Development of Contact Resistance Measurement Capability and Application to New Photovoltaic Materials

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Introduction

- **The motivation for designing and developing an in house contact resistance measurement procedure is so our research group can measure and optimize the contact resistance of photovoltaic devices we are currently developing using thin film semiconductors such as WSe2**
- The larger the contact resistance the lower the efficiency of a device.
- The desired electrical contact on a semiconductor device is a low resistance **ohmic contact**
- The only way to evaluate and optimize the contact resistance is through measurement

Background

- It is not possible to measure contact resistance with a single measurement
- The Transfer Length Method[1] (TLM) was chosen because it is accurate and can be used in our lab
- The mask shown in Figure 4 was designed and ordered specifically for this project

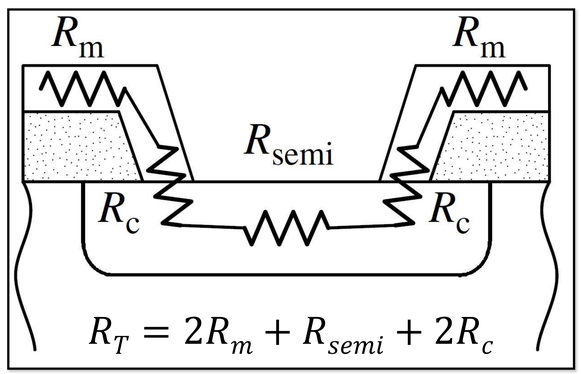

Figure 1: Diagram of the resistances in series with the contact resistance. Rm is metal resistance, Rc is contact resistance and Rsemi is the semiconductor sheet resistance.

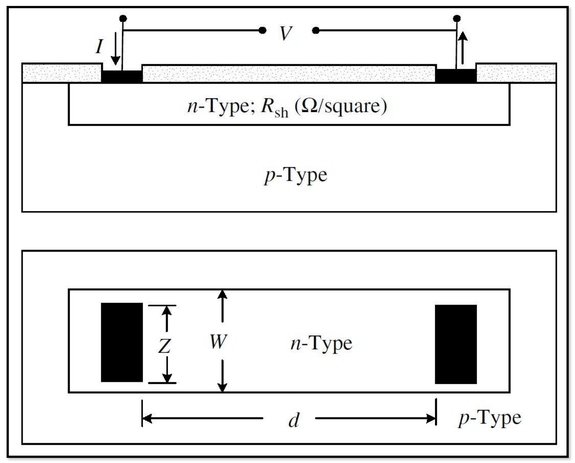

Figure 2: Current and Voltage probe positions for performing the contact resistance measurement.

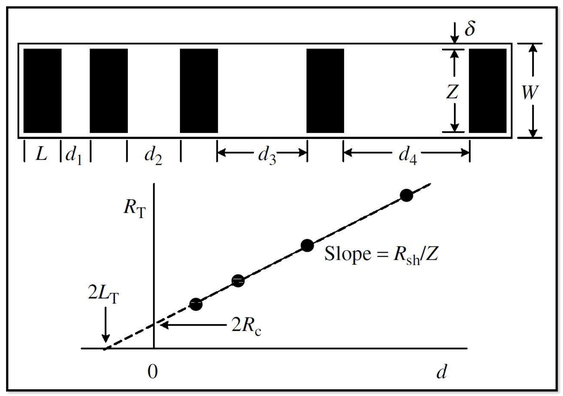

Figure 3: Black contacts on silicon wafer on top. Graph showing how the Contact resistance is extrapolated on bottom.

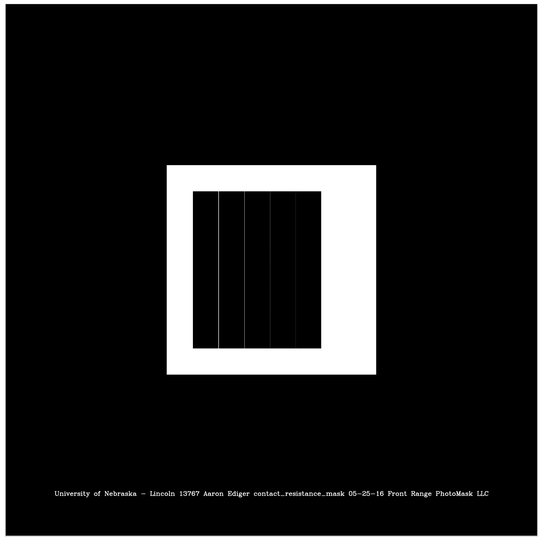

Figure 4: Mask used for photolithography pattern

Preparation

- The process to prepare a contact resistance measurement has many steps and refining these steps has consumed the bulk of the time for this project
- The steps are: Deposit a film, imprint a photoresist pattern, develop the photoresist with the TLM mask, etch the photoresist, etch the metal, and finally remove photoresist
- The photolithography process is in Figure 5 and the photoresist on Si is in Figure 6
- After all of the preparation has been completed a set TLM contact resistance measurements are made

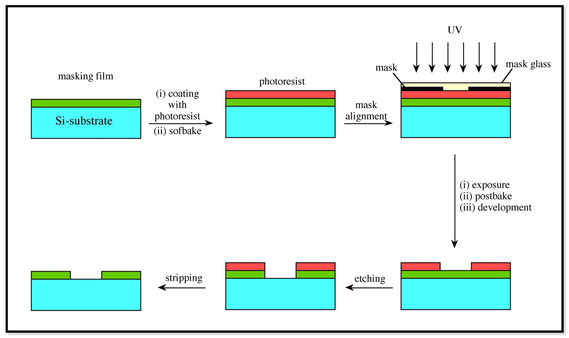

Figure 5: Photolithography procedure [2]

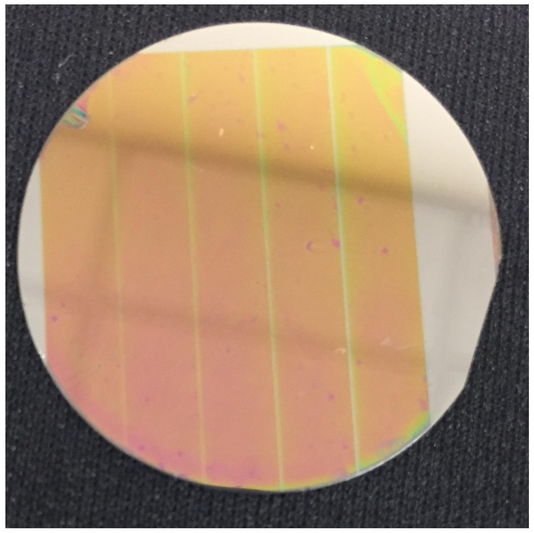

Figure 6: Photoresist on a Silicon wafer

Measurement Setup

- After the semiconductor has been prepared, there are five metal pads contacting the semiconductor
- The measurement consists of taking 4 I-V measurements as shown in Figure 3
- The I-V measurements give a resistance with respect to the distance of semiconductor and this can be extrapolated back to a distance of zero and the contact resistance can be found.

Results and Conclusion

- The TLM method of measuring the contact resistance requires a very specific and controlled set of conditions and all have been achieved in completing this project
- The first TLM measurement of contact resistance using our in house methods and equipment was made using Chromium contacts on lightly doped p-type silicon shown in Figure 7
- This project has been a success and will continue to be useful in the development of Photovoltaic devices in our lab

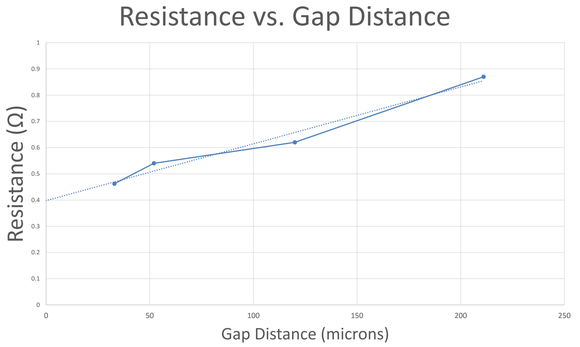

Figure 7: Resistance of chromium contacts on a lightly doped Silicon wafer. At x=0 Rc can be determined to be 0.20 Ohms

References

[1] Dieter K Schroeder. 2006. Semiconductor Material and Device Characterization. 3rd Edition. Hoboken (NJ): John Wiley & Sons Inc.

[2] http://archive.cnx.org/contents/0661ebbe-52fb-48b1-a96a-0878fa6270ed@4/optical-issues-in-photolithography