Characterization of SU-8 5 for MEMS Applications

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Abstract– SU-8 is a negative photoresist that is mainly used for MEMS technology. It is currently being used for micro-machined gears, accelerometers, and host of other MEMS structures. In these types of MEMS devices it is important to get an image with nearly vertical sidewall angles. For example with a micro-machined gear, the gear would slip easily if the gears sidewall angle not near vertical. The focus of this project was to model the sidewall angle through a designed experiment and an ANOVA was run on the data using a computer program. Also, using a linear regression analysis the functionality of the sidewall angle is determined within the specified design space. The design space for the main design was set up by using testing and screening experiment where the all the factors were set to the high levels and low levels of the design for feasibility of the main design. The sidewall angle was obtained by using Scanning Electron Microscope to view the cross-section of the samples in the DOE.

1. OPTIMUM PROCEDURES

First the wafers were scribed with the date and the tc of the designed experiment. Then the wafers were baked at 200 degrees Celsius for 30 minutes. Then a quarter size of SU8 5 was hand dispensed using a plastic cup. Then spin the spinner a 800-rpm's for 60 sec. Then spin the spinner for 5 minutes at 500 rpm. Next is a 55-degree celcuis bake in a convention oven. It is important in this step to the wafer suspended in the convention oven meaning only a small portion of the wafer is touching something. This step allows the resist to flow and reduce the edge bead and planarize the resist. Next a softbake is down at 90 degrees Celsius for 5 minutes and 40 sec. It is important to make sure that the all hotplate are level so the resist when it flows it will not make the films uniformity get worse when it is on the hotplate. The exposure was done a 536 mJ/cm^2 on a Karl Suss contact aligner. Then the do a post exposure bake for 15 minutes at 90 degrees celcuis. Next let the wafer sit on a clean room wipe to allow the wafer to cool. Now do a development with SU8 developer for 5 minutes at room temperature. Next a Phillips SEM was used to take the pictures and a protractor was used to measure the angle.

2. RESULTS AND ANALYSIS

Just to illustrate what was actually measured with the sidewall angle a sample SEM picture is shown below:

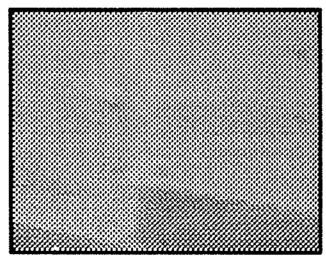

Figure 1: This is a picture Oe3 which has a sidewall angle of 77 degrees.

The following sidewall angle data was collected using a Phillips SEM and is found below:

Run #	tc	Softbake (Sec.)	PEB (Sec.)	Develop (Sec.)	Sidewall (°)
3	(c)	260	690	385	74
5	a	340	690	215	82
7	b	260	1110	215	74
1	ab(c)	340	1110	385	85
6	Oe1	300	900	300	77
4	Oe2	300	900	300	79
2	Oe3	300	900	300	77

Table 1: This was the data used for statistical analysis and this shows that a 85 degree sidewall angle was achieved.

The data from the DOE was run on RS/1 which is statistical software. The first ANOVA was run with softbake time, PEB time, and develop time and the only factor that was to be found significant was the softbake time. So a second ANOVA was done with just the softbake time to get a better estimate of the residual. A

linear regression was then done to obtain th (1) found below:

Least Squares Coefficients

Term	Coeff.	Std. Error	T-value	Signif.
1 1	78.571429	0.461807		
2 ~S	4.750000	0.610913	7.78	0.0006

No. cases = 7	R-sq. = 0.9236	RMS Error = 1.222
Resid. df = 5	R-sq-adj. = 0.9083	Cond. No. = 1

From this analysis it shown that 92.36% in the variation in the sidewall angle was coming from the softbake time. The significance value of 0.00006 so that there is 99.94% confidence level that the softbake time is controlling the sidewall angle with a linear relationship. Also, a t-test was done with the 3 center-points and the 2^{3-1} fractional factorial design. By doing this t-test it was found that there was no curvilinear relationship between the softbake time and the sidewall angle. Also from this analysis the linear equation relating the softbake time with the sidewall angle is found below:

$$Y = 78.571429 + ((S - 300) * .11875)$$

In this equation Y stands for the sidewall angle in degrees and the S stands for softbake time in seconds.

5. CONCLUSION

The goal of the experiment was to test the hypothesis that the softbake time, Post Exposure Bake (PEB) time, and Develop time was a function of the sidewall angle. To test the hypothesis a 2^{3-1} fractional factorial design was used and RS/1 was used to perform the statistical analysis. The softbake time accounted for 92.36% of the variation in the sidewall angle with 99.94% confidence in the data. The linear equation for the sidewall angle (Y) is $Y = 78.571429 + [(S - 300) * 0.11875]$ where S is the softbake time in seconds. This equation is valid when S is between 260 seconds – 340 seconds at 90°C, the PEB time is 15 minutes at 90°C and the develop time is 5 minutes at room temperature. With this equation the predicted sidewall angle within the design space is 83.32°. If this equation is extrapolated outside of the design space, the predicted softbake time for vertical sidewalls is 6 minutes 36 seconds at 90°C, the PEB time is 15 minutes at 90°C and a develop time is 5 minutes at room temperature.

REFERENCES

[1] James R. Sheats and Bruce W. Smith, "Microlithography, Vol. 1-Science and Technology", Marcel Dekker Inc., NY, Chapter 9, 1998.

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Sean Corcoran, Camillus, NY, received B.S in Microelectronic Engineering from Rochester Institute of Technology in 2001. He attained co-op work experience at Intel, CVC products, and Xerox. He is currently looking for employment, so give him a call and he will talk business.