ACID TEXTURIZATION OF POLYSILICION FOR SOLAR CELL APPLICATIONS

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Abstract

In the fabrication of polysilicon solar cell, efficiency of the solar cell is the key issue. We have used the polysilicon wafers obtained directly from the manufacturer, which have lots of saw damages on its surface. We have removed the saw damage using $HF : HNO_3 : H_2O$ solution in different proportions. After saw damage removal texturization on the same wafers were carried out using the mixtures of acid solutions of HF, HNO_3, H_2O and H_2SO_4 in with different combinations. The solution preparation and texturization are the exothermic reactions. Since the process of texturization is highly sensitive for temperature, therefore, a constant temperature bath was designed and fabricated in house to carry out the reaction at constant temperature. The textured surface was analyzed by high resolution optical microscope, surface profiling and scanning electron microscope. We have achieved the reflectance of light up to 18%, while the initial bare wafers were having the reflectance of 30%. As a consequence the light reflected on the wafer is less that leads to the solar cell to utilize maximum illumination for the conversion of the optical energy into electrical energy. The micrographs and etch rate etc were studied thoroughly and have been presented.

Keywords --- Etching, Texturization, Saw damage, Polysilicon, Multi-Crystalline

I. INTRODUCTION

The multi-crystalline silicon wafer surface texturization is a crucial issue before the processing of solar cells. Texturization can be done by alkaline etching or reactive ion etching; we have chosen the acidic etching. At first the saw damage has to be removed followed by acid texturization. Most of the acidic etching and hence the texturization process are of empirical in character depending on the constituents ratio, temperature and physical agitation. Texturization of mc-silicon (polysilicon) wafers is a well known method to improve the solar cell efficiency [1]. Apart from the improvement in the reflectance, increasing the light trapping by the textured surface becomes more important when the silicon wafers become thin [2]. The parameters of solar cell significantly improve by the textured surface [3-5]. The complex acidic etching behavior requires a detailed knowledge of every parameter like temperature, physical agitation, constituents involved and their ratio which influence the texturization. The texturization process depends on the temperature; we have studied the process at room temperature without any agitation for better control [6]. The texturization can be carried out in an automatic in-line process [7]. We have used HF, HNO_3, H_2O and H_2SO_4 in different ratios to study the etch rate, surface roughness and surface morphology to achieve minimum surface reflectance.

II. EXPERIMENTAL DETAILS

The 5"×5" multi-crystalline silicon wafers of around 200 microns thickness were taken for the experiments. The wafers were first degreased using acetone and trichloroethylene and than dried using nitrogen. The saw damage removal and texturization experiments were carried out at room temperature (21oC) without agitation in the constant temperature bath as shown in Figure 1.

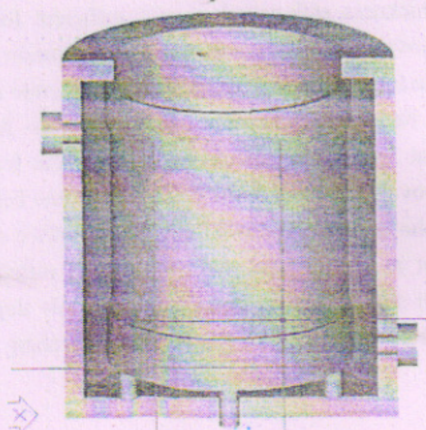

Fig.1 Constant Temperature Bath

The grains were seen using microscope and CCTV on the monitor. The magnification of the microscope was 50x and CCTV monitor 50x. So total it was 2500 magnification. The roughness was measured using Dectak 6M surface

profiler. The saw damage removal was done in four different solutions as shown in Table-1.

Table 1: Solutions for Saw Damage and Texturization

Solution No.	Saw Damage Removal	Texturization
	Ratio HF : HNO3 : H2SO4 : H2O	Ratio HF : HNO3 : H2SO4 : H2O
Sol.1	1 : 5 : 0 : 1	10 : 10 : 16: 20
Sol.2	1 : 20 : 0 : 1	10 : 10 : 80 : 0
Sol.3	1 : 1 : 1 : 10	5 : 5 : 80 : 2
Sol.4	1 : 10 : 0 : 1	1 : 1: 18 : 2

Thickness and surface roughness of the wafers were measured before saw damage removal, after saw damage removal and finally after texturization. Micrographs of the textured surfaces were done using scanning electron microscope.

III. RESULTS & DISCUSSION

It was found that the saw damage were completely removed in HF, HNO3, H2SO4 and H2O solution in all the four types of the solutions we have used. The etched thickness with time is shown in Figure 2. It is clear from the graph that etching rate is maximum in solution 1 and minimum in solution 2. However, the saw damage is removed in all the solutions as it is clear from the grains shape and surface roughness shown in Figure 4.1 to Figure 4.4. Since the silicon wafers are already thin hence we want minimum thickness etch which is just sufficient for saw damage removal. Therefore, solution 2 and solution 3 are most suitable for our purpose where control etch rate is less hence can be controlled more easily. It was further observed that 3 to 4 microns etching is sufficient for saw damage removal. The etched thickness versus time behaves linearly as shown in Figure 3. Although the surface seems to be similar in all the four solutions but the reflectance measurement shows that the reflectance not only depends on the solution used but also on the time of etching. It is also noticed that the surface reflectance has no direct relationship with the surface roughness but depends on the grains structure on the surfaces. The reflectance and surface roughness data is shown in Table-2.

IV. CONCLUSION

On 5"×5" polysilicon wafers of 200 microns thick saw damage has been removed successfully. The acid texturization has been carried out resulting into reduction of the surface reflectance from 30% to 18% on texturization. We found that the solution no. 1 i.e. HF : HNO3 : H2SO4 : H2O in the ratio of 10 : 10 : 16 : 20 gives the minimum surface reflectance on texturization on polysilicon wafers. The textured surface has uniform grains structure having granular shape on the whole surface.

V. REFERENCES

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Fig 4.1 Sol 1 Fig 4.2 Sol 2 Fig 4.3 Sol 3 Fig 4.4 Sol 4

Saw Damage Removed Surfaces

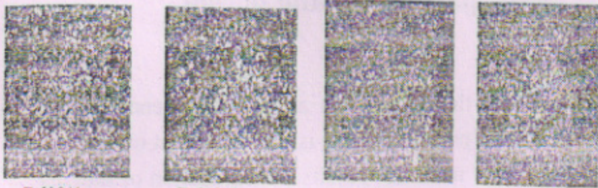

Fig 5.1 Sol 1 Fig 5.2 Sol 2 Fig 5.3 Sol 3 Fig 5.4 Sol 4

Texturized Surfaces

Fig 6 Micrograph

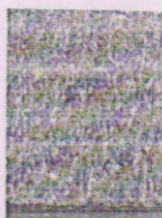

Fig 7 Micrograph

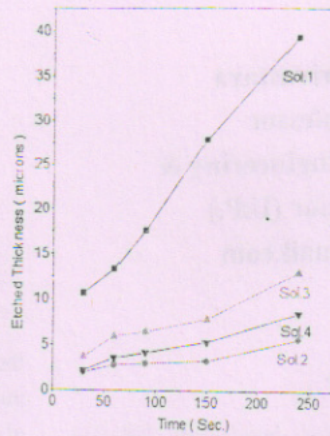

Figure 2. SawDamage Removal

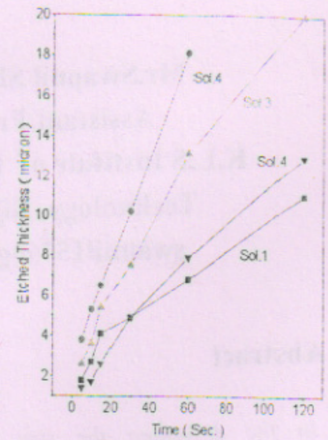

Figure3. Texturization

	Saw Damage Removal				Texturization			
	Sol. 1	Sol. 2	Sol. 3	Sol. 4	Sol. 1	Sol. 2	Sol. 3	Sol. 4
Roughness (nm)	644	558	310	522	340	392	1168	494
Reflectance (%)	-	-	-	-	18.21	21.2	33.2	23.0

Table-2: Reflectance and Roughness