Improvement of Ni/Cu plating by plasma treatment for the metallization of Heterojunctions solar cells

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***Abstract* — Heterojunction solar cells are promising technologies for high efficiency silicon-based solar cells fabrication. However, their cost remains larger than competing technologies, mostly because of the cost of silver. Metal plating has been proposed to replace screen-printed silver, however, adhesion issues prevented the direct plating on the transparent electrode of the cell. This work aims to develop plasma processes to enable the direct plating of metal on indium tin oxide, for lower cost heterojunction solar cells fabrication. We show that atmospheric plasma treatment with Ar/H_2 can enable direct plating of Ni/Cu on ITO.**

Keywords— Heterojunction, solar cells, plasma treatment, electroplating, ITO, lifetime measurement.

1. Introduction

Today, silicon solar cells technologies cover more than 80% [1] of the photovoltaic market. Among these varieties of silicon solar cells, heterojunctions solar cells are the most efficient. Unfortunately, the production cost of heterojunctions cells is expensive, especially when using expensive materials like silver for the metallization. Currently, 2,000 tons of silver per year are consumed for solar energy [2]. Due to the high demand, the price of silver increases. Therefore, it is our interest to look for an alternative metal, such as copper. Many laboratories work on this topic, e.g. CESM Laboratory made cells with copper metallization [3]. Some challenges still exist, such as the metal adhesion to Indium Tin Oxide (ITO) surface, the high contact resistance and delamination. By using plasma atmospheric treatment, this work aims to improve the copper adhesion and to reduce the contact resistance.

2. Contextual setting

It is known that Plasma treatment can improve the adhesion properties and reduce the metal to oxide [4]. Thus, to promote a-Si:H/c-Si heterojunctions technology through the solar cells metallization, this work tries to answer whether a plasma treatment can enable Nickel/Copper plating on ITOs by improving its adhesion. We propose to implement a plasma treatment process on the ITO layer in order to reduce the oxide to Indium and promote both the adhesion of electroplated metal and the decrease of the contact resistance.

3. Methodology

In this project, a suitable lithography mask has been designed with 5 fingers and 2 busbars closed to standard cells. Subsequently, a reducing plasma atmospheric protocol was implemented. After that, 2µm of nickel was deposited as a barrier layer prior 10µm Copper plating. After this process, an adhesion measurement was performed. Minorith carrier lifetime was also analyzed before and after plasma treatment to verify the quality of the semiconductor-passivation is not degraded by the plasma treatment. Finally, Si:H/c-Si heterojunctions solar cells with Nickel/Copper electroplated contacts were fabricated and characterized to ensure the role of the plasma treatment.

4. Results

Si:H/c-Si heterojunctions solar cells without plasma and with plasma where fabricated. Before plasma treatment, lifetime measurement of the cells is between 600 to 1200 µs. After 5min of treatment with Ar/H_2, it was seen that the minority carrier lifetime change from one point to another on the surface of the cell and result is similar with the lifetime analyze before the plasma treatment.

While we did peel-test measurement, it was demonstrated that there is no delamination with the solar cell treated by Ar/H_2. Without plasma, there is a delamination between the interface of Nickel and the transparent electrode.

By the way, the external quantum efficiency measurement showed that we got the same current density (Jsc ~ 35 mA/cm²) with a comparable curve shape for the cells with plasma and without plasma. Here, we can say that the plasma treatment does not damage the quantum efficiency of the cells. Here, the cells manufactured are without backside contact and the 1 sun simulator measurement of one of our best wafers show that the cell works and got a high VoC ~ 700 mV.

5. Conclusion

In this work, atmospheric plasma treatment with Ar/H_2 have enable direct plating of Ni/Cu on ITO. This process enhances the adhesion of metal to the transparent electrode and it was demonstrated that the quantum efficiency was not damage.

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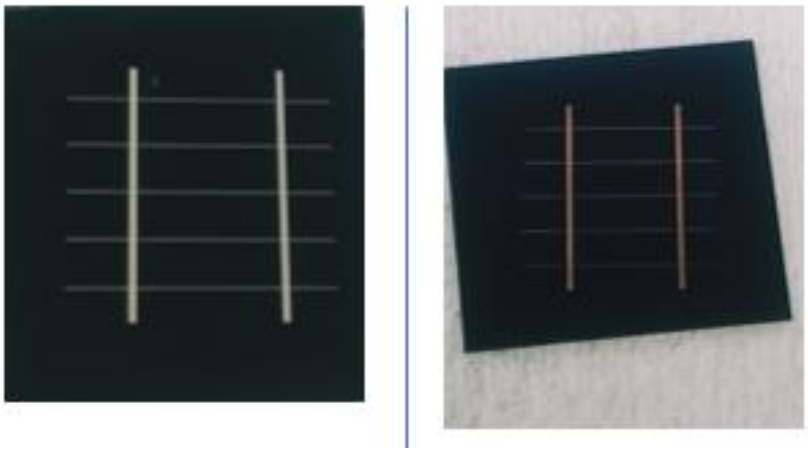

Figure 1 : Solar cell with Nickel plating and solar cell with Nickel/Copper