was performed by various experiments on triangular mask patterns as for fabrication of single-tip microneedle(see Fig. 1(a)). The measurement according to a mask pattern compared to fabricated structure by SEM photos and laser beam microscope is shown in Fig. 1(b). Additionally, the microneedle array exposed by using the double-right triangle mask pattern was fabricated in order to use for medical applications, so called quadruplets microneedle. The resulting structure was shown in Fig.2(a). After applying the compensation method, the structure became as in Fig.2 (b).

Moreover, the compensation-method for rectangular mask has also been investigated. The experiment was done by various dimensions and aspect ratio of rectangular masks. The results are shown in Table.1. The prediction of highly precise 3-dimensional microfabrication technology can be succeeded where the compensation study has been taken into consideration. The compensation study will be continued further with other factors in order to obtain a perfectly predictable shape of microstructure.

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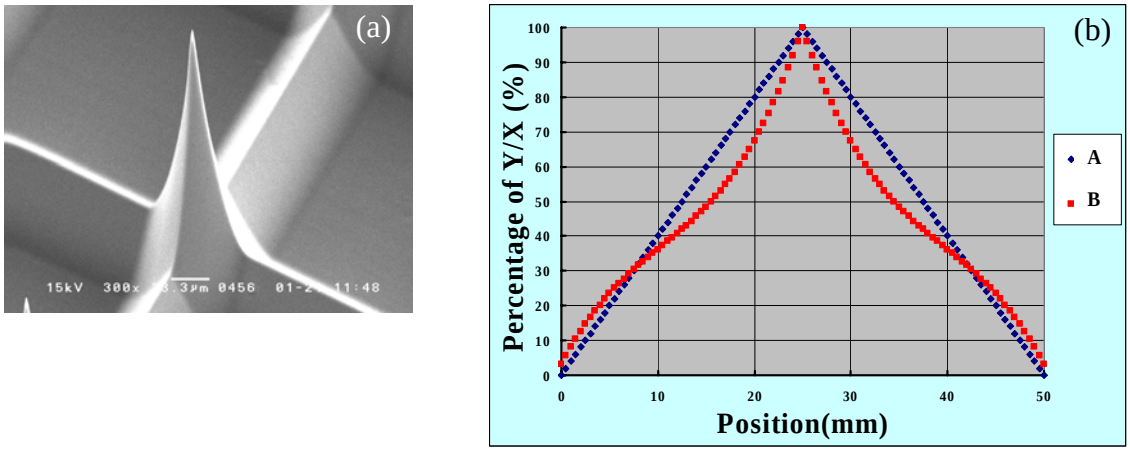


Fig.1 (a) curved side-wall of single-tip microneedle and (b) compensation study. The blue line is required structure and red line is simulation for achieving the blue line.

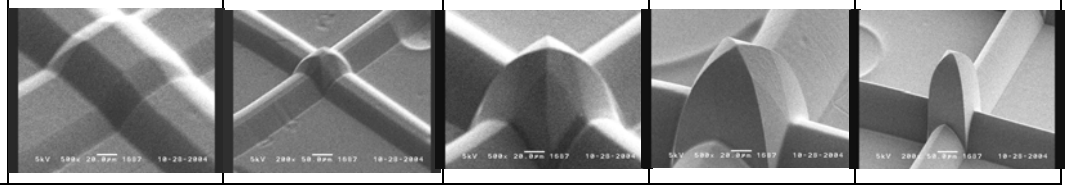
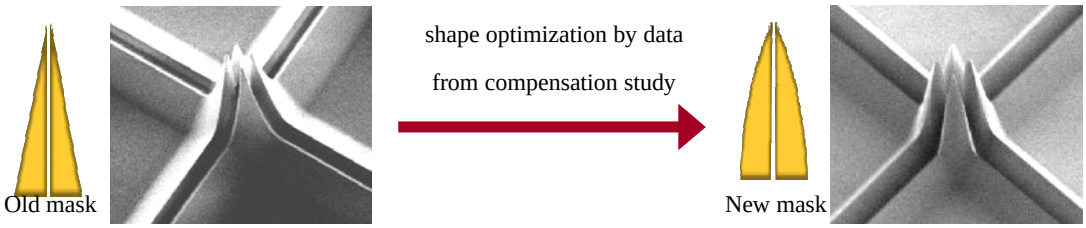
Absorber portion (%)	10	30	50	70	90
Non-Absorber portion (%)	90	70	50	30	10
SEM Photo					

Table 1. The % portion of absorber and non-absorber area with SEM photos of the structure formed by rectangular mask.



(a) (b)

Fig. 2 Quadruplets-microneedle (a) before applying the compensation study to the X-ray mask and (b) after applying the compensation study

References

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[2] G. Feierag, W. Ehrfeld, H. Lehr, A. Schmidt and M. Schmidt, J.Micromech Microeng. (1997) 323