Reflection Transmission Modulator

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Abstract– Microelectromechanical systems (MEMS) have gained increasing importance in the semiconductor industry. The research done had three main goals. The first was to pattern a corrugated pattern in photoresist. The second was to obtain a variation in the stress of the materials used and the third was to fabricate a micro. The micro shutter is constructed using a stack consisting of Amorphous Carbon and Aluminum and is anchored at one end to the substrate. In this study two of the three goals were met however there were some difficulties with the fabrication of the micro shutter that will be discussed later on.

1. INTRODUCTION

MEMS has been a major interest in the semiconductor industry since the 1960's when Richard Feynman offered prize money for a micromotor and then came up with the fabrication process that used a sacrificial layer. By the 1990's MEMS had become an integral part of automotive, medical, and consumer applications to name a few.

MEMS is the marriage of computation and physical sensing and actuation. In short it is the combination of both electrical and mechanical components. This is beneficial because MEMS utilizes the same general processes used in microelectronics. The devices are miniaturized and can be produced in mass. One can even build IC devices and MEMS devices together on the same chip. Figure 1 shows the integration of the standard CMOS process and a MEMS cantilever.

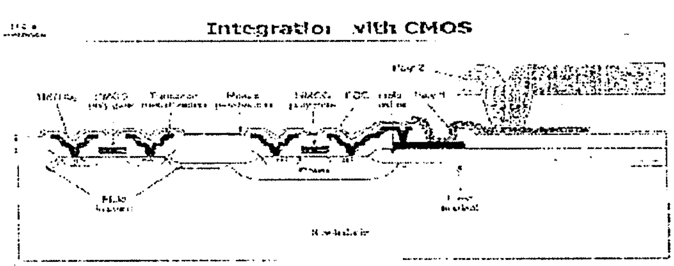

Figure 1: MEMS integration with CMOS

Most of the consumer applications use MEMS applications where the cantilever is corrugated. This corrugation in the cantilever is there to one, reduce the stiction between the cantilever and the substrate and two, allow the cantilever to curl in only one direction just like a piece of corrugated cardboard. The way that the dimple is formed is by depositing the metal and then etching into it to form the dimples. This project will explore patterning the cantilever by patterning the sacrificial material.

2. PROCEDURE

The work done on this project was completed in three major sections. The first was to obtain the corrugation in the resist. The second was to obtain different stresses in the materials of the cantilever and the third was to actually fabricate the device.

A. Corrugation of sacrificial layer

The sacrificial layer used was positive photoresist with a thickness of about one micron. A Box-Behnken design of experiment was set up to generate runs that might yield the necessary corrugation.

Run#	Develop Time(s)	Exposure Time(s)	Focus(Units)
1	20	4	225
2	10	4	250
3	10	[illegible]	250
4	20	4	275
5	10	3	225
6	30	3	225
7	20	3	250
8	30	[illegible]	250
9	20	3	250
10	10	3	275
11	30	3	275
12	20	2	225
13	10	2	250
14	30	2	250
15	[illegible]	2	275

Table 1: Design of Experiment Run order

B. Stress Analysis

The cantilever that was fabricated for this project was done using a two level stack consisting of amorphous carbon on the bottom and aluminum on the top. The reason for using the two different materials is because they are deposited to have opposing stresses. The amorphous

carbon is compressive while the aluminum is tensile. The opposing stresses is what will cause the cantilever to curl up in the relaxed state.

The aluminum was deposited in the evaporator and the amorphous carbon was deposited in the Drytek Quad using the following recipe:

Time = 45 seconds
CH_4 = 50 sccm
Pressure = 100 mTorr
Power = 300 watts

C. Device Fabrication

Once a recipe was chosen for the corrugation of the sacrificial material and the proper stress measurements were obtained on the cantilever materials the device was ready to be fabricated. The procedure used to fabricate the device is found below.

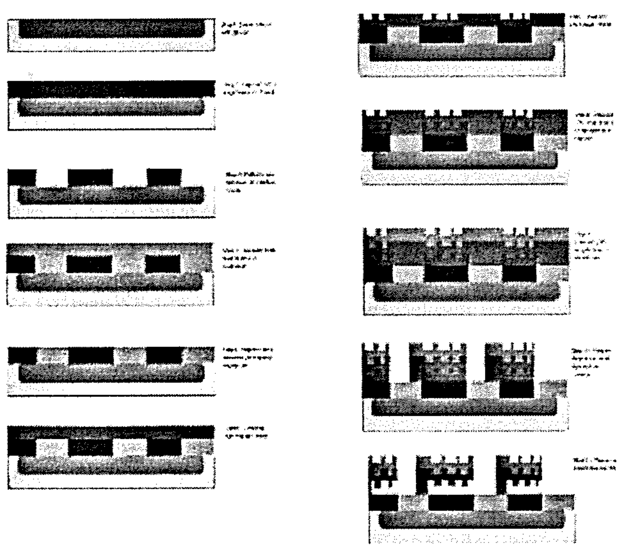

Figure 2: Reflection/Transmission Modulator Process Flow

3. RESULTS

Figure3: Too little corrugation (1)

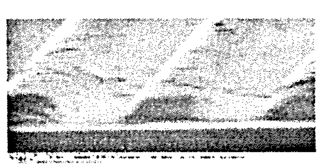

Figure4: Too much corrugation

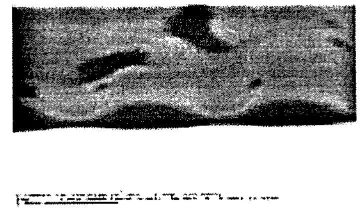

Figure5: Corrugation used in fabricating device

Figure6: Stress Analysis of Amorphous Carbon

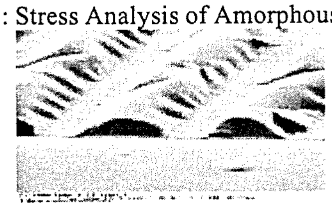

Figure7: Failed Fabricated Device

Figure 3 shows one of the Design of Experiment runs that shows that corrugation was achieved but it was not enough. Figure 4 shows too much corrugation and figure 5 shows the recipe that was used in fabricating the device. Figure 6 shows what the measurements were from the stress analysis of the Aluminum and amorphous carbon. Figure 7 shows the picture of the failed device.

4. CONCLUSION

The reason this is called a reflection/transmission modulator is because this is one of the few optical MEMS devices that has the capability to both reflect light and allow it to be transmitted through. When the voltage is applied and the cantilever is extended light is reflected off the top surface. If the device were fabricated on top of a glass substrate when the device is in the curled state light can be transmitted all the way through.

This project shows that obtaining the corrugated pattern in the sacrificial material is possible and through the use of a design of experiment can be optimized so that the depth of the valleys in the corrugation are not so deep. When the resist corrugation has become ideal, the device should operate correctly.

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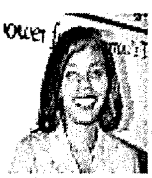

Ti'ona I. McCauley, originally from Rochester, NY, received B.S in Microelectronic Engineering from Rochester Institute of Technology in 2001. She attained co-op work experience at Carborundum Corporation, Standard Microsystems, and CVC Products. She is joining LSI Logic Corporation as a chemical mechanical polishing equipment engineer starting June 2001.