Characterization of AlSi and AlSi-$TiSi_2$ M-S Contacts

Mark Davis, Advisor: Dr. Michael Jackson

Rochester Institute of Technology, Department of Electrical and Microelectronic Engineering, Rochester NY 14623

Project Objectives

Goal: Characterize Properties of M-S Contacts

- **Determine Al/Si Ratio Across Deposition Methods**
  - **Measure with XPS and SIMS**
- **Characterize Physical Properties of the Films**
  - **Image Sintered Films, Relate to Al/Si Content**
- **Examine TLM and Diode Characteristics**
  - **Relate to Al/Si Content and Diode Dimensions**

Motivation

- Previous work in the RIT SMFL found defects in Flash Evaporated AlSi Films post 450°C Sinter, hypothesized to be Junction Spiking due to a Silicon-starved deposition

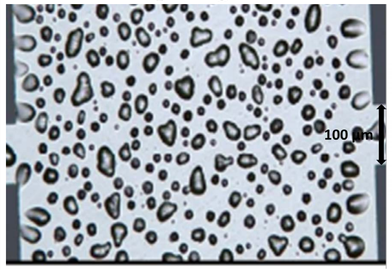

Fig 1. Defective AlSi Layer from Flash Evaporation[1]

Fig 2. Cross Section of Junction Spiking[2]

- AlSi Films Deposited via the CVC601 DC Sputter system had a high resistivity, hypothesized to be due to a Silicon-rich deposition

Chemical Analysis of Al Depositions

- The AlSi Films will be Analyzed with X-ray Photoelectron Spectroscopy (XPS) and Secondary Ion Mass Spectrometry (SIMS)

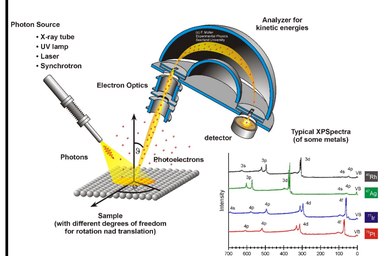

Fig 3. The General Operation and Output of XPS [3]

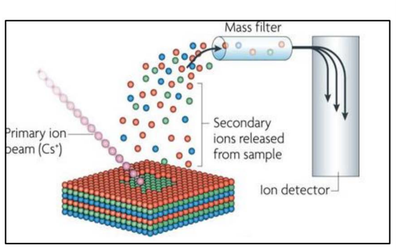

Fig 4. The General Operation of SIMS [4]

- These methods can provide the Al:Si ratios, the results of which can be related to the electrical and physical results of this study

XPS Results

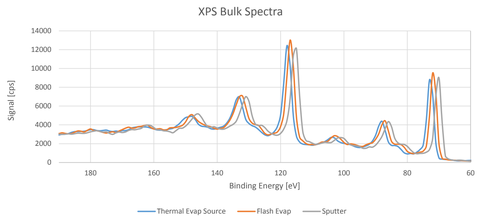

Fig. 5. Full Spectra of AlSi Films

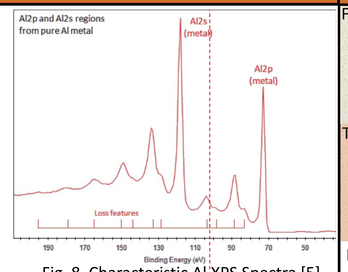

Fig. 8. Characteristic Al XPS Spectra [5]

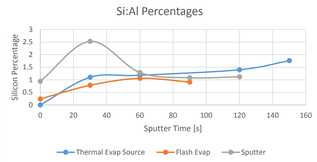

Fig. 6. Si Percentage vs FIB Sputter Time

Sample	Bulk %	Normalized Amount
Thermal Evap	1.29	1
Flash Evap	0.916	0.71
Sputter	1.1	0.85

Fig. 7. Normalized Bulk Si Percentage

- Surface Plasmon Peaks from the Al interfere with the Si Signal

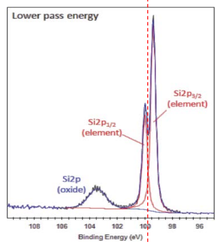

Fig. 9. Characteristic Si XPS Spectra [5]

- The Si Signal can be deconvolved from the Al Plasmon Peaks, but this introduces large error margins due to the sample's low Si content

Electrical Results

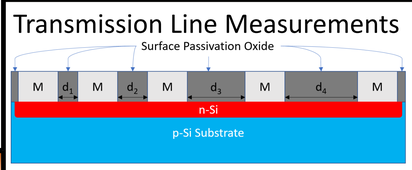

Fig. 10. TLM for Extracting Contact Resistance

- Due to Al to n-Si M-S contact and a low n-type contact doping, the contacts rectified

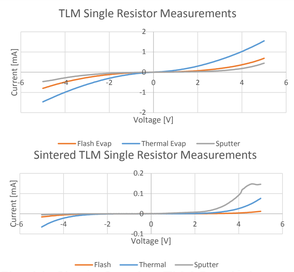

Fig. 11. Single Spacing TLM Rectifying Resistance Curves

Diodes

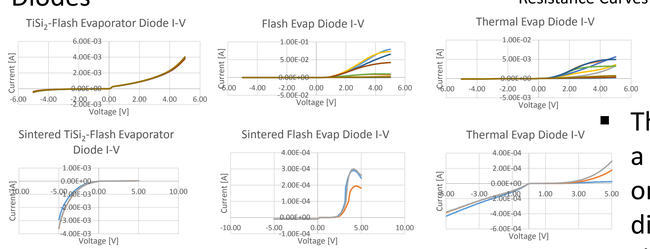

Fig. 12. Sinter's Varying Effects on Diode Characteristics

- The Sinter had a major effect on every diode's I-V characteristic

Acknowledgements

- SMFL Staff
- Dr. Robert Pearson
- Dr. Dale Ewbank
- Dr. Lynn Fuller
- Matt Hartensveld
- Jenna Doran
- Josh Wallace

Physical Results

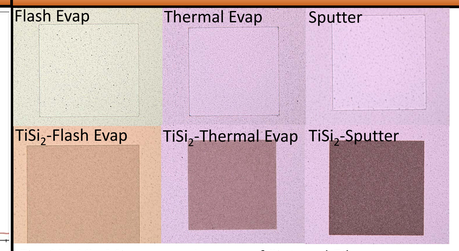

Fig. 13. 10x Microscope Images of Sintered Films

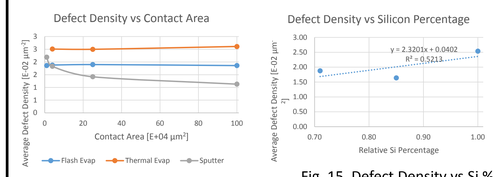

Fig. 14. Defect Density vs Contact Area

Fig. 15. Defect Density vs Si %

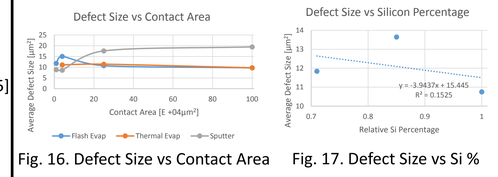

Fig. 16. Defect Size vs Contact Area

Fig. 17. Defect Size vs Si %

- The spotted film defect appears to match that of Figure 1
- This defect appeared in every film deposited after Sinter
- The defect manifested on every topology; over Si, over SiO_2, and over $TiSi_2$

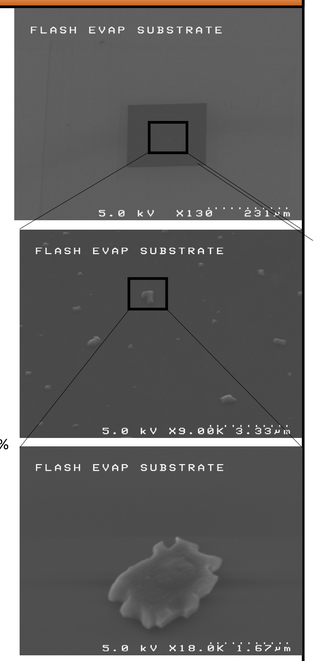

Fig. 18. SEM Images of Defects after Al Etch, Average Height of 1734Å

- Upon Etching the Al, the roughness pattern remained
- The roughness presented itself as particles left on the surface, not pits from Junction Spiking

Conclusions

- The Defect Found in the Flash Evaporator is likely not Junction Spiking, but may be a function of the Silicon content in the deposited AlSi Film

Future Work

- Fabricate functional TLM structures to examine Contact Resistances of the films
- Use SIMS or Auger analysis to quantify the Silicon Content within the AlSi films
- Use EDS to determine the chemical makeup of the residue left on the Silicon

References

[1] K. S. Duggimpudi, "Characterization of Grid Contacts for n-Si Emitter Solar Cells," Microelectronic Engineering, Microelectronic Engineering, Rochester Institute of Technology, 2016.
[2] S. Grover, "Effect of Transmission Line Measurement (TLM) Geometry on Specific Contact Resistivity Determination," Master of Science, Materials Science, Rochester Institute of Technology, 2016.
[3] http://jacobs.physik.uni-saarland.de/
[4] https://www.researchgate.net/
[5] https://xpssimplified.com/periodictable.php