Characterization of Contact Resistance Properties of Different TLM Structure Designs

Nicole Karam Pannaci[1], Kristopher Davis , Ph.D.[12], Mengjie Li, Ph.D.[1]

[1]Material Science and Engineering Department, University of Central Florida, Orlando, FL 32816, USA

[2]Florida Solar Energy Center, University of Central Florida, Cocoa, FL 32922, USA

Introduction

Silicon solar cells have been in development for the past century for their renewable energy potential. Screen printed contact has been widely used in industrial solar cell fabrications. Previous study has shown that the firing temperature has a significant impact on the formation of the metal-Si interface. There are three loss mechanisms in a solar cell: optical, resistive, and recombination. This project will cover the resistive part of the solar cells. The resistive characteristic covers emitter resistance, contact resistance, and finger resistance. Additionally, recent work has shown that contact resistance (ρc) can also be affected by the physical dimensions of test structure design. Transmission line method (TLM) is the most commonly used method to measure the contact resistivity. Our research objective is to compare two TLM structures, the thick TLM structure, and thin TLM structure, in the basis of firing temperature.

Methods

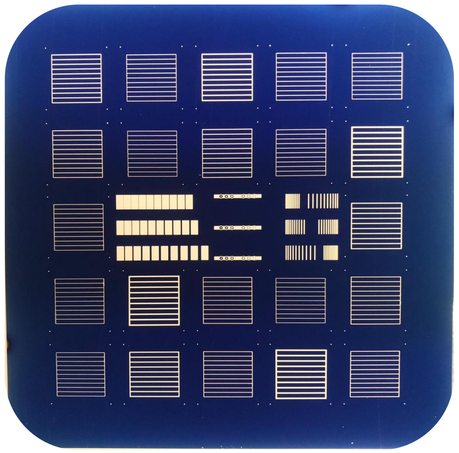

Figure 1: One of 20 samples (one of 4 groups)

1) Laser cut of both TLM structures
2) Measuring the Thick TLM using ContactSpot for both Front Only and Front and Rear Contact samples

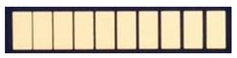

Figure 2: Laser cut of a middle Thick TLM

Figure 3: Laser cut of a middle Thin TLM

3) Measuring the Thin TLM using a probe machine with Labview to gather 100 data points of each sample for both Front Only and Front and Rear Contact samples
4) Analyze the data using Excel for the Thick TLM
5) Analyze the slope of the 100 data points of the Thin TLM data using Excel
6) Plot the data using Origin

Results

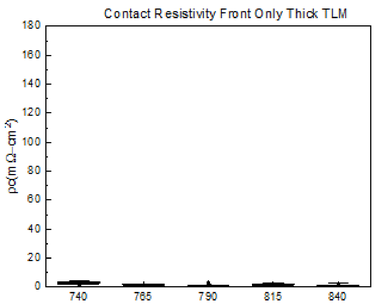

Figure 4: contact resistivity results of the Thick TLM only front contact.

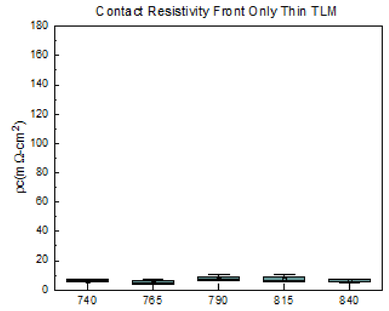

Figure 5: contact resistivity results of Thin TLM only front contact.

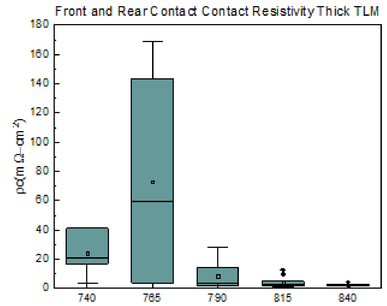

Figure 6: contact resistivity results of Thick TLM front and rear Contact.

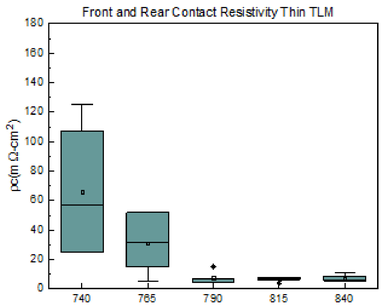

Figure 7: contact resistivity results of Thin TLM front and rear contact

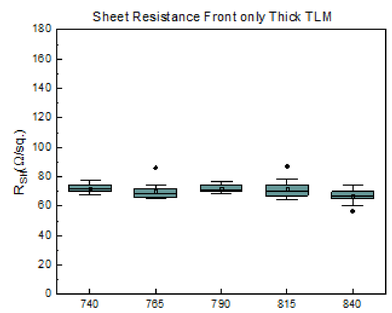

Figure 8: Sheet Resistance results of the Thick TLM only front contact.

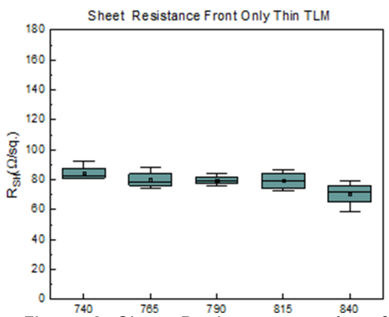

Figure 9: Sheet Resistance results of the Thin TLM only front contact.

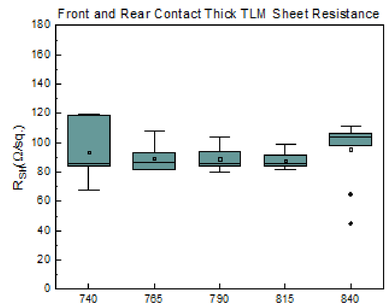

Figure 10: Sheet Resistance results of the Thick TLM only front and rear contact.

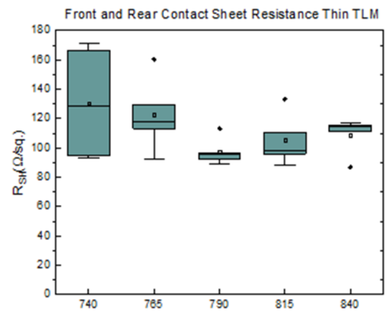

Figure 11: Sheet Resistance results of the Thin TLM only front and rear contact.

Conclusions

The conclusions of this work are the following: the results show front only samples show lower contact resistivity than the samples with both front and rear contacts. Additionally, the contact resistivity of samples with both front and rear contacts shows large spreading, especially for samples fired at 740 and 765. This suggest that for the paste we studied here, 740 and 765 are lower than the optimum firing temperature. 790 might be the optimum firing temperature; When the thin TLM data was analyzed, there was a pattern of firing temperature increase and an increase of values that showed a higher value of the contact resistivity when analyzed with the Thicker TLM. This information provides more insights of the screen-printed contact and can be used to optimize the H-pattern design of Si solar cells, reduce resistive loss and improve the solar cell efficiency.

Acknowledgements

I would like to thank the following people: my mentors for making this possible and having the patience of teaching me along the way ; Geoff Gregory for helping me to understand the samples a little better;. Nasif Iqbal for helping me understand the material;. And, the UCF SURF program and the Office of Undergraduate Research for helping me to further develop my skills on research and for their support.

This material is based upon work supported by the U.S. Department of Energy's Solar Energy Technologies Office