PERFORMANCE OF SILICON SOLAR CELL WITH VARIOUS SURFACE TEXTURES

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ABSTRACT

The performance of solar cell with various surface texture patterns was reported. Wet, RIE, one and two dimensions texturing with and without the nitride antireflection coating were compared. An *I-V* tester calibrated by Sandia National Laboratory was used. The surface texture of the solar cells were as follows (a) solar cell with 2D texturing without nitride antireflection, (b) solar cell with 1D texturing with nitride antireflection (c) solar cell with 1D texturing without nitride antireflection, (d) solar cell with wet texturing without nitride antireflection, (e) solar cell with wet texturing with nitride antireflection (f) solar cell with RIE texturing with nitride antireflection. RIE and two dimension surface texturing showed the best output with maximum short density current of 0.042 mA/cm^2 and of 0.045 mA/cm^2 respectively.

Keywords: Texturing, RIE, One and two dimensions grating, Efficiency, Current variation

ABSTRAK

Unjuk kerja *solar cell* dengan berbagai pola kekasaran (*texture*)permukaan dilaporkan. Wet, RIE, satu dan dua dimensi permukaan dengan dan tanpa pelapisan anti refleksi nitrit dibandingkan. Peralatan uji I-V yang digunakan dikalibrasi oleh Sandia National Laboratory. Kekasaran permukaan *solar cell* adalah (a) *solar cell* dengan dua dimensi kekasaran tanpa lapisan anti refleksi nitrit, (b) *solar cell* dengan satu dimensi kekasaran dengan lapisan anti refleksi nitrit, (c) *solar cell* dengan 1 dimensi kekasaran tanpa lapisan anti refleksi nitrit, (d) *solar cell* dengan kekasaran wet tanpa lapisan anti refleksi nitrit, (e) *solar cell* dengan kekasaran wet dengan lapisan anti refleksi nitrit, (f) *solar cell* dengan kekasaran RIE dengan lapisan anti refleksi nitrit. RIE dan 2 dimensi kekasaran permukaan menunjukkan output terbaik dengan kerapatan arus pendek maksimum sebesar 0,042 mA/cm^2 dan 0,045 mA/cm^2

Keywords: Pengkasaran (*texturing*), RIE, Satu dan dua dimensi parutan, Efisienci, Variasi arus

1. INTRODUCTION

It was shown texturing can be considered as a good candidate to solve the cost price and efficiency problem of thin solar cell [1]. By texturing the light are traveled more inside the cell and the absorption of it was increased as the length of traveling increased. The shape and the size of the patterns could affects on the efficiency.

The interaction of KOH with silicon was making very fine pyramids as a texturing in the solar cell. In micro-electronics area the photolithography method, made some investigation on texturing and good efficiency such as inverted pyramids that used in PERL cell or PESC cell structure. In both of these two kinds, diffusion and surface passivation, by oxide or nitride, are effected early in the cell fabrication sequence, after surface etching and texturing [2]. RIE and one and two dimension grating are other candidates of texturing that recently are investigated [3, 4, 5].

This paper presents the performance of the solar cell with various texturing namely (a) solar cell with 2D texturing without nitride antireflection, (b) solar cell with 1D texturing without nitride antireflection (c) solar cell with 1D texturing without nitride antireflection, (d) solar cell with wet texturing without nitride antireflection, (e) solar cell with wet texturing with nitride antireflection (f) solar cell with RIE texturing with nitride antireflection.

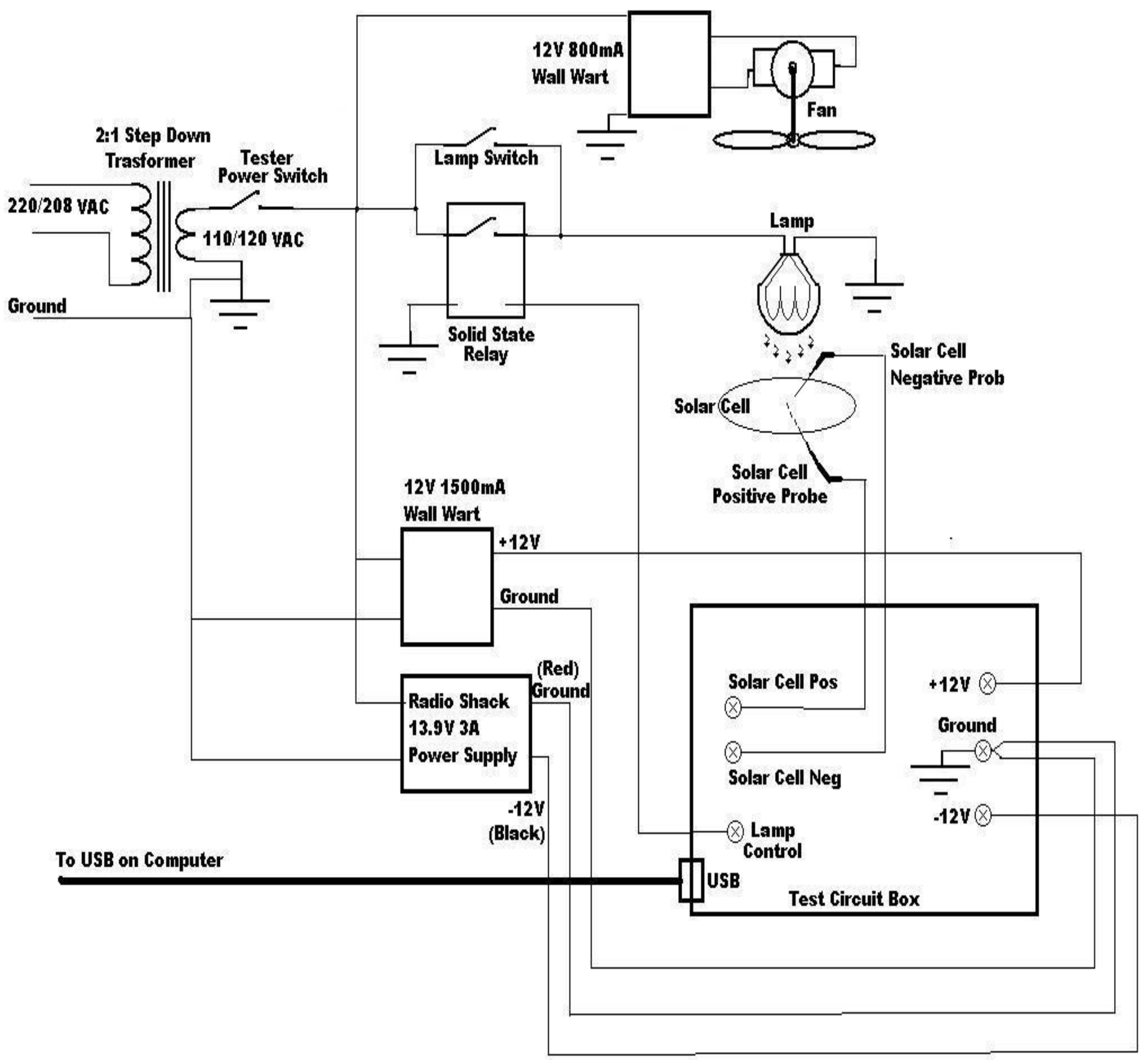

Fig.1. A schematic circuit of I-V tester that was used in measurement.

2. I-V CURVE TESTER

The I-V curve testers was designed and fabricated by Grating, Inc company and was calibrated by Sandia National Laboratories. A halogen lamp in 1 meter height was used as the optical source. Two probes and a copper base were used to collect the current from the surface of solar cell and induce the reverse voltage. With an electronic circuit the applied voltage changes in specific equal intervals. With an interpolator as software we find out the real I-V curve and monitoring by a computer. **Fig. 1** show internal circuit of the tester. The output curve is shown in **Fig. 2**. Usually for comparison we use Sigma Plot to change output data to graphical data.

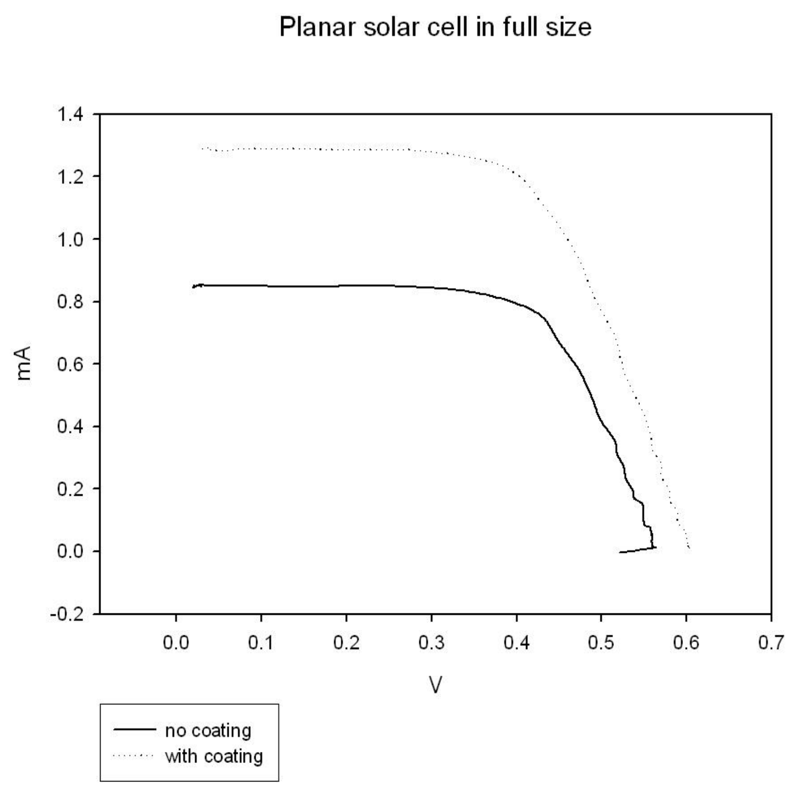

Fig. 2. I-V plot of planar solar cell with and without antireflection nitride layer in 1 sun measurement

3. RESULTS AND OBSERVATIONS

Seven samples in our propose measurements. Some of these samples have more than one texture on it. A 1 cm^2 mask is used to cover it in order to protect the other part from light exposes. The first two samples are planer solar cell without any texture (bare). **Table 1** shows the open circuit voltage and the short circuit current of the samples. The measurements were conducted at 1 sun illumination.

Table 1. Open circuit voltage and short circuit current for different solar cell texturing samples in 1 sun illumination

Sample	Size (mm)	V_{oc} (Volts)	I_{sc} (mA)
711-grat 2 (zone 1)	10×10	0.42	0.035
711-grat2 (zone 2)	10×10	0.41	0.037
711-grat2 (zone 3)	10×10	0.41	0.032
711-grat2 (zone 4)	10×10	0.46	0.042
711-grat2 (zone 5)	10×10	0.44	0.030
711-grat1 (zone 1)	10×10	0.38	0.042
711-grat1 (zone 2)	10×10	0.36	0.037
711-RIE-nitride (zone 1)	10×10	0.49	0.039
711-RIE-nitride (zone 2)	10×10	0.49	0.044
711-wet- nitride	61×70	0.6	1.35
711-wet- nitride	10×10	0.49	0.045
711-planar-nitride	61×70	0.62	1.25
711-planar-nitride	10×10	0.5	0.045
711-wet-tex1	61×70	0.6	1.26
711-wet-tex1	10×10	0.49	0.042
711-planar	61×70	0.57	0.85
711-planar	10×10	0.46	0.030

Figure 2 shows the I-V curve of these two samples. Both are non-textured (planar) with coating and without antireflective coating. As expected the performance of cell with nitride antireflection is much better than another. The results for wet texture, with and without nitride antireflections are shown in **Fig. 3**. As expected, the cell with coating has better performance. In **Fig. 4**, two dimensions grating with various periods in deferent zone of cells are shown. Each zone introduces a particular period of two dimensions grating. Zone 3 of these measurements shows the good quality and characteristics of two dimension grating. **Figure 5** show the I-V curve for 2D and 1D surface texturing for 1cm^2 respectively.

Figure 6 shows the I-V plot of RIE texturing in 1 cm^2.

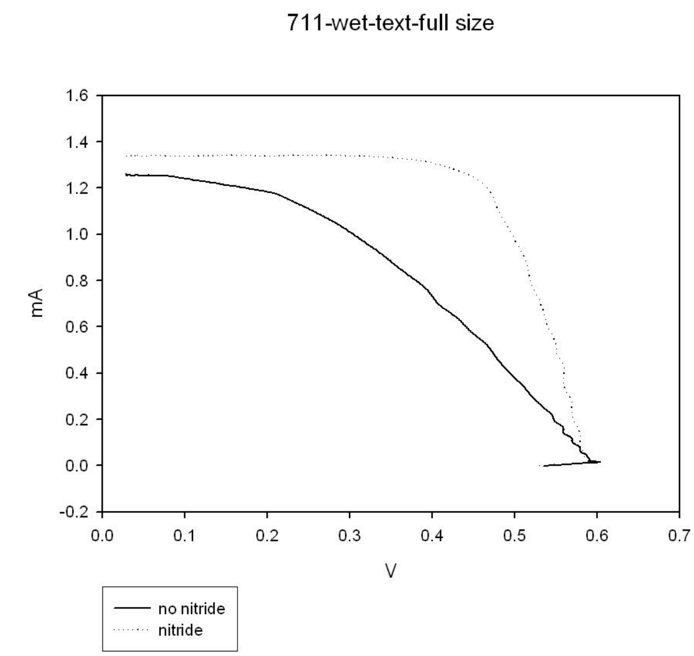

Fig. 3. I-V plot of wet texture solar cell with and without antireflection nitride layer in 1 sun measurement

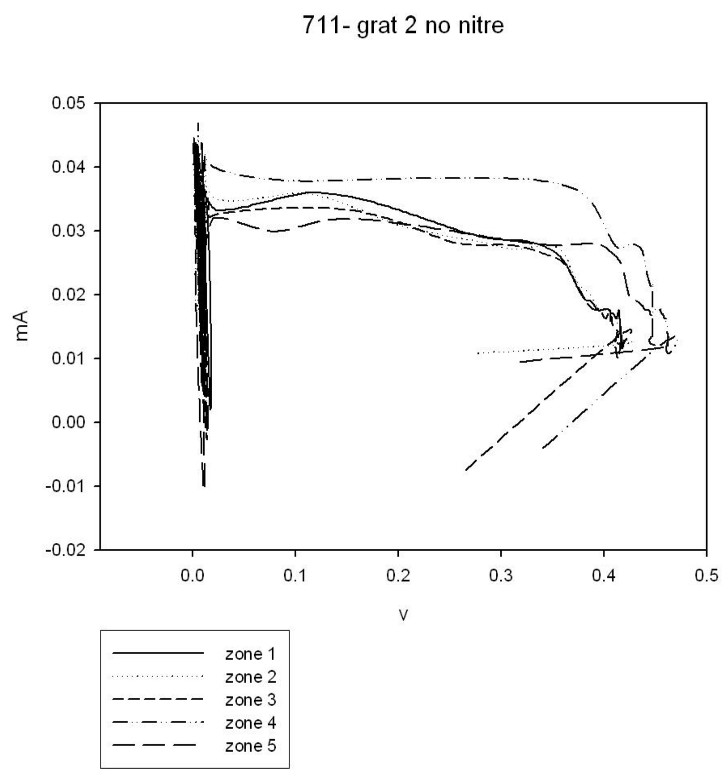

Fig. 4. I-V plot of 2D textured solar cell with and without antireflection nitride layer in $1cm^2$ in 1 sun measurement

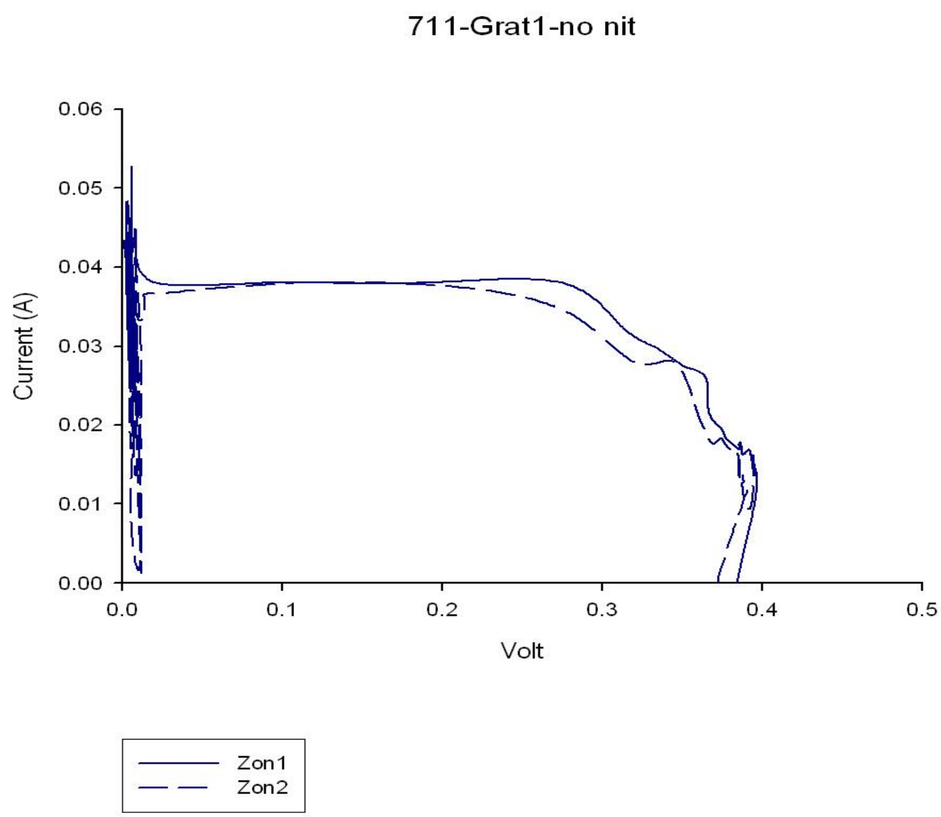

Fig. 5. I-V plot of 1D textured solar cell with and without antireflection nitride layer in 1cm^2 in 1 sun measurement

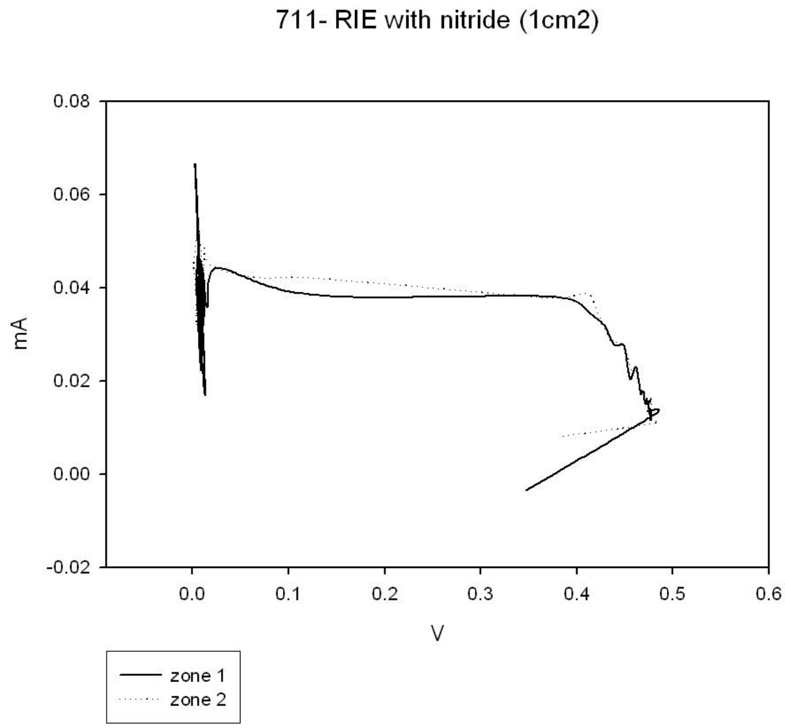

Fig. 6. I-V plot of RIE texture solar cell with and without antireflection nitride layer in 1cm^2 in 1 sun measurement.

We have found during the test that shaking and noise make an uncertainty in our measurement. These nosey plus might be related to solar connections with I-V tester. It was suggested to by using a vacuum pump we could find good connections and therefore increase the quality of measurements. Another problem in our measurements comes from the musk, because it could not cover the zones and therefore some extra light coming inside the zones and disturbed the results. Indeed, it has made some extra current during the measurements.

4. CONCLUSIONS

The performance of solar cells changed as the texturing changed. It is found that RIE texturing and 2D texturing has good output and performance in compare to other samples. In our measurement we have not good plot because of nose and lack of good connection and unsuitable mask using vacuum pump and using each sample in one unit cell could increase the correct measurements.

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