FORWARD BIAS PLATED NICKEL-COPPER-TIN CONTACTS FOR CRYSTALLINE SILICON SOLAR CELLS

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Abstract:

In silicon solar cell technology, an advanced metallization plays an important role to enhance the cell efficiency. Ni/Cu/Sn plating metallization is employed as front side contact for n-type Si solar cells. In this work, the thickness of Cu conductive layer varies with the plating time to reduce the finger resistivity. Besides, the front-side shading issue is improved via laser ablation and Sn plating processes. The Sn capping layer may be applied for corrosion resistance and enhanced solder. Finally, the performance of Ni/Cu plating cell with 8min-Sn capping layer exhibits a 0.08 mA/cm^2 increase of short-circuit current density (J_{sc}), 0.3% increase of FF, and 0.1% increase of conversion efficiency (η).

1. Experiment

Ni/Cu/Sn plating metallization is employed as front side contact and Ag printing metallization is used as rear side contact for n-type Si solar cells. The 156 mm n-type mono-crystalline silicon wafers with industrial texture are used as substrates. A plated Ni contact layer, plated Cu conductive layer, and plated Sn capping are applied to n^+np^+ front emitter solar cell structure consisting of boron doped emitter, intrinsic, and phosphor doped surface field. Prior to metallization, selective ablation of anti-reflection and passivation coating are performed via 532 nm wavelength of nanosecond pulse laser.

2. Results and discussion

Fig 1(a) and (b) show the SEM image and the EDX spectrum of laser ablated region. The width of laser ablation is about 26 μm. No oxide and nitride signals are detected in the contact open region. Fig 2 shows the microscope images of front-side surface before and after Sn plating. Red circles mark certain ghost plating particles. Fig 3 shows the SEM images of Ni/Cu and Ni/Cu/Sn plating metallization. After 8min Sn plating, the width of contact finger is about 49 μm. Fig 4(a) shows the cell performances with different Cu plating time. As the FBP time increases, the improvement of FF and Rs values are obtained. . Fig 4(b) shows Sn thickness with different Sn plating time. Table 1 shows the variations of Ni/Cu/Sn-cell characteristics and finger width (ΔW). Finally, the performance of Ni/Cu/8min-Sn plating cell exhibits a 0.08 mA/cm^2 increase of Jsc, 0.3% increase of FF, and 0.1% increase of η.

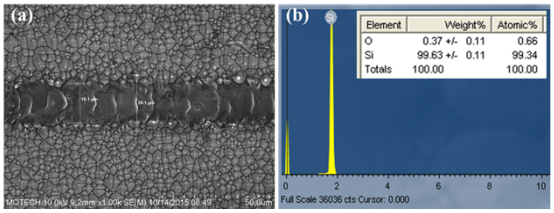

Fig 1. (a) SEM image of laser ablated finger (b) EDX spectrum of laser ablated region.

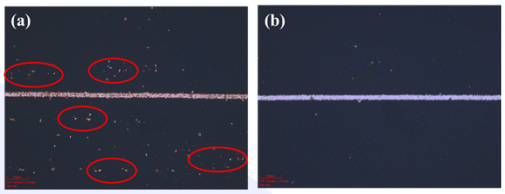

Fig 2. Microscope images of cell surface (a) before and (b) after Sn plating.

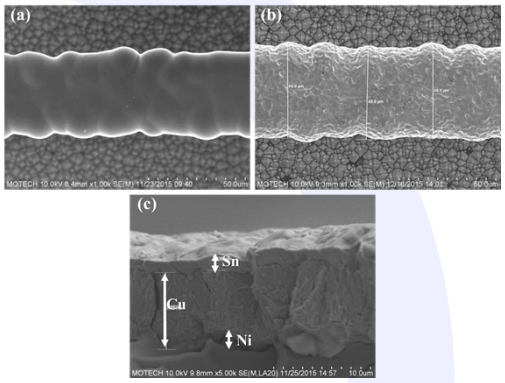

Fig 3. SEM images of (a) Ni/Cu plating finger (b) Ni/Cu/Sn plating finger (c) cross-section of Ni/Cu/Sn metallization

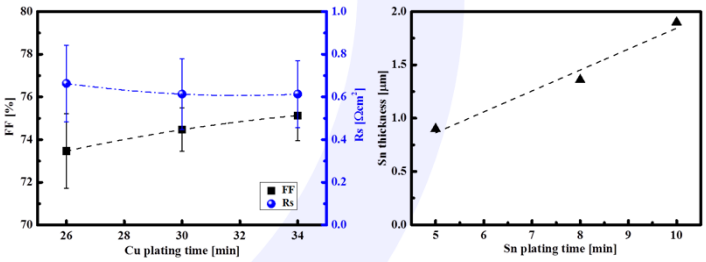

Fig 4. (a) Fill factor (FF) and series resistance (Rs) versus Cu plating time. (b) Sn thickness versus Sn plating time.

Table 1. The performances of Ni/Cu/Sn plating cells. The differences between Ni/Cu and Ni/Cu/Sn plating cells are shown.

	Δη [%]	ΔFF [%]	ΔJsc [mA/cm^2]	ΔVoc [mV]
Ni/Cu/5min-Sn plating cell	-0.04	-0.6	+0.27	+0
Ni/Cu/8min-Sn plating cell	+0.10	+0.3	+0.08	+0
Ni/Cu/10min-Sn plating cell	-0.12	-0.1	-0.08	+0

3. Summary

Mono-crystalline silicon based solar cells with Ni/Cu/Sn front side metallization have been fabricated via forward bias plating (FBP) technology. The narrow plated finger width is achieved by laser ablation technique, resulting in the low shadow areas. Besides, the ghost plating particles are improved during Sn plating process. The Rs values of Ni/Cu cells decrease with Cu plating time. After 8min Sn capping layer, the enhancement of average cell efficiency is about 0.1%.

4. References

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