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WET ETCHING ON GaAs WAFER AT INSTITUTE OF ELECTRONICS CLEAN ROOM FACILITY

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ABSTRACT

The study involves the cleaning, wet etching and characterization of GaAs wafer in the first semiconductor device fabrication Laboratory at the Institute of Electronics, Atomic Energy Research Establishment, Savar, Dhaka, Bangladesh during the year 2011. The primary step is to develop necessary photolithography skill and thoroughly characterize equipment needed to perform photolithography including Hot plate, Spinner, Mask Aligner. Here, the studies are extended to photo resist thickness measurements using surface profiler and SEM to view etched surface quality. The experiences and the results of this study will benefit the students who are interested in the semiconductor fabrication field in Bangladesh.

Keywords: Wet etching, Photolithography and Nano fabrication.

INTRODUCTION

Semiconductor devices are the basic building blocks of optoelectronic and photonic integrated circuits and next generation supercomputers. The laboratory which was outfitted for the purpose to promote VLSI technology in Bangladesh, was equipped with a LPCVD, PECVD, RTP, RIE, e-beam evaporator, Dektak, 4-Probe station etc. The purpose of the study is to have the capabilities of designing and fabricating semiconductor devices for various applications. The lab is first of its kind and is fully equipped with device fabrication facilities. The aim of the study is also to produce trained human resource in semiconductor processing. The first step of nano device fabrication is to learn the process of photolithography to make pattern on wafer and fabricate device on the following the patterns. Here we studied wet etching of GaAs wafer. GaAs having the properties required for optoelectronic devices are being used for the fabrication of these devices and often the processing steps for the devices demand smooth etched bed and surface (Meyyappan *et al.*,1992 and Mahmood *et al.*, 2000). In order to achieve this goal, it is necessary to develop skills in wafer cleaning, spin photo resist, wafer masking, duration of UV expose and characterization. During this experiment calibration of Hot plate, low cost UV exposer unit and Spinner has been performed.

METHODOLOGY

The study was performed at newly established clean room facility for Very Large Scale Integration (VLSI) laboratory under Institute of Electronics, Atomic energy research establishment, Savar, Dhaka, Bangladesh. Study on the chemical etching on GaAs wafer was done in a dust free environment to avoid impurities during the process. Yellow light environment were used to transfer pattern on the wafer as photoresist are kind of white light sensitive chemical. Photolithography is the process used to transfer the pattern on the mask to the GaAs wafer. In our study, the S1813 (positive) photo resist was used. For positive photolithography, GaAs wafer was cleaned with Acetone, IPA, Methanol, DIW, in an ultrasonic bath for 5 minutes. Then dry with nitrogen gas. The photo resist is applied to the GaAs wafer on a wafer spinner. We set the spinner at a maximum rpm 4000. Acceleration and deceleration rate was controlled for create a uniform layer of photo resist. Next, a 10 min bake is performed on 110^0C hot plate, followed by the variable duration UV light exposure with rectangular shape mask for five different durations. Next, the wafer is developed in the MF 319 Developer. A 3:1 ratio of de-ionized (DI) water to Developer is used for better process control. Dektak surface profiler was used to measure photo resist thickness. The wafer is then etched in the solution of Phosphoric acid (H_3PO_4), Hydrogen

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per oxide (H_2O_2), DIW at a ratio of 1ml: 3ml: 25ml. The wafer is then rinsed by DIW, dry with N_2 gas (Tsung-Ta Ho and Michael, 2003). Dektak surface profiler was used to measure depth of etched surface. This process was repeated for five samples. Graphs generated from Dektak surface profiler is given in result.

RESULTS AND DISCUSSION

In this work, GaAs wafer was etched at a rate of 0.24 micrometer per minute. Five samples were prepared. Thickness of photo resist and depth of etched surface was measured by Dektak surface profiler which is shown in fig. 4. Etched surface smoothness was observed by SEM image which is also shown in discussion.

Table 1. Determination of etch rate for sample 4.

Photo resist thickness in micrometer (μm)	Etch time in Min	Etched in μm	Etch Rate in μm/min
2.3	1	2.564	0.24
	3	3.277	
	3	3.527	

Table 2. Determination of Photo resist thickness and wall angle due to change in UV exposer duration.

Sample	UV Exposer Duration in Sec	Photo resist thickness in μm	Wall Angle (From graph) In degree
Sample 1	15	4.4	90
Sample 2	30	4	90
Sample 3	45	4	105
Sample 4	60	2.4	95
Sample 5	120	2.2	110

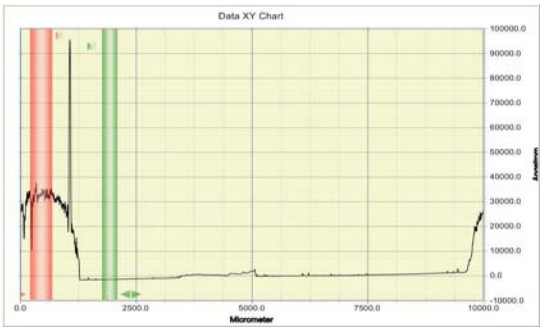

Fig. 1. Sample 4 etched for 1 min.

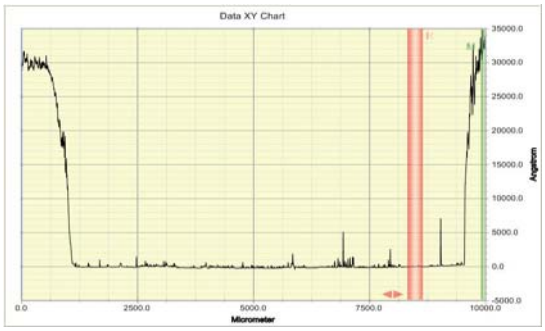

Fig. 2. Sample 4 etched for 4 min.

From table 1 and fig. 4 etch rate was determined. We observed anomalous data i.e etch rate was not constant. The etch rate can be varied by changing the ratio of the solution. A lower concentration of H_3PO_4 can be used to slow down etch rate. Also it will provide a smooth etched surface. Fig. 1 represents depth of etched surface after 1min etched in solution. It is seen that there are very few roughness in the range 2 to 10 nm over the etched surface. Fig. 2 and fig. 3 represents depth of etched surface after 4 min and 7 min respectively where few spikes generated, it can be minimised using a low concentration solution of H_3PO_4. From fig. 1, fig. 2 and fig. 3 it is also seen that the layer of photo resists were not uniform through out the wafer surface. It is because of the duration of pre bake at hot plate. As we bake the sample for 10 minute, varying this duration, roughness in photo resist layer can be minimised. Here graphs are shown produced from sample 4. Wall angle Changes due to UV expose duration measured from fig.1, fig.2 and fig.3 are shown in table 2.

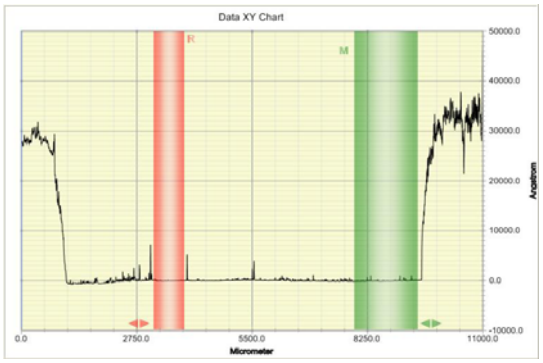

Fig. 3. Sample 4 etched for 7 min.

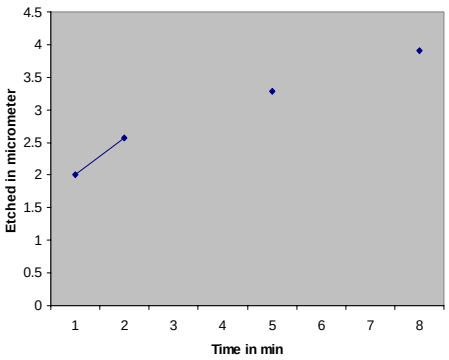

Fig. 4. Etch Rate for GaAs wafer.

(a)

Fig. 5 (a). SEM image of Etched surface.

(b)

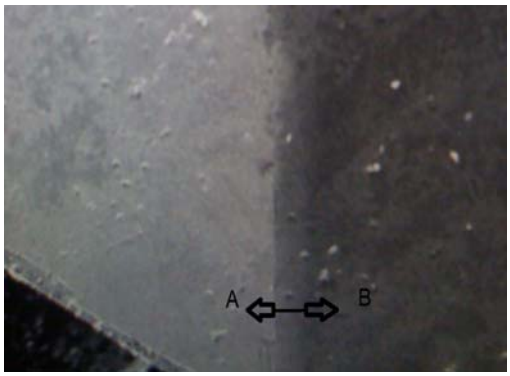

Fig. 5 (b). Wall (A-B) is showing in image.

From fig. 5 (a) we found that small portion of etched surface were smooth. Numbers of big dark circles are remaining of photo resist. Numbers of white spots are observed through out the sample both on etched surface and on photo resist. Here fig. 5(b) showing side wall of the etched sample. Here A is etched surface, B is photo resist and Straight line between A and B represents height of side wall.

CONCLUSION

In the present study wet etching was performed on GaAs. We have found that photolithography could be done using a low cost UV exposure unit. However a detail study on photolithography would be attempted with different feature of masks also with Si wafer. We are looking forward to perform deposition on the etched surface.

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