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Effect of Additives in the Acid System on the Performance of Diamond Wire Sawn Multi-crystalline Silicon

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Abstract

In the texturing process of diamond wire polycrystalline silicon solar cells optimizing the preparation of the light-trapping texture structure needs to add texturing additives. In this paper, we compared the effects of different velvet additives on the surface morphology, reflectivity and performance of diamond wire cut polysilicon. It is found that the distribution range of Isc, Uoc and Ncell of polycrystalline battery prepared by additive A is relatively concentrated, and higher than that of additive B. This is mainly due to the good light trapping effect of the down sheet prepared by additive A, and the larger down surface is conducive to the surface passivation of the battery.

Keywords

Diamond Wire; Additives, Etching; Reflectivity; Performance.

1. Introduction

Diamond wire silicon wafer cutting technology is now recognized as an advanced slicing technology, it can greatly reduce the cost of silicon wafer single compared with the mortar slice, and has many advantages, such as environmental friendly, less loss, high slicing efficiency. Diamond wire silicon wafer has been fully promoted on the cutting of monocrystal silicon wafer through various anisotropic alkali corrosion. However, due to the existence of a layer of amorphous silicon on the surface of the diamond wire cut polycrystalline silicon wafer [1,2], this layer of amorphous silicon film greatly reduces the etching speed of the liquid-making liquid. Sank in the silicon wafer surface preparation of light suede structure is difficult by using traditional polysilicon acid corrosion system were all gay [3, 4], at the same time line marks on the surface of the silicon crystal defects such as can not completely remove , resulting in the system after the velvet suede structure is not ideal, affecting the surface of the battery in the light effect, further influence the efficiency of the battery. Therefore, how to improve the flannelmaking effect of diamond wire cut polycrystalline silicon sheet and reduce the reflectivity of flannelette has become the focus of industry research.

At present, the acid flushing solution commonly used in the industry is the mixture of $HF/HNO_3/H_2O$. In this paper, the surface tension and wettability between silicon wafer and flushing solution are improved by adding flushing additives in the acid flushing solution, which can obtain the ideal flushing structure, reduce the surface reflectivity of silicon wafer and improve the conversion efficiency of polysilicon cell.

Based on this scheme, this paper experimentally verified the effect of different additives on the flannelmaking of diamond wire cut polysilicon wafers, and obtained the better flannelmaking method of diamond wire cut polysilicon by comparing the flannelmaking structure, surface reflectivity and the electrical properties after processing into batteries.

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2. Experimental Section

2.1 Working principle of texturing additives

The main function of polycrystalline fleece-making additives is to reduce the light trapping effect of the fleece-making surface and improve the conversion efficiency of polycrystalline cells, which is used in the fleece-making process of crystalline silicon solar cells. According to the principle of polycrystalline cashmere additives, the cashmere can be roughly divided into the following three types:

(1) Ionization balance type: additional oxidants or weak acids such as CH_3COOH, H_3PO_4 and H_2SO_4 are adopted according to the principle of ionization balance to realize the inhibition of H^+ concentration or NO^{2-} concentration in the fleece-making solution, and the uniformity of the fleece-making surface is improved by reducing the reaction speed of the fleece-making solution .

(2) Surface tension type: the use of surfactant to reduce the surface tension of the flushing liquid, increase the spread of the flushing liquid on the surface of the silicon wafer, the actual flushing reaction is more uniform;

(3)Organic form type: Utilizing the adsorption characteristics of the surfactant and the surface of the silicon wafer, the surfactant acts as a template on the basis of improving the uniformity of the suede. The suede structure obtained after the sueding is a composite of large suedes nested with small suedes Suede.

2.2 Experimental equipment and reagents

The main experimental materials and equipment used are shown in Table 1 and Table 2 respectively.

Table 1. Main experimental materials

Material name	Molecular formula	Content W/%	Instrument model
P-type silicon wafer	Si	>99.9999	GCL-Poly, polycrystalline P type 158.75mm*158.75mm
Hydrofluoric acid	HF	49	Wuxi Dongfeng, EL class
Nitric acid	HNO_3	68	Wuxi Dongfeng, EL class
Additive A			Manufacturer A
Additive B			Manufacturer B
Deionized water	DI-Water		

Table 2. Main test equipment

Equipment name	Model	Manufacturer	Instrument use
Laser scanning confocal 3D microscope	OLS4000	Olympus Japan (OLYMPUS)	Characterize topography
Standard 8 degree angle integral reflectometer	D8	Zhidong Optoelectronics Technology (Shanghai)	Reflectivity test
Halm tester	CetisPV-CTL1	h.a.l.m. elektronik gmbh	Conversion efficiency test

2.3 Experimental method

2.3.1 Suede silicon wafer preparation

Place the original silicon wafer in a certain ratio of HF: HNO_3: H_2O mixture, and react at a certain temperature to remove the damage layer produced by the cutting of the silicon wafer surface to prepare a light-trapping suede structure. Compare the detailed texturing process of the combined experimental group See Table 3. After the test is completed, the surface morphology and reflectivity of the silicon wafer are measured in time.

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Table 3. Texturing process of different experimental additives

ITEM	Solution ratio (L)				Process conditions		Remarks
	HF	HNO_3	DI-Water	Additive	Temperature (℃)	Reaction time (s)	
Experiment A	65	210	105	3	7	65	Additive A
Experiment B	70	200	110	3	7	65	Additive B

2.3.2 Battery preparation

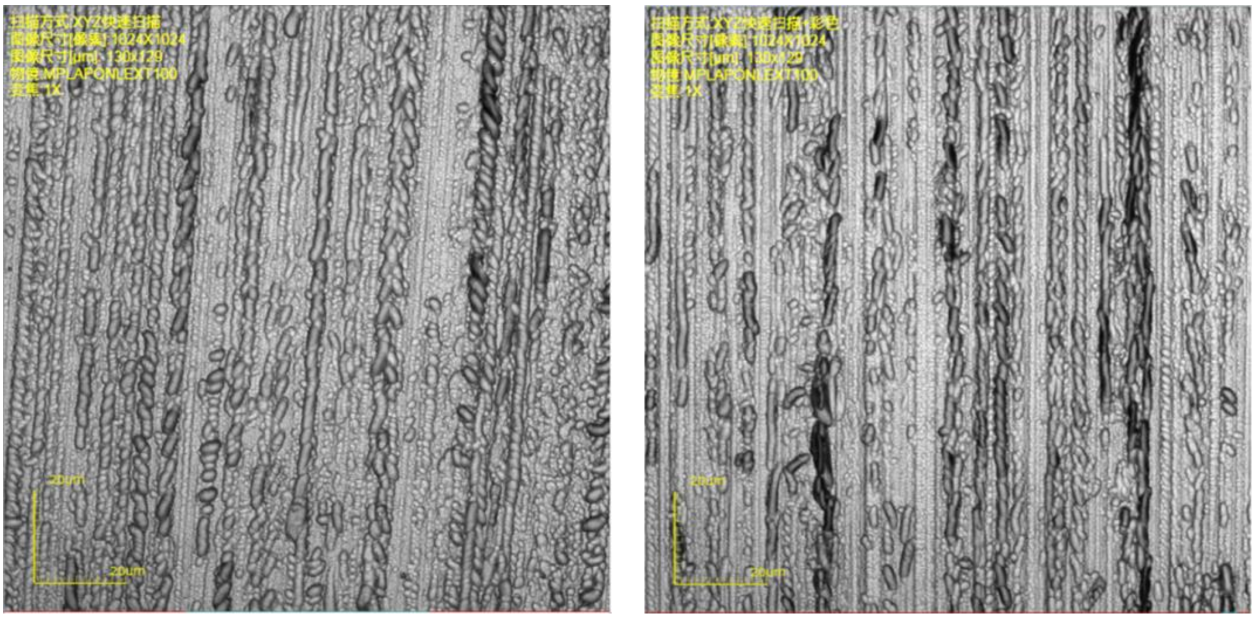
Polycrystalline silicon wafers are prepared by texturing process formula, and the obtained polycrystalline silicon wafers are produced according to the same process path and raw materials, and the electrical parameters of experimental group A and experimental group B are tested. The texturing process formula is shown in Table

3. Experimental results and discussion

3.1 Influence of additives on suede structure and reflectivity

Figure 1 shows the test diagrams of the suede structure after two sets of experiments. It can be seen from the figure that the experimental group A has obvious advantages over the experimental group B in terms of the fleece rate and the uniformity of the suede surface. Through the surface structure test of the fleece sheet obtained after texturing with two additives, it is found that the suede structure prepared in experiment A is better than experiment B in terms of width, depth, surface area, etc. The detailed test data is shown in Table 4 Show. This is attributed to the fact that the additive A has a promoting effect on the corrosion rate of the silicon wafer, the texturing effect on the surface of the silicon wafer, and the degree of reaction of the diamond wire cutting silicon wafer surface during the texturing process, thereby improving the width and depth of the texturing surface of the silicon wafer. Make the suede more even.

The weighted average reflectance of the two groups of fleece backs in experiment A and B were 22.6% and 23.8%, respectively. The comparison of reflectance is shown in Figure 2. Experiment A has a lower surface reflectance, which is attributed to the fact that the texturing additives used in experiment A have a more uniform distribution of the suede structure after texturing, so that it can better absorb photons and increase the light trapping effect, so it is better matched Photon wavelength (400-1100nm).



Experiment A Experiment B

Figure 1. Suede structure diagram prepared by different experiments

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Table 4. The suede structure test and the weighted average reflectance of the suede back sheet in different experiments

Project	Width (um)	Depth (um)	area (um^2)	Surface area (um^2)	Average weighted reflectance
Experiment A	3.339	0.577	16766	18784	22.6%
Experiment B	2.801	0.503	16766	18243	23.8%

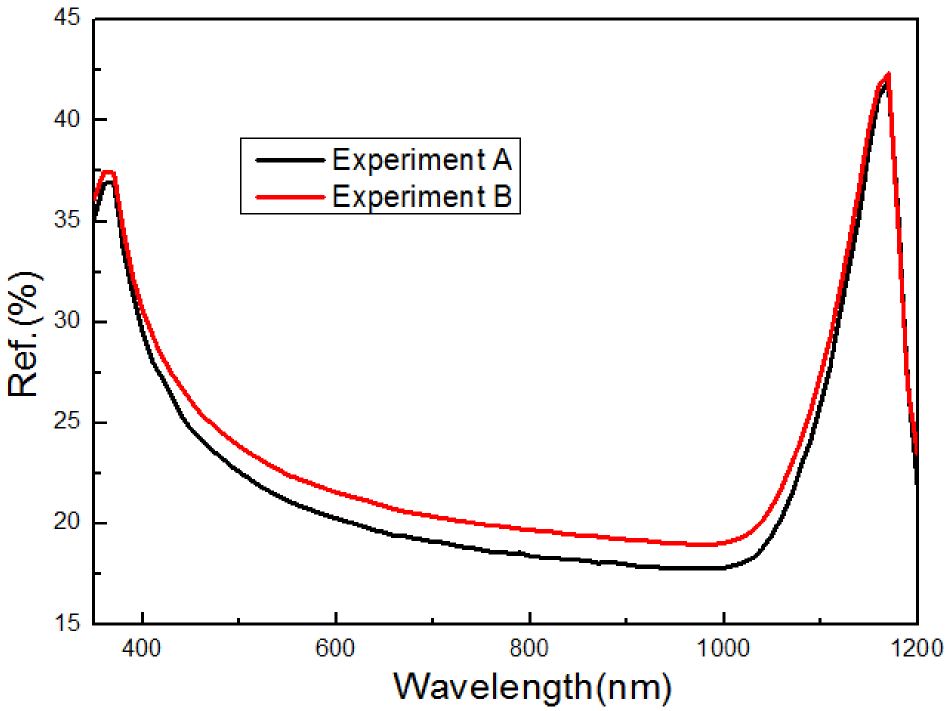

Figure 2. Comparison of reflectivity of fleece backsheets prepared in different experiments

3.2 The influence of additives on the electrical energy of polycrystalline batteries

Table 5 shows the comparison data of the electrical properties of the suede sheets prepared in experiments A and B after processing into polycrystalline cells. According to the statistical results of the two groups of experimental batteries Ncell, Uoc, Isc and other electrical performance parameters in Figure 3. It can be seen that the Isc of experiment A has increased by 26mA compared to experiment B, and the distribution is also relatively concentrated. The Uoc of experiment A has also achieved a slight increase of 0.7mV, and finally realized a polycrystalline cell efficiency increase of 0.08%. The concentration of cell efficiency distribution can not only reduce the number of bins in cell bins, reduce product types and the probability of low-efficiency cells, improve cell yield, and increase the packaging power of polycrystalline solar cell modules [5]. The efficiency improvement and distribution concentration of experiment A are mainly due to the following two factors: one is the better light trapping effect of the suede structure prepared by additive A; the second is that the suede structure is uniform and the relatively large width is beneficial to the passivation of the silicon nitride film. Therefore, the distribution of the electrical performance data of the cells prepared by Additive A will be relatively concentrated under the stable production conditions of the process.

Table 5. Comparison of electrical performance of different experiments

Item	Count	Uoc(**mV**)	Isc(**A**)	Rs(**Ω**)	Rsh(**Ω**)	FF	Ncell
Experiment A	17016	640.7	9.0422	1.48	266.55	80.13	18.90%
Experiment B	17417	640.0	9.0161	1.50	232.59	80.10	18.82%
Experiment A–B		0.7	0.0261	-0.02	33.96	0.03	0.08%

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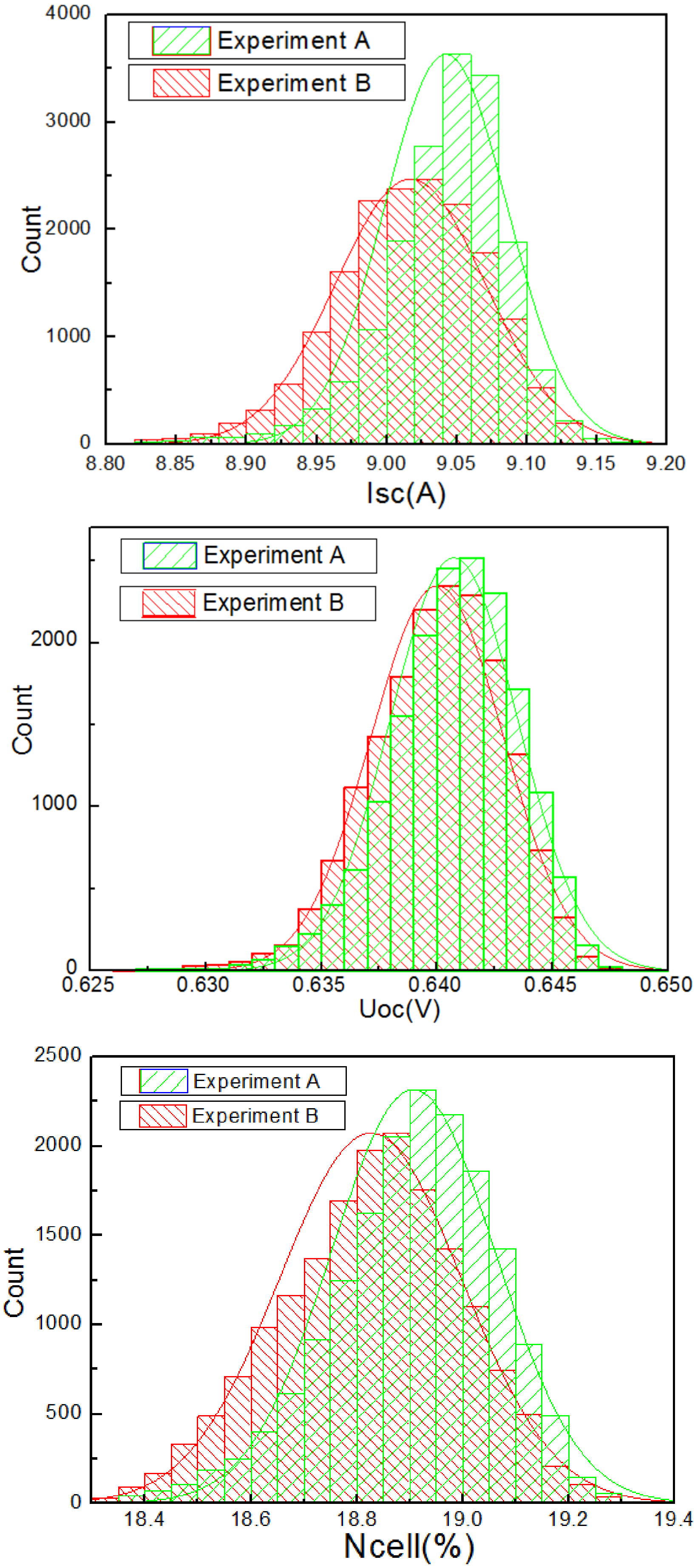

Figure 3. Statistical results of electrical performance parameters of different experiments

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4. Conclusion

This paper analyzes the texturing principles of different polycrystalline texturing additives, and verifies the effects of different texturing additives on the texturing structure, reflectivity and battery electrical properties of the diamond-cut polycrystalline silicon wafers through experiments. We found that the surface morphology and reflectivity of the fleece prepared by different texturing additives are different. Comparing the electrical performance, it is found that the distribution intervals of Isc, Uoc, and Ncell of the polycrystalline battery prepared by Additive A are relatively concentrated, and they are all higher than those of Additive B. This is mainly due to the fact that the velvet backsheet prepared by additive A not only has a good light trapping effect, but the larger velvet surface is conducive to the passivation of the battery surface.

References

[1] Chen, K., Liu, Y., Wang, X., et al. Novel texturing process for diamond-wire-sawn single-crystalline silicon solar cell, Solar Energy Materials and Solar Cells 133 (2015) 148–155.

[2] Bidiville, A., Wasmer, K., Kraft, R., and Ballif, C., Diamond wire-sawn silicon wafers-from the lab to the cell production, In Proceedings of the 24th EU PV-SEC (2009) 1400–1405.

[3] Wu H. Fundamental investigations of cutting of silicon for photovoltaic applications[D]. Georgia Institute of Technology, 2012.

[4] Bidiville A., Heiber J., Wasmer K., et al. Diamond wire wafering: wafer morphology in comparison to slurry sawn wafers [C]. 25th European Photovoltaic Solar Energy & Exhibition, 2010:1673-1676.

[5] Wang Qi, Zhichun Ni, Jianhua Zhao, et al. Research on power loss of solar cell modules[J]. Photovoltaics International, 2011, 12(5):148-156.