Fabrication of Self-Shunted Ti_xN Barrier Josephson Junctions

Nathan Cernetic
Dr. Nathan Newman
School of Mechanical, Aerospace, Chemical and **Materials Engineering**

Arizona Space Grant Statewide Symposium

Saturday, April 17th, 2010

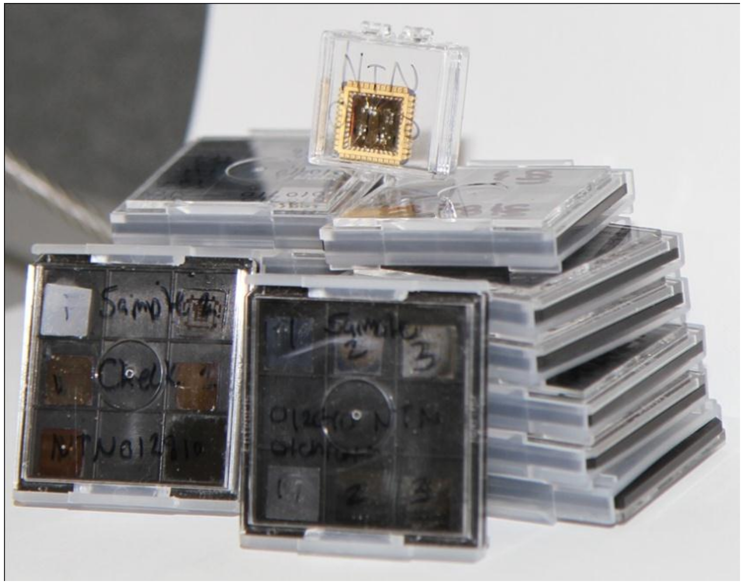
ASU Arizona State University

Arizona Space Grant Consortium

NASA

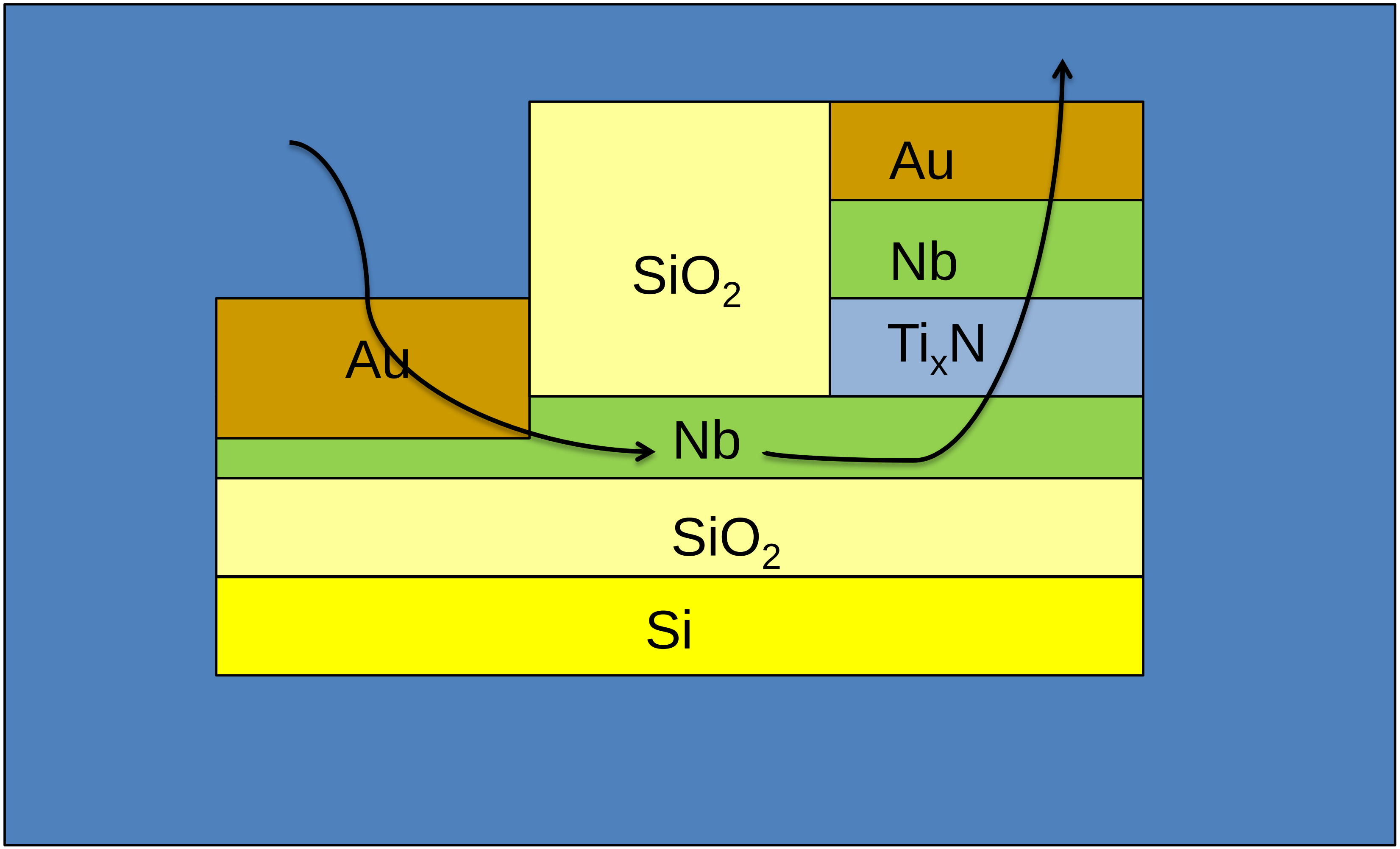
Background & Objective

- Titanium Nitride thin films with resistivities near the Metal-Insulator Transition (MIT) are being developed for use as barriers in Josephson junctions. Resistivities near the MIT allows for the fabrication of “self-shunted” junctions which can potentially produce compact IR sensors, SQUID magnetometers & 100+ GHz digital devices.



- Background: The stoichiometry of Ti_xN can be adjusted to produce electrical properties near the metal-insulator transition (MIT). This suggests that Ti_xN can be used to make conductive barrier junctions which don’t require the shunt resistors used in current AlO_x barrier junctions.

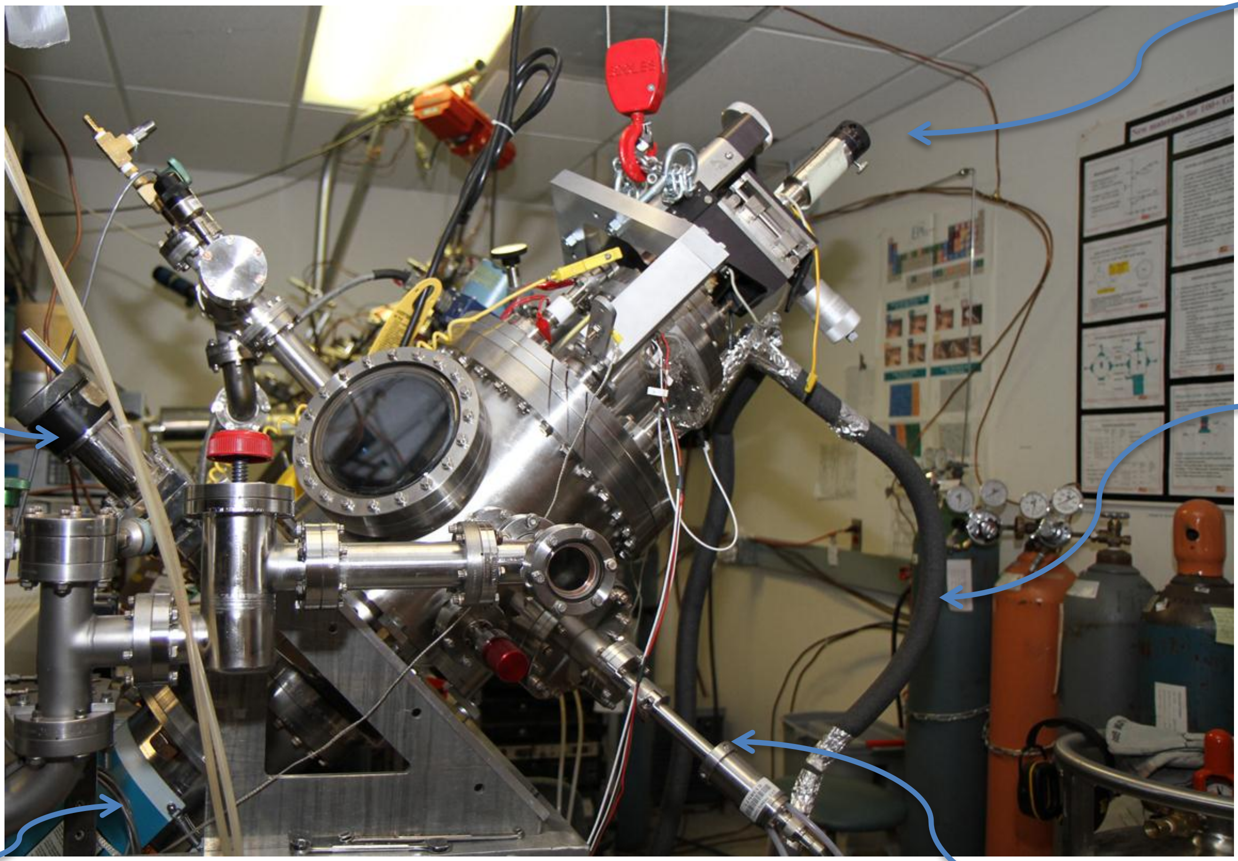
Junction Configuration



Methods (Sputter)

Heater Manipulator

Gate Valve

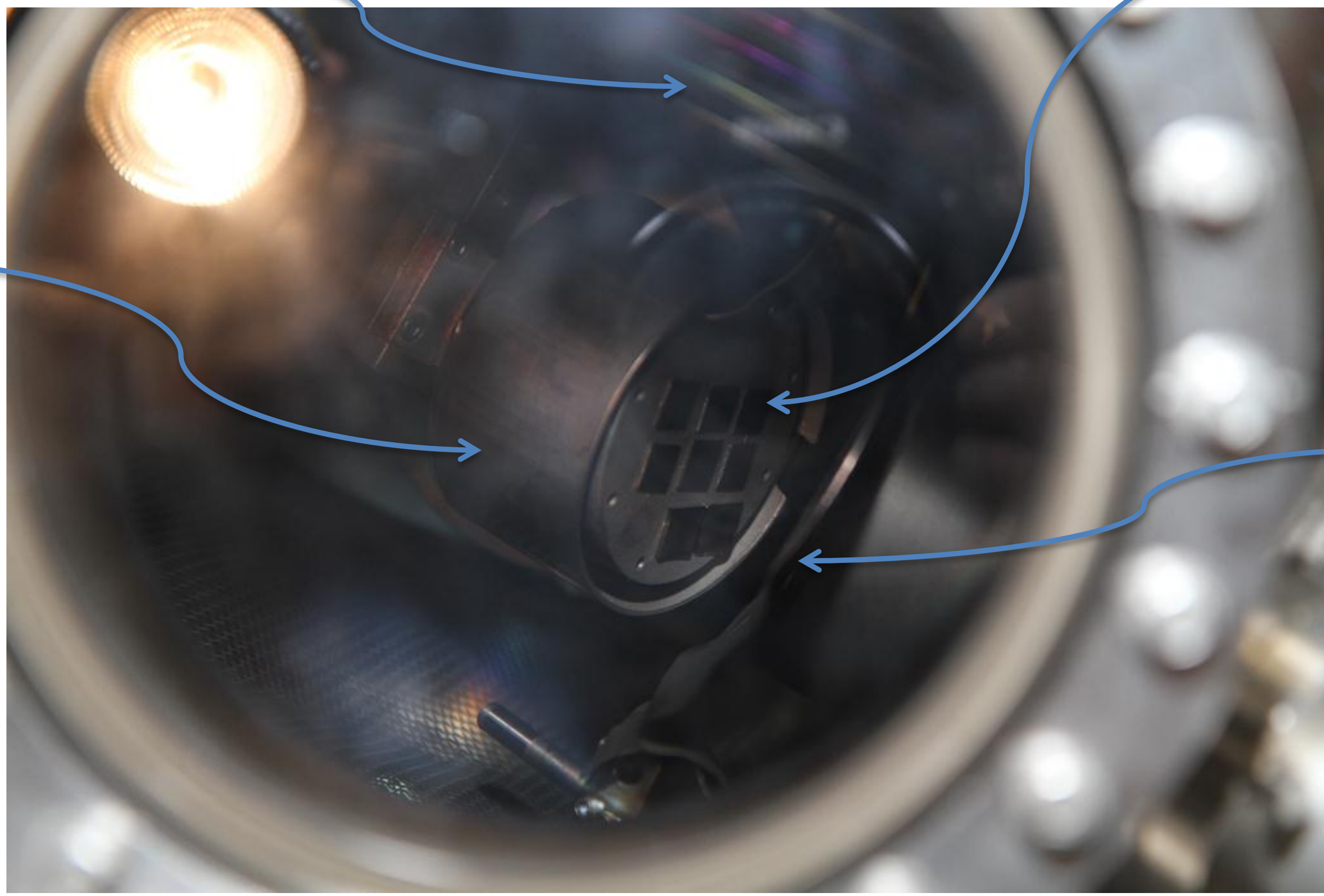


Liquid Nitrogen
Tubing for
Cryoshroud

Cryo Pump

Nb Sputter Gun

Methods (Sputter)



Methods (Photolithography)

Methods (Photolithography)

Photolithographic Contact Aligner

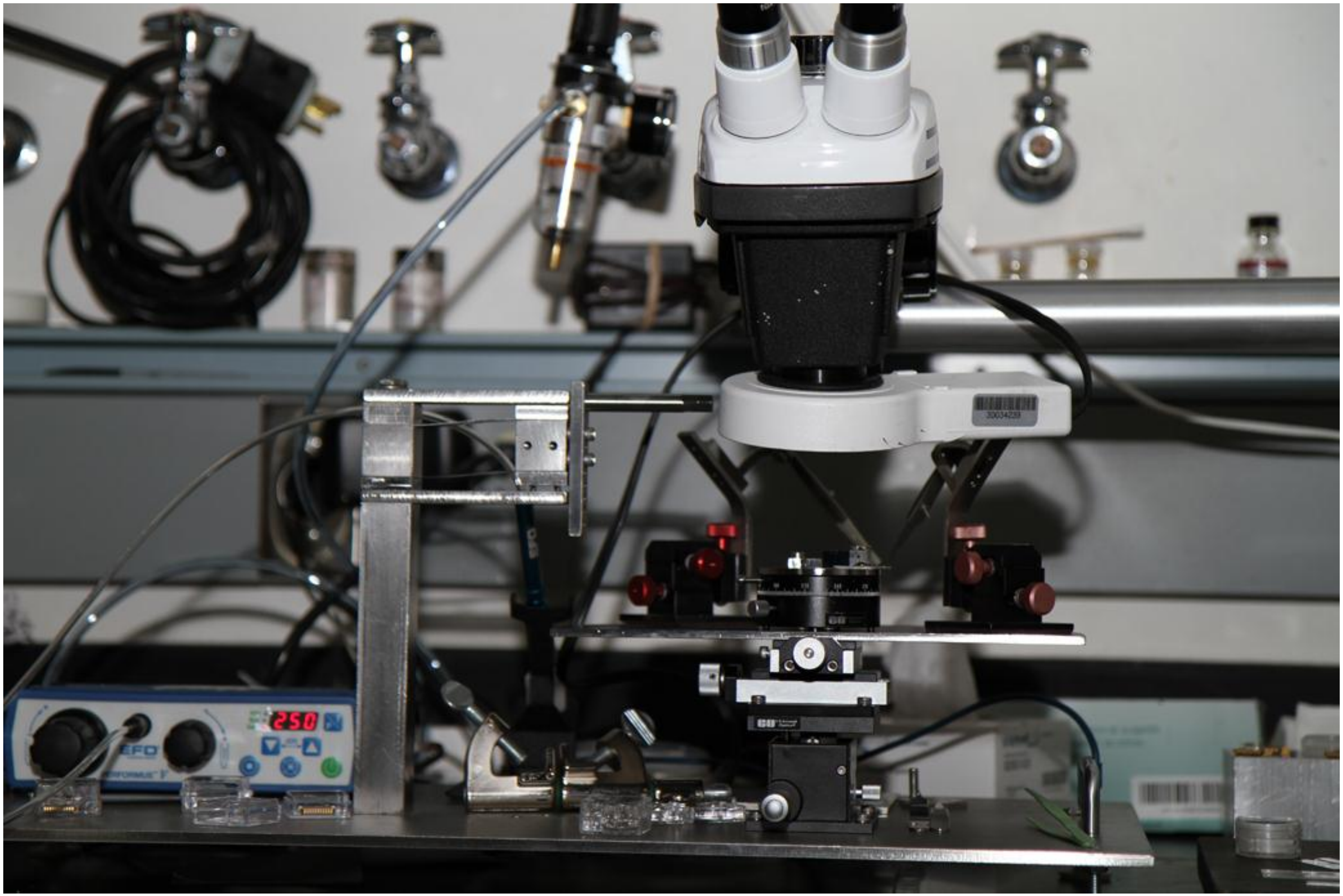
Chrome Alignment Masks

Spin Coater

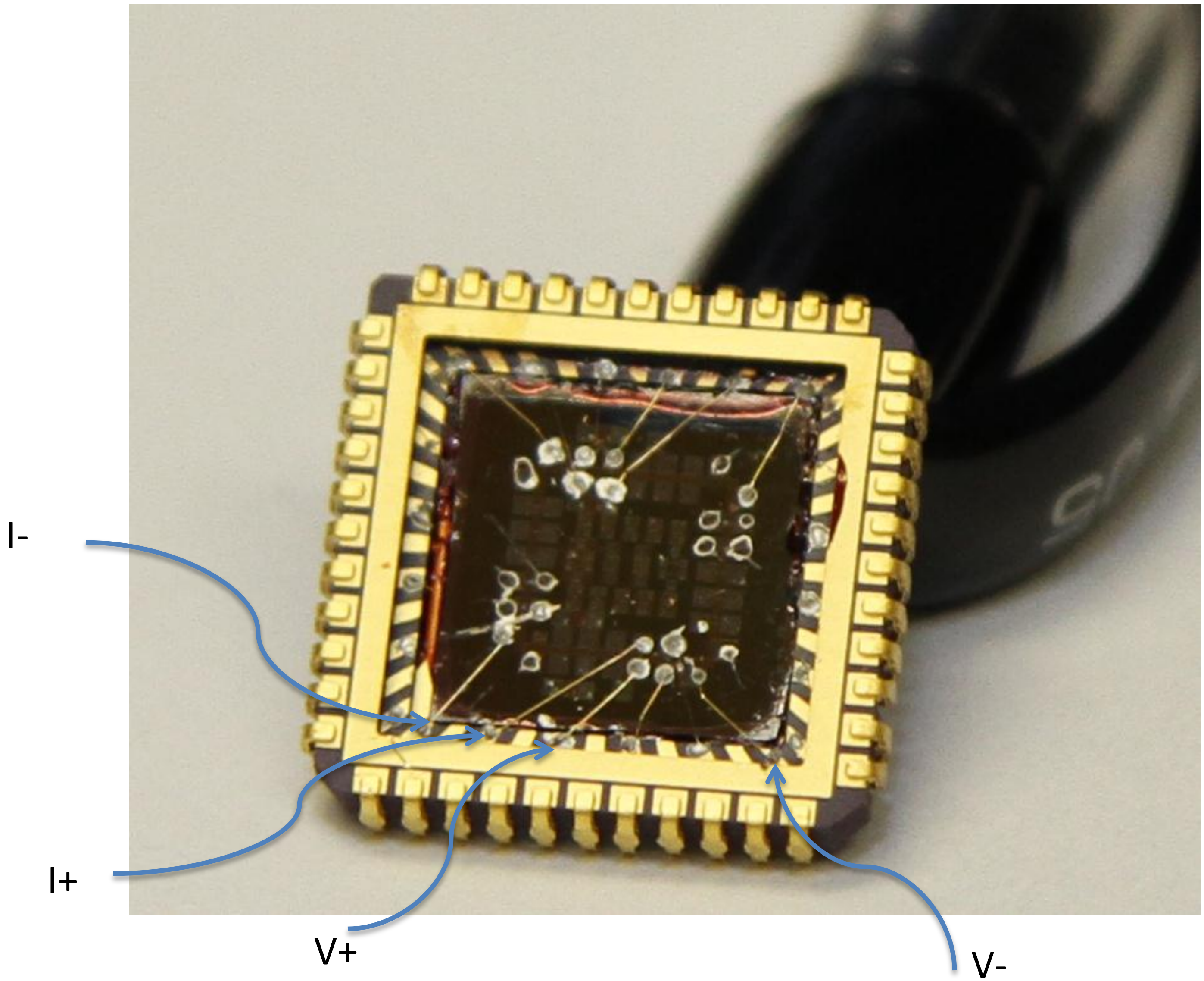
Methods (Reactive Ion Etching)

Methods (Thermal Evaporation)

Methods (Wire Bonding)



Device



Characterization

Results

- Thin Ti_xN layers (between 3 to 5 nm), relatively thin top Nb layers (~150 nm) and a fast etch rate (~30 nm/min) resulted in a low yield of usable devices.

- Common problems were over-etching which resulted in the inability to do electrical measurements of the junction. Additional issues such as variable etch rates, unpredictable growth patterns, and varying levels of oxygen content in the Ti_xN caused additional challenges during the fabrication and characterization process.

Conclusions

- Addition of qualification steps have resulted in considerably higher device yield.
- Qualification steps include verification of etch rate times, as well as sister-sample included during etch. Results in much more accurate etch depths that can be verified without destroying the device.
- Additional steps to change the lithography process and photoresist removal process have resulted in less physical damage to device.

Due to the addition of these steps device yield has since increased and measurements are pending.

THANK YOU!