LIGA for Lobster IV

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The purpose of this research was to fabricate arrays of SU-8 columns with different size, aspect ratio and spacing between them so as to carry out experiments for doing Nickel electroplating at Minifab, Australia and to undertake an investigation of the development time & error in pattern transfer as a function of process parameters and open area for 30µm square columns.

Initial experiments included deposition of Ti/Cu metal layer on glass slides. The thickness of Ti layer was 20nm and that of Cu layer was 50nm. SU-8 was cast on this metal layer to achieve thicknesses of 1.5mm, 1mm, 600µm, 500µm and 150µm. The pre-bake time was selected to retain 5% of the solvent, which has been shown to provide good resolution in x-ray lithography.

Using the x-ray mask and optimized process parameters from the experiments of the last two visits, we carried out a series of x-ray exposures, top-plate fabrication, post-baking and development of SU-8 samples to obtain arrays of various size, aspect ratio and spacings.

For the calibration of dissolution rate of SU-8 resist as a function of x-ray dose, samples were prepared with 120µm thick SU-8 resist, x-ray exposed with different bottom dose, post-baked and developed for a certain time. The thickness of the resist before and after development was measured using optical microscopy and the dissolution rate in µm/sec was determined for each x-ray dose. The graph below plots the dissolution curve.

The dissolution rate, R in µm/s, as a function of absorbed energy for SU-8 can be represented by

$$R(E) = R_{\max}(1-E)^{N}\left[\frac{(a+1)(1-E)N_{notch}}{a+(1-E)N_{notch}}\right] + R_{\min}\left[\frac{S}{S^{E}}\right]\left[1-\frac{(a+1)(1-E)N_{notch}}{a+(1-E)N_{notch}}\right]$$

where $$a = \frac{(N_{notch}+1)}{(N_{notch}-1)}(1-E_{th})^{Nnotch}$$

and R_{max} = 0.366, R_{min} = 0.00045, N = 2.1, N_{notch} = 21.5, E_{th} = 0.43 and S = 4.

A series of experiments were carried out to measure the development times and dimensional error during pattern transfer as a function of x-ray exposure dose, PEB time, development time and ratio of spacing to feature. The results of these experiments are tabulated below.

The development times of these experiments were compared to the dissolution model and were found to be much higher then the prediction. The higher development times can be attributed to the fact that as the spacing between the columns decreases, the velocity of the developer at the bottom of the feature decreases which in turn will decrease the mass transport rate of the dissolved SU-8 species to the bulk of developer. The entire development process will be diffusion dominated. We are carrying out further work to determine the diffusion coefficient of SU-8 in the developer.

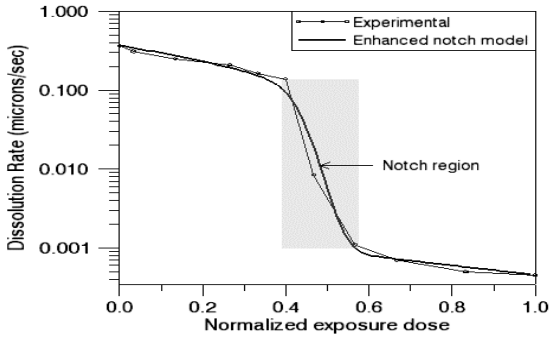

Figure 1. Experimental dissolution rate of SU-8 as a function of exposure dose.

Exposure (mA.min/cm)	Bottom dose in resist (J/cm^3)	Dose under absorber (J/cm^3)	PEB (minutes)	Space to Feature ratio	Development time (minutes)	Dimensional error (%)
100	12.96	0.74	30	1.2	60	3.3
100	12.96	0.74	45	0.4	85	5
100	12.96	0.74	60	0.2	110	6.6
150	17.42	1.1	30	0.4	80	5
150	17.42	1.1	45	0.2	120	6.6
150	17.42	1.1	60	1.2	75	5
200	23.61	1.48	30	0.2	125	6.6
200	23.61	1.48	45	1.2	80	5
200	23.61	1.48	60	0.4	115	7.5

Table 1. Table showing results of experiments carried out with different combinations of the input parameters