Improvement of Front Side Contact of Solar Cell through Light Induced Plating without any External Bias at Different Conditions

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ABSTRACT
This experimental study mainly focused on the improvement of solar cell front contacts. Industrial solar cell's front contacts are made by screen printing method using Ag-paste material, but there are some processing steps drawbacks. Mainly on the surface of the front contacts create some unwanted pores those increases the series resistance and edge of the front contacts form unwanted Ag-paste dots and different structures which increase optical loss. By optimizing the concentration of solution, light intensity, and chemical treatment in Light Induced Plating (LIP) solar efficiency increases up to~1.2% is possible.

Keywords*:* LIP (Light Induced Plating); Air-voids; Screen Printing: Series Resistance; Optical Loss.

1. INTRODUCTION
Silver (Ag) screen-printing has been the dominant technology for front-side metallization of silicon (Si) solar cells for industrial applications. But due to different chemical and thermal steps in the screen printing method different types of problem arises as a result unwanted increases in series resistance and optical shading which reduces the solar efficiency. So improvement of screen printing contact material is also important. Next generation selective-emitter technology, such as laser-doping [1–4] are increasingly looking to replace it with self-aligning, also lower-cost metal plating processes to raise efficiencies and reduce wafer to cell manufacturing costs. Light-induced plating (LIP) approaches have been suggested for solar cell metallization [1, 5, and 6] for overcome screen printing problem. Efficiency of Solar cell by photolithography of front contact in laboratory is 0.5% more than screen printed contact [7]. And also A. Ebon group shows that by doing edge treatment solar cell Fill Factor increases 0.753 to 0.782[8]. Light induced electroplating of silver (Ag) metal on top of the front contact grid has shown promise in reducing line resistance and increasing cell power output [10, 11].

In this study a simplest method of light induced plating is considered and series resistance and fill factor are optimized.

2. EXPERIMENTAL DISCUSSIONS
Experimental details: The experimental study is done in three steps

- HF dipped of mother solar cell for different times.
- LIP by changing different Electrolyte solution concentration and different light intensity.
- HF dipped and IPA ringed for final sample.

First hydro fluoric (HF) acid is taken in a PTFE beaker and then two different types of solar cells are dipped into the HF for four different times as 30 sec, 40 sec, 50 sec, 60 sec consecutively.

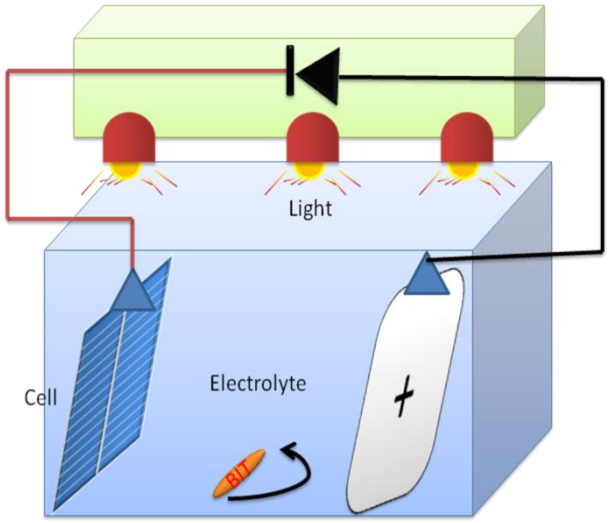

Figure 1. LIP experimental setup

After that 5 gm, 12.5 gm, and 15 gm of Potassium Argentum Cyanide (PAC) is mixed in 1000 ml DI water, and stirred the PCA solution for five minutes. Ag-plate of Round shaped is taken as anode and Solar cell as cathode. P-side of solar cell is connected with the anode plate by a conducting wire. Solar cell is placed horizontally on the bottom of the beaker and Anode plate was placed around the solar cell and applied variable light energy of maximum intensity 1000 w/m^2.

Again the solar cell is dipped into the HF for 10-20 seconds followed by Isopropyl Alcohol and ringed by DI water.

3. RESULT AND DISCUSSIONS
We have first studied on edge of fingers and bus-bars. To remove extra shading areas a different type of Chemical treatment is applied. Front contacts are the important part of the solar cell. Hydro Fluoric Acid (40% of MERCK) is taken and dipped the different base intensities solar cell into the HF for different times. The HF etches the oxide of the front surface and lift-off the extra Ag particles. And most of the solar cell at time 40 to 50 seconds gives better improvement of Fill Factor without changing the efficiency and series resistance. This time fully depends on the amount of unwanted edge particles. Then it is optimized that the concentration of Electrolyte Solution. LIP technology without applying any bias is taken for this experimental study. Then light intensity is also important for

LIP deposition. The light intensity from 200 w/m^2 to 700 w/m^2 is tested and seen that higher intensity give better result. When the light applied on the solar cell's front surface the huge no of electrons gathered on the n-surface. P-side of the solar cell is shorted with the silver Anode plate. (Here the N-side is cathode and Ag plate is anode.) So the Ag+ ions from electrolyte solution reflected by the Ag-plate anode and created field line between anode and solar cell. As a result Ag + ions deposited on the front printed contacts. The round shaped anode is taken (shown in picture: 1) for uniform field line (which gives uniform deposition) on the solar front contacts. The surface of the front contact has some air voids. Due to the air-voids series resistance increase and also the air-voids form capacitor which increase convergence resistance. As a whole the electron flow in the front contacts material goes down and efficiency decreases. In the LIP field lines goes much more to the air-voids and filled the voids faster than plane surface. And it increases the height which decreases the series resistance also efficiency. But LIP for long time the height and width both will increase and more width will have to take it under consideration because it increases the optical shading. Also due to the huge surface electron some Ag particle will deposited on the N-type front surface. It also creates optical shading and again reduces efficiency. So after LIP process dipped in HF for removing unwanted surface and front contact edge particles is also important.

In first step after each dipping into HF it shows that the fill factor and series resistance. And every time the series resistance was unchanged, but Fill factor was improving gradually. When dipping process is done more than 50 seconds the HF affect the surface of the solar cell and Fill Factor and Efficiency both goes down, because HF creates unwanted black shading on the surface. After each dipping in HF the solar cell should clean by DI water for three or four times.

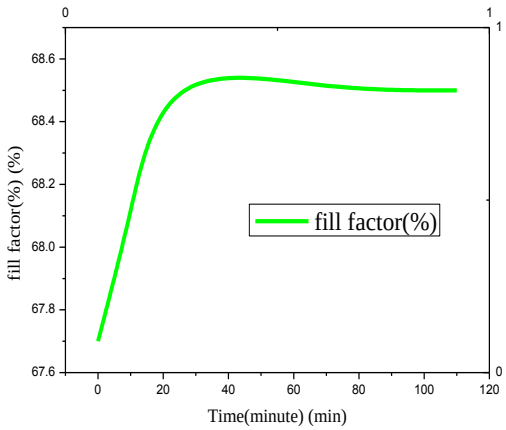

Figure 2: FF up to 50 sec going higher again after 50 sec it is going down. Time 0 indicating FF before dipping

LIP process is finished by different optimization first optimizing the light intensity. At lower intensity (300w/m2) the series resistance changes very slowly where for the intensity more than 600w/m^2 the series resistance decreases faster(Shown in Graph 2). Again the light intensity increased very high then due to high collection of electron on the n-side Ag+ deposited on the n-side so there create shading loss.

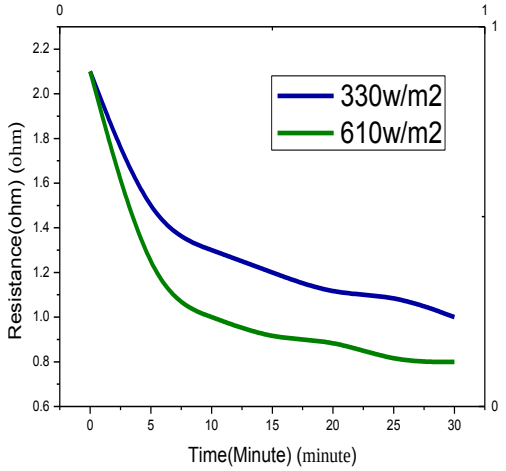

Figure 3: Series resistance changes due to 2 different light intensity at different time

After that changed concentration is taken of electrolyte solution with our optimized light intensity and seen that at lower concentration adhesion is good but it takes long lime to change the series resistance. Different concentration of electrolyte solution like 5gm/lit, 12.5 gm/lit, 15 gm/lit is taken and got better results at 12.5 gm/lit concentration. Figure shows the finger thickness for three different times at 5gm/lit cyanide solution and 610wt/m^2 light intensity.

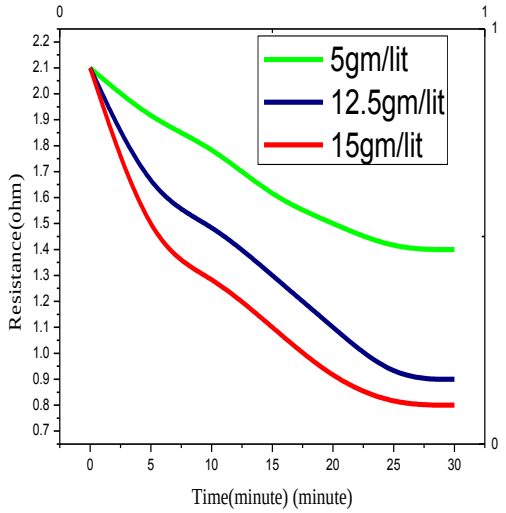

Figure 4: Resistance change for different concentration of electrolyte

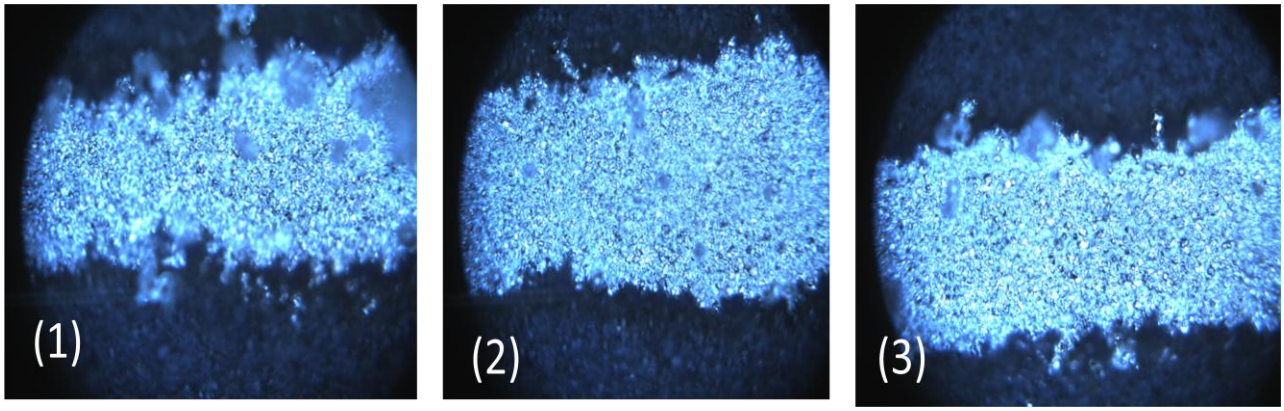

Figure 5. (1)Finger after 5minutes of LIP (2) Finger after 10minutes of LIP (3) Finger after 15minutes of LIP

4. CONCLUSIONS

With the light induced plating process solar cell efficiency can be improve. Also it is seen that by using this process the optical shading due to unwanted silver paste can be avoided at the same time series resistance can be improve as a result fill factor can be improve.

5. ACKNOWLEDGEMENTS

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