Screen Printing for Perovskite Solar Cells Metallization

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INTRODUCTION

The objective of this project is to evaluate the method of forming the metal contact by Screen Printing, a method which is commonly used in standard manufacturing process for crystalline silicon photovoltaic cells, contributing to help reducing the costs and to introduce improvements in the manufacturing processes.

To achieve this, we have study the use of different kinds of silver pastes and inks by screen printing them over planar structures based on methylammonium lead iodide perovskite (MAPI), and trying to obtain the right conditions to avoid damaging the molecular nature of the deposited layers, while correctly drying and curing the electrodes without losing their conductive properties, thus following the manner in which manufacture processing could be like for this kind of solar cells.

A FIVE-PHASE STUDY METHODOLOGY

Phase I: Analysis and design of the contact geometry

- Several geometric configurations
- Variations on the cathode shape
- Reduced contact areas for avoiding structural imperfection

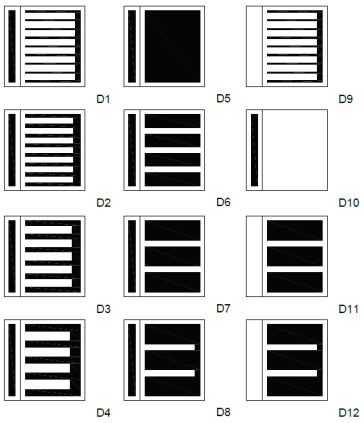

Figure 1: Screen designs

Phase II: Preparation of the substrate

Laser ablation technique for avoiding potential short circuits.

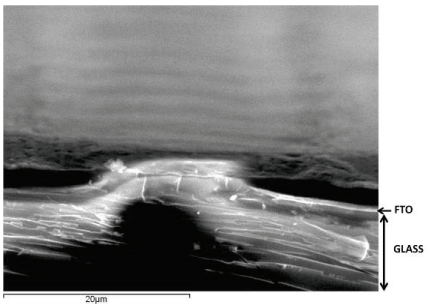

Figure. 2: SEM image of a sample section, with an inclination of 7 degrees and an increase of 5000X, focusing on an area showing the FTO layer ablated.

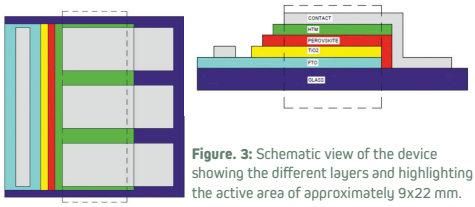

Figure. 3: Schematic view of the device showing the different layers and highlighting the active area of approximately 9x22 mm.

Phase III: Metal contact study over non conductive subtrates

- Selection of the pastes
- Deposition on non-conductive substrates

Table 1: Pastes and inks under study.

ID	Usage	Thickness (fired)	Type	Material	% Silver
A	c-Si	15-25 µm	Paste	Silver	89.54
B	c-Si	4-8 µm	Paste	Silver	53.04
C	MTS	8-10 µm	Ink	Silver	54.00

Phase IV: Device implementation

- Deposition on MAPI substrates

Phase V: Device characterization

- 4 Probe resistivity test on non-conductive and MAPI substrates

EQUIPMENT DESCRIPTION

- Process carried out in ISO 7 (Class 10,000) clean room
- Laser ablation for layer isolation
- High precision screen printer for metal formation
- Drying chamber for curing the printed electrodes was used
- Semiconductor characterization system and Faraday cage for 4 probe measurement tests

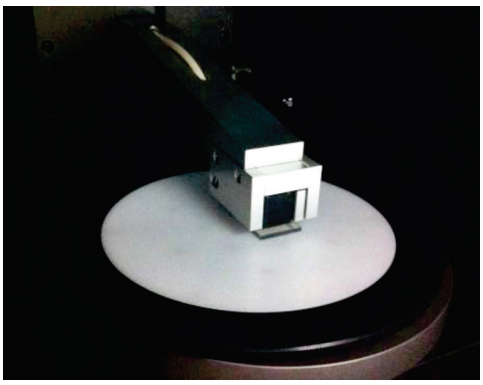

Figure 4: 4-Probe resistivity measurement for a cathode contact

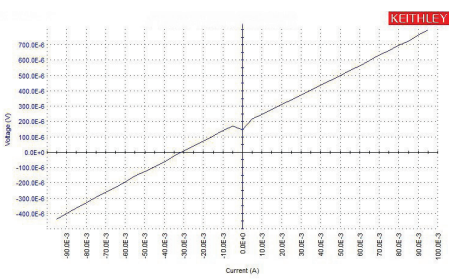

Figure 5: A type material resistance

FABRICATION PROCESS

- Phases II and IV being the most critical ones
- Pastes and inks deposited over FTO and HTM layers
- Electrodes were cured in a drying chamber during 10 minutes at 100°C
- 20 minutes cool down at room temperature

Figure 6: Image of the screen printer in operation.

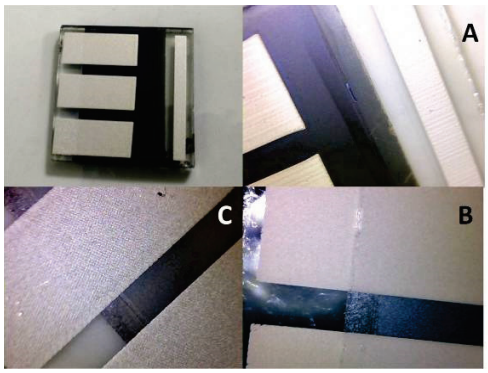

Figure 7: Close up view of finished devices, showing the different types of metal contacts.

FIRST RESULTS

Table 2: Contacts resistivity values over non-conductive substractes.

ID	Contact	Resistance (mΩ)	ρs (mΩ/sq)	ρ (mΩ/sq/mils)
A	Anode	17.75	34.57	13.83
	Cathode	6.9	33.38	13.35
B	Anode	30	58.48	23.37
	Cathode	15	72.56	29.02
C	Anode	21	40.90	16.36
	Cathode	9	43.53	17.41

Table 3: Contacts resistivity values over fully finished devices.

ID	Contact	Resistance (mΩ)	ρs (mΩ/sq)	ρ (mΩ/sq/mils)
A	Anode	16.76	81.05	32.42
	Cathode	30.98	60.33	24.13
B	Anode	478.74	2315.47	926.19
	Cathode	269.45	524.73	209.89
C	Anode	19.75	95.52	38.21
	Cathode	26.63	51.86	20.74

CONCLUSION AND DISCUSSION

- It is possible to perform electrode deposition with enough reliability and adequate conductivity by using screen printing methods in conditions of low curing temperature.
- Increase on volume resistivity were related to device serial resistance produced by the deposited layers. Effect on the PCE due to the use of different pastes and inks not yet established.
- Forecast on the use of this technique to include:
  > Doped pastes
  > Carbon pastes