Thick Photoresist optimization for MEMS Structures

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Abstract

Thick photoresist applications have been a key field of interest in recent years for fabrication of microstructures. Besides bump fabrication and wire interconnect technology, the method of patterning thick layer photoresist by UV lithography is specially developed for MEMS applications. In this paper, a new photoresist AZ9260 (commercially available) is optimized for various thicknesses and the effect of speed and ramp on the thickness is analyzed with a set of experiments. Thickness of 6 µm, 9.8 µm, and 14 µm has been optimized with a smooth surface profile at a ramp of 5000 rpm/sec. The spin speed and ramp affects thickness and uniformity respectively. The standard deviation for lower and higher ramp is 0.8500 and 0.0933 respectively. Prebaking and exposure times are also optimized. The exposure time is 20 sec and developing time is 130 sec.

Keywords: AZ9260, electroplating, positive photoresist, moulds, aspect ratio

Introduction

Ultra-thick photoresists have numerous applications including thin film head manufacturing, fluidic chambers, electroforming moulds and bump bonding. Many new equipment and photoresists have been developed to overcome the challenges of preparing thick photoresist layers, patterning these resists and to handle the difficulties of the electroplating step that follows. A commercially available photoresist AZ9260 (520 cps) [1] is used for realizing thick moulds with high resolution, superior aspect ratios [2-5] and good sidewall profiles. Several methods are used for fabricating moulds for metal plated structures.

Although LIGA [6] is a very prominent technique to fabricate thick structures, few can utilize the process due to lack of access to the synchrotron radiation source. Moreover, the fabrication cost is also high. Alternatively, UV lithography has been used to fabricate plating moulds.

Experiment

AZ9260 is a thick photoresist with high viscosity and transparency. It is optimized to fabricate mould for electroplating bridge in MEMS switch with a gap of 3 µm. Though recipe is provided by the vendor; it is difficult to replicate the recipes due to different coating units. The recipe provided is according to the dispense system and it is augmented according to the spin coater at a relative humidity of 48% and at a temperature of 20ºC. For the process, 2 inch wafers are used. Prior to coating, HMDS is used as an adhesion promoter. Next, the photoresist is spin in three steps.

1. Spin at 400 rpm for 5 sec.
2. Instantly the speed is changed to desired value for 15 sec.
3. Spin speed is changed to 1000 rpm.

The foregoing sequence is used to obtain films of varied thickness. The second step mainly decides the thickness of the film. During this step, almost all of the solvent is evaporated and a solid film is formed. The third step does not affect the thickness; it only accelerates the solvent evaporation. The ramp plays a significant role in deciding the uniformity of the film deposited. Two iterations are performed to analyze the effect of the ramp on uniformity. First iteration is accomplished at higher ramp and the other at lower ramp. The variation is listed in table 1.1 and 1.2.

Table 1.1 Higher Ramp at 5000 rpm/s

Spin Speed (rpm)	Thickness(um)		Ramp (rpm/s)	Time (s)
	Expected	Measured		
1000	14	12.002	5000	15
2500	9.8	7.8621	5000	15
5500	6	5.0539	5000	15

Table 1.2 Lower Ramp at 300 rpm/s

Spin Speed (rpm)	Thickness(um)		Ramp (rpm/s)	Time (s)
	Expected	Measured		
1000	14	12.002	300	15
2500	9.8	7.8621	300	15
5500	6	5.0539	300	15

After coating prebake is given for 25 sec at 60ºC. After prebake, the photoresist is exposed using a contact mask aligner (Karl Suss, MA6) with a near-UV light source. The exposure dose is calculated as follows:

dose (mJ/cm2) = intensity (mW/cm2) x time (sec).

The exposure time is 20sec. The photoresist is developed using a potassium-based alkaline developer (Hoechst, AZ400K), diluted by 1:4 in deionized (DI) water. The developing time is given for 130 sec. Post baking is not required for this photoresist. The thickness of photoresist is measured by the surface profilometer.

Results and Discussion

The surface profiles are shown below in fig.1 and 2 for higher and lower ramp respectively. The standard deviation for lower ramp and higher ramp is 0.8500 and 0.0933 respectively.

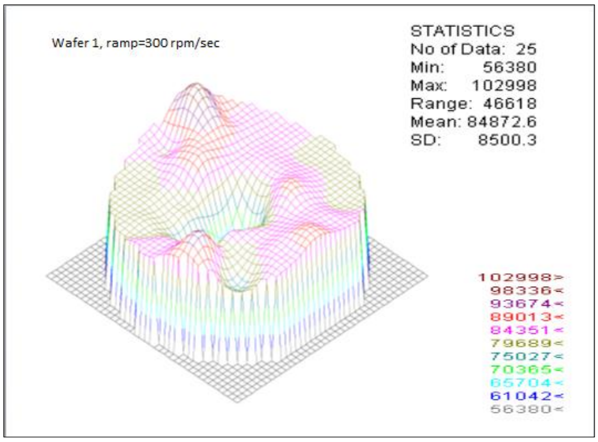

fig 1: Surface profile at ramp = 300rpm/sec

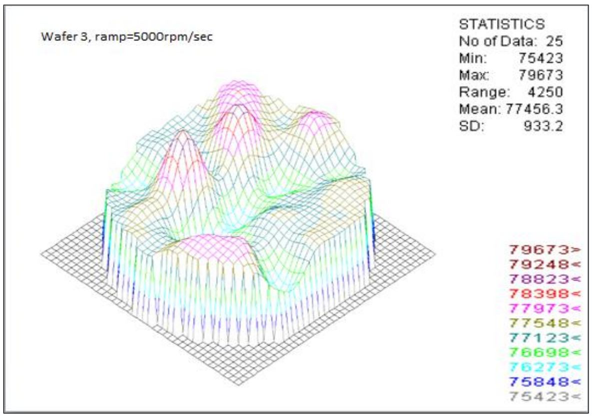

fig 2: Surface profile at ramp = 5000rpm/sec

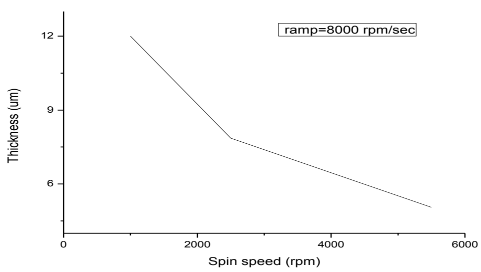

fig 3: Thickness versus Spin speed.

It is seen that ramp affects the uniformity and to deposit a uniform layer of photoresist higher ramp is required. The thickness of the film is decided by the spin speed. It varies inversely to the square root of the spin speed as shown in fig 3.

Conclusion

The recipe for different thickness of the photoresist is optimized. It is concluded that the thickness is decided by the spin speed and ramp affects the uniformity of the film deposited. The exposure time and developing time is also optimized.

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