Fab at NU

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Northwestern

Tools

Depositions

- eBeam Evaporator-AJA
  - Gold
- Thermal Evaporator - Denton
  - Aluminum
- Sputter I,II,III-AJA
- Quantum Deposition System - Plassys

DEPOSITION & ETCH

NUFAB's Deposition Bay is suitable for a wide variety of deposition techniques, including both PVD anf CVD methods.

Sputter I, II, & III - AJA

Sputter I

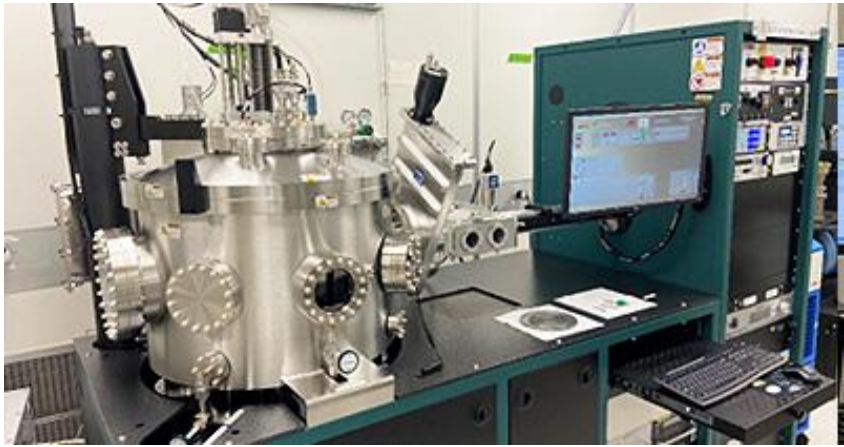
- No loadlock chamber, otherwise Identical

Sputter II

- Materials: Aluminum, Aluminum doped with Manganese, etc.
- Three 3″ diameter sputter guns in sputter up configuration
- Two 3″ and two 2″ diameter sputter guns in sputter up configuration (Sputter II)
- 4″ substrate holder with heater up to 850 C
- 6″ substrate holder with heater up to 400 C
- DC, Pulse, and RF Power Supplies
- Substrate rotation for +/- 2.5% film thickness uniformity
- Substrate bias
- Turbo pump backed by a dry roughing pump

Sputter III

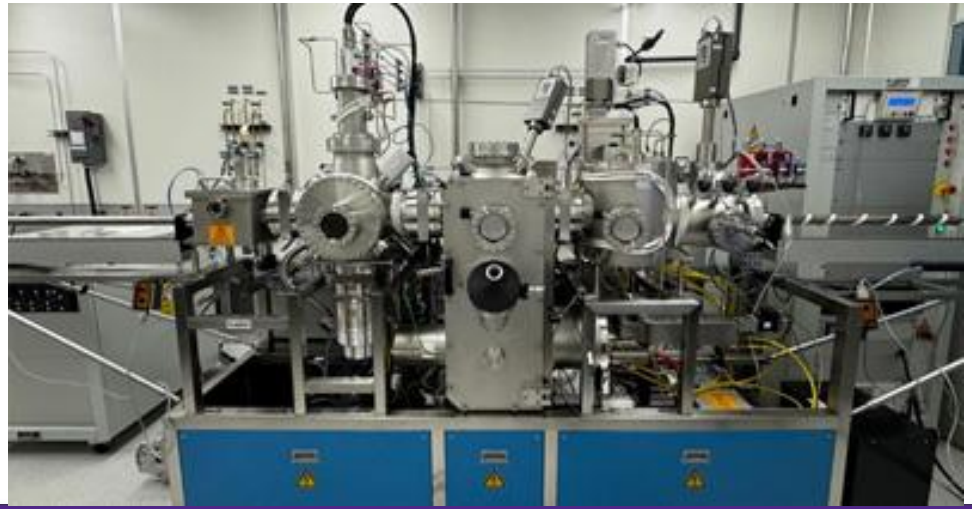
- Same as sputter II except it uses exclusively Niobium and Tantalum



Quantum Deposition System - Plassys

Features:

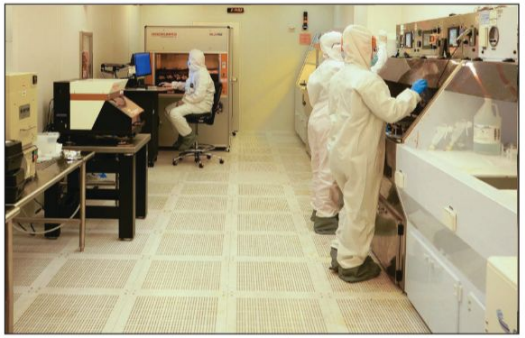
- Materials: Aluminum, Niobium, Tantalum
- Multi-chamber UHV system for fabrication of quantum devices
- Four chambers (from left to right): Load-lock (LL), Ion Milling, Evaporation, Oxidation
- Automatic linear substrate transfer to and processing in all chambers through a single recipe
- Substrate size: Small chips to 4-inch diameter wafers



Lithography

- Maskless Aligner - Heidelberg MLA 150
- Maskless Aligner - Heidelberg uPG501
- High-performance E-beam Writer - Raith VOYAGER 100
- Automatic Develop System - Osiris UNIXX S 20 D

PHOTOLITHOGRAPHY



NUFAB's Photolithography Bay is configured for both mask and maskless lithography processes, including single micron scale optical lithography.

Maskless Aligner - Heidelberg MLA 150

Features:

- Non contact
- Topside and backside alignment
- Minimum Feature Size: 1 micron
- 375 nm and 405 nm exposure with LED lasers
- Write Speed: 9 minutes for 100 mm x 100 mm area
- Maximum Write Area: 150 mm x 150 mm
- Gray scale exposure mode with 256 intensity levels
- Conversion software for DXF, CIF, GDSII, and Gerber files for binary exposures; and BMP, and ASCII files for grayscale

Maskless Aligner - Heidelberg uPG501

Features:

- Maximum substrate size: 6” x 6”
- Minimum substrate size: 6 x 6 mm²
- Substrate thickness: 0 to 6 mm
- Encoder resolution: 20 nm
- Optical system including highly reflective mirrors and DMDTM
- Real-time air-gauge autofocus with dynamic range of 80 µm
- Camera system for substrate inspection, automatic alignment, and basic measurement functions
- Basic gray scale exposure mode with 128 intensity levels
- Conversion software for DXF, CIF, GDSII, and Gerber files for binary exposures and BMP, STL, and ASCII files for gray scale
- LED Illumination Module (390nm)
- Minimum structure size [µm]: 1
- Line width uniformity [3σ, nm]: 200
- Alignment Accuracy [3σ, nm]: 200
- Write speed [mm2/minute]: 50
- Maximum write area [mm x mm]: 125 x 125

High-performance E-beam Writer - Raith VOYAGER 100

Features:

- 50 kV column
- Overlay accuracy <10 nm
- Stich field accuracy <10 nm
- Universal sample holder for small chips to 3-inch wafers
- 4”x4” mask holder
- 4” wafer holder
- Interferometric stage with 100 x 100 mm^2 x-y travel with 1 nm positioning accuracy
- 50 MHz pattern generator with 20-bit resolution
- Traxx option – stitch error-free fixed beam moving stage exposure
- User-selectable high throughput or high-resolution writing modes

Automatic Develop System - Osiris UNIXX S 20 D

Features:

- Touch Screen Interface
- Up to 6 process chemicals
- Maximum substrate size: 8”
- Minimum substrate size: none
- Encoded spin motor for precise positioning and speed control
- Available Chucks: 4” and 5” mask plates, 3” and 4” wafers, and small piece

Dry Etching

Reactive Ion Etcher (RIE) – Samco RIE-10NR

- Wafer size: up to 200 mm
- Turbo pump backed by a dry roughing pump
- RF Power: 13.56 MHz, 300 W
- Six gas lines: CF4, CHF3, SF6, O2 (20 sccm), O2 (200 sccm), Ar/N2

Plasma Cleaner – Samco PC-300

- Touch Screen Interface
- RF power 300W max, 13.56 MHz
- Maximum substrate size: 12” x 9”
- Minimum substrate size: none
- Reactive Ion Etching
- Plasma Etching
- O_2 Plasma

Samco RIE-10NR

Samco PC-300

Characterization

FIB-SEM - JEOL JIB-4700F

- Secondary Electron Detection -- Lower, Upper, and FIB imaging.
- Backscattered Electron Detection -- Composite and Topographical imaging
- Energy Dispersive Spectroscopy
- Combination of detector signals is possible.

Electrical Test Station – Signatone

- 6’’ gold plated sample stage with vacuum chuck
- Four standard probes with ground and guard
- Two RF probes with GSG, 150 mm and 40 GHz configuration
- Dark box on vibration isolation table

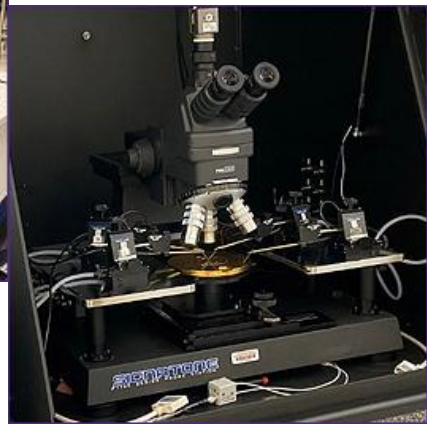
3D Optical Profiler – Zygo

- Z precision: less than 1 nm

Atomic Force Microscope – Bruker Edge

- Z precision: less than 1 nm

FIB-SEM - JEOL JIB-4700F



Electrical Test Station

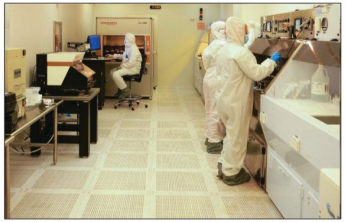
https://nuance.northwestern.edu/facilities/nufab/nufab-instruments/index.html

CHARACTERIZATION

NUFAB's Characterization Bay allows for fine measurement of physcial, electrical and optical properties of materials and devices.

- **Fluorescence/DIC Microscope** Nikon LV150
- **Reflectometer** Filmetrics F20
- **Stylus Profilometer** Veeco Dektak-8
- **3D Optical Profilometer** Zygo
- **IV/CV Probe Station Ellipsometer** J.A. Woollam alpha-SE
- **Ball Bonder and Wedge Bonder**
- **Contact Angle Measurement** VCA Optima XE
- **Thin Film Stress Measurement** Toho FLX-2320S

PHOTOLITHOGRAPHY



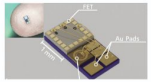
NUFAB's Photolithography Bay is configured for both mask and maskless lithography processes, including single micron scale optical lithography.

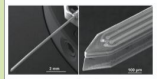
- **Mask Aligners** Suss MABA6, Suss MJB4
- **Laser Writer** Heidelberg MLA150, uPG 501
- **Convection Ovens** Blue M DCC-146-C-ST350
- **Microscope** Nikon LV150
- **Spinner Hood**
- **Automatic Develop Hood** Osiris UNIXX
- **Ultraviolet Flood Exposure System** Inpro Technologies F300S
- **Ultrasonic & Megasonic Cleaners**
- **VacuumOven (YES)**

RESEARCH at NUFAB

Above: Optofluidic micro-Systems for optogenetics and photopharmacology
– Rogers Group, Northwestern

Below: A 3 pJ/bit free space optical interlink platform for self-powered sensing & opto-spintronic RF-to-optical transduction
– Mohseni Group, Northwestern





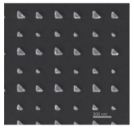
Above: Brain-Implantable Multifunctional Probe for Simultaneous Detection of Glutamate and GABA Neurotransmitters
– N. Moldovan, Alcorix Co

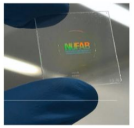
Above: Ambipolar inverters based on cofacial vertical organic electrochemical transistor pairs for biosignal amplification
– Rivnay Group, Northwestern

ELECTRON BEAM LITHOGRAPHY

Raith Voyager 100

- <10 nm structures
- cm scale exposure
- High speed pattern generator
- 50 kV





DEPOSITION & ETCH

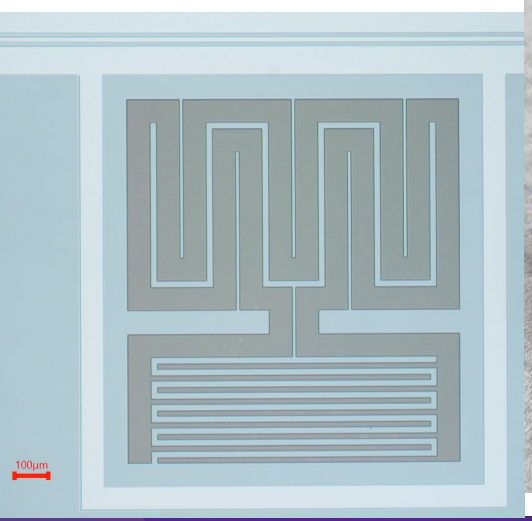
NUFAB's Deposition Bay is suitable for a wide variety of deposition techniques, including both PVD anf CVD methods.

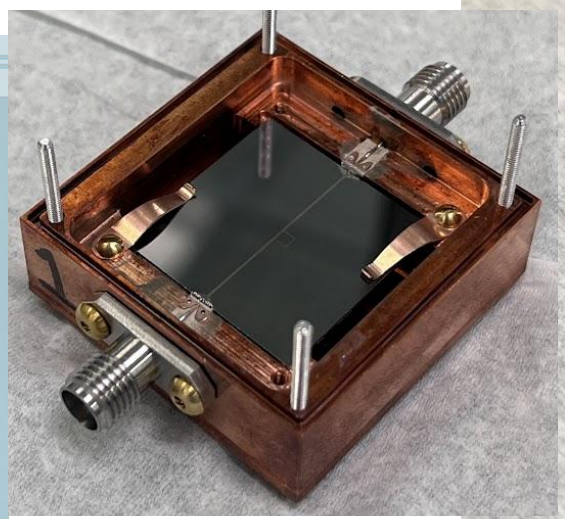
- **Automatic Acid Etcher**
- **Annealing Tube Furnace** Lindberg/Blue M
- **Plasma Enhanced Chemical Vapor Deposition** STS LpX CVD
- **AJA E-Beam Evaporator**
- **Thermal Evaporator** Denton Vacuum Explorer 14
- **Parylene Coater** SCS Labcoter2 Parylene Deposition System
- **Sputters** AJA Orion Sputter I & II
- **Deep Reactive Ion Etcher (DRIE)** STS LpX Pegasus
- **Reactive Ion Etcher (RIE)** Samco RIE-10NR
- **Xenon Difluoride Etcher** Xactix
- **Rapid Thermal Processor (RTP)** AW-610
- **P/N Doping Furnaces**
- **Tystar Low Pressure CVD**
- **Critical Point Dryer** Tousimis Automegasamdri – 915B, Series C

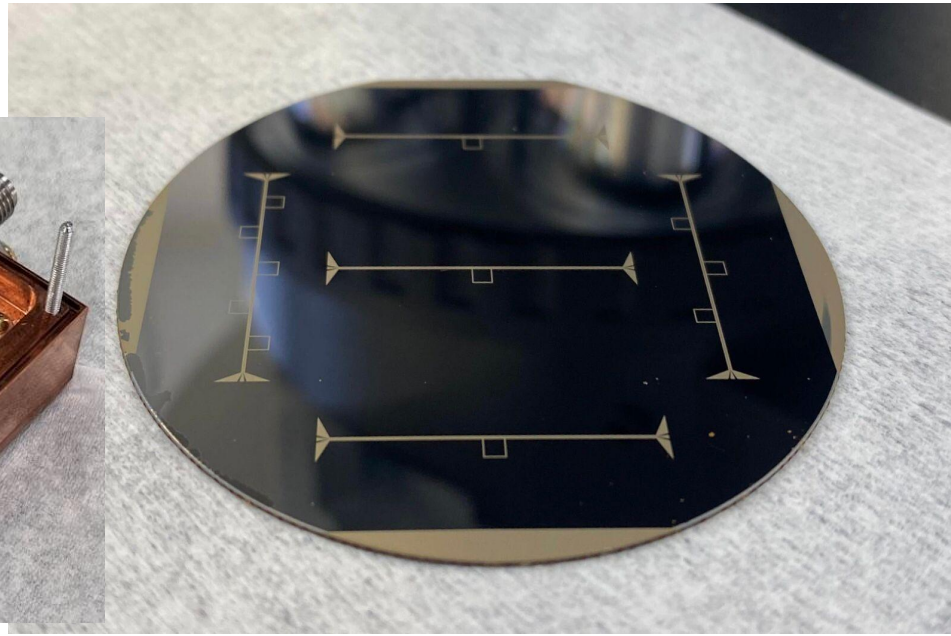
Fabrication Status

MKID Device

- Entirely made at NUFAB
  - Al and Nb on Silicon wafer
- Currently being tested underground
- We see resonances!

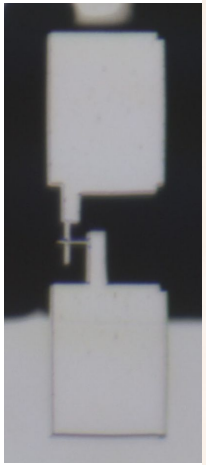


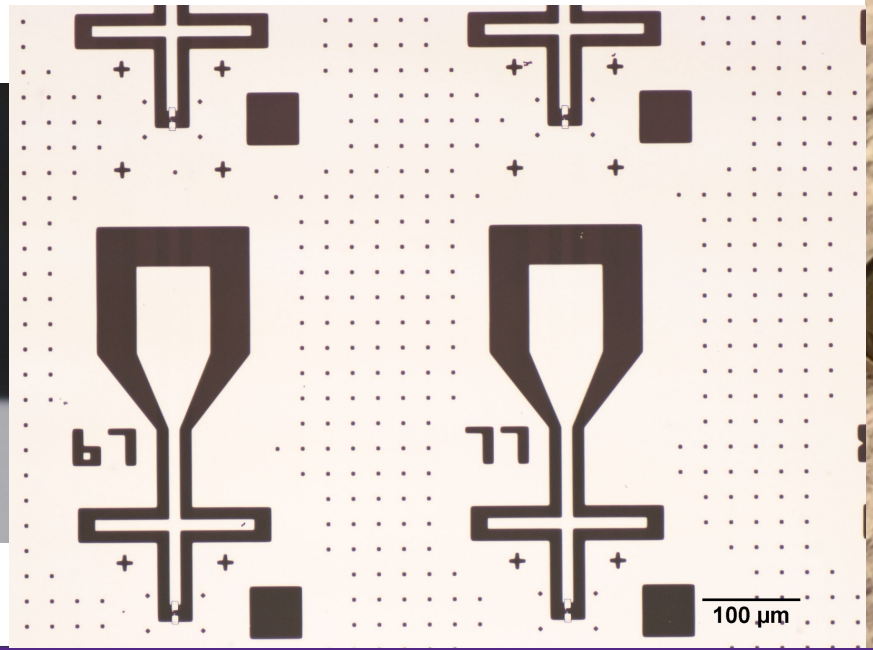


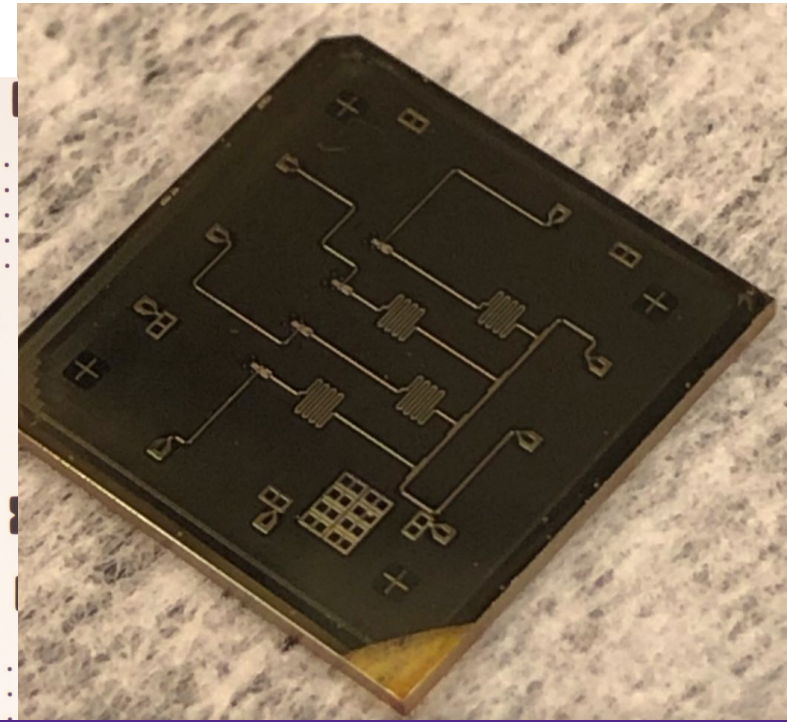


Transmon Qubit

- Done using Al, Al/Mn, Nb
- Full chip not made yet but, very soon

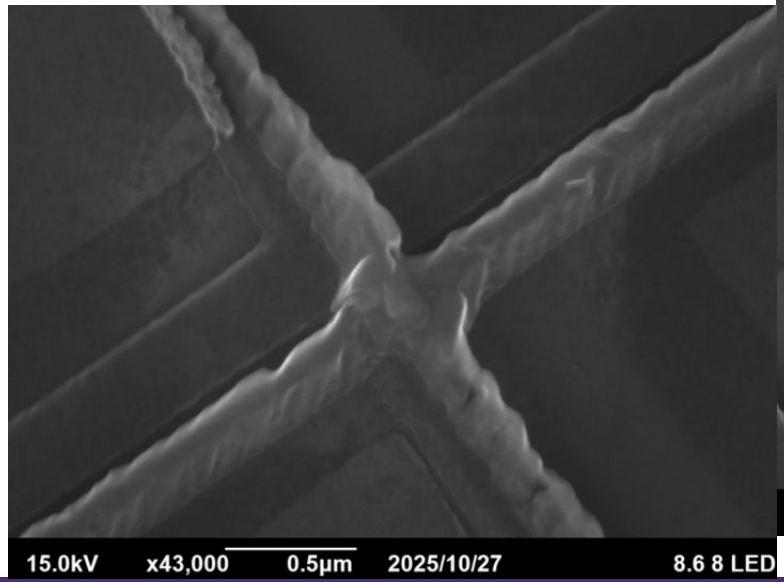


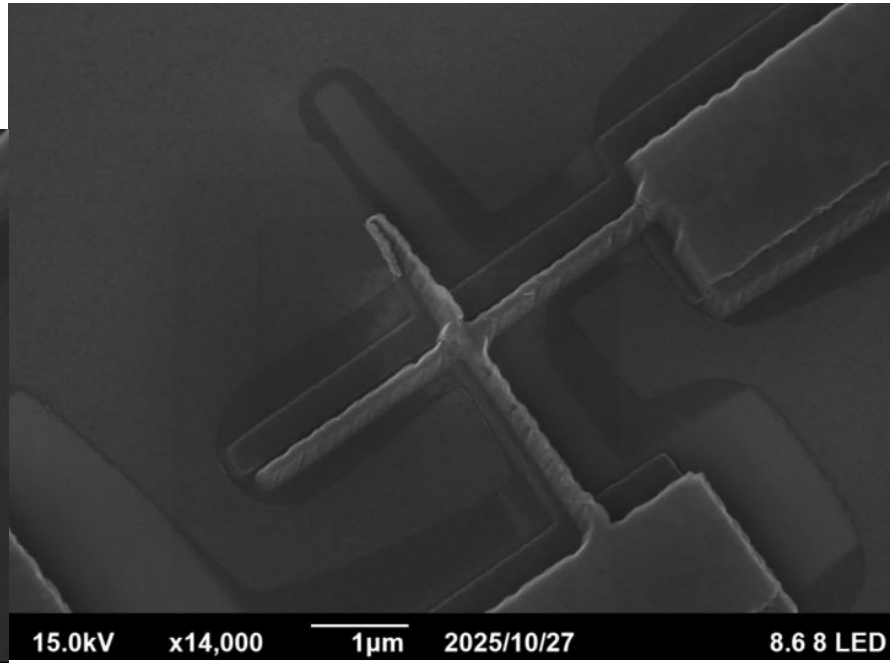




Manhattan JJs

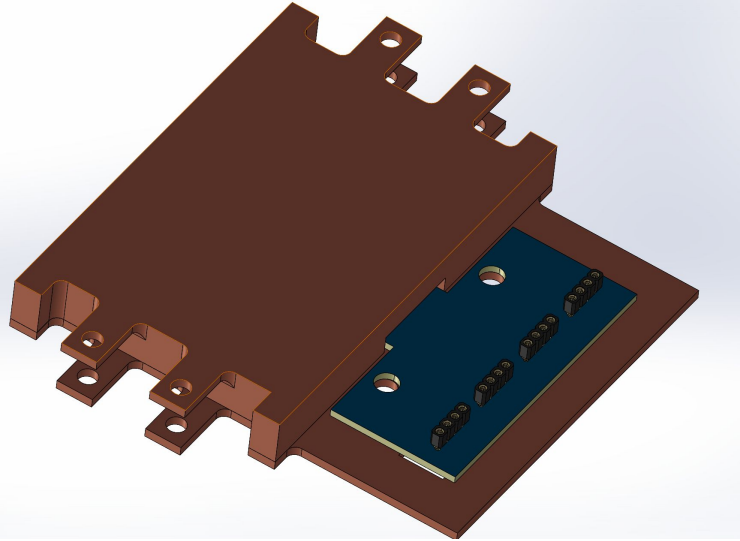
- Finalizing fabrication process for Manhattan JJs with Aluminum
  - Normal and gap-engineered
- In the future can do Nb, Ta and CMOS style JJs

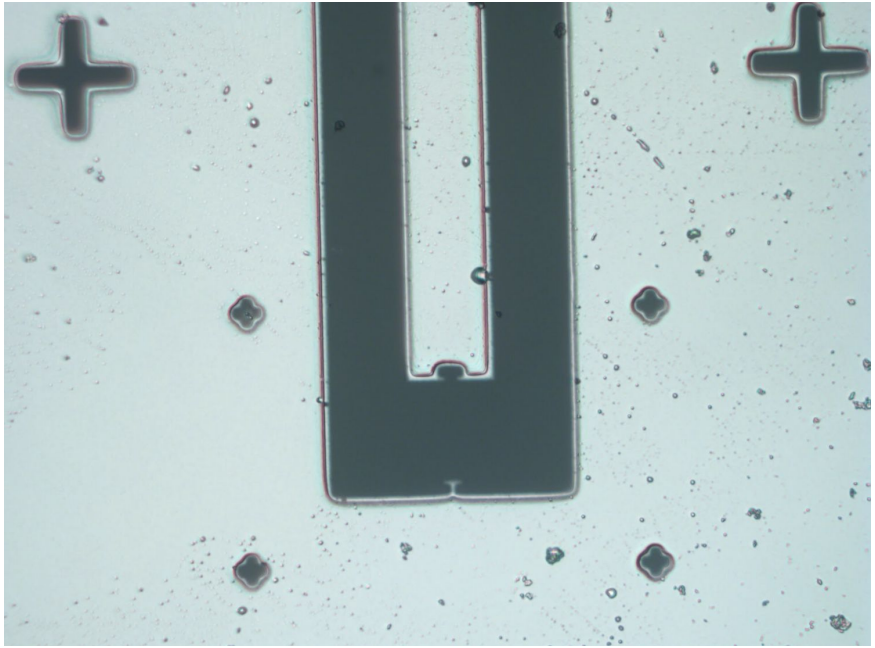




Low Tc Films

- 2000,2600,2800 ppm Al/Mn depo/lithography
- Progressing towards Tc testing of the films
- Expect Tc range ~50 mK to ~300mK





Questions?

Sputter III - AJA

Features:

- Material: Exclusively Niobium
- Load-locked ultrahigh vacuum (UHV) sputter system with vacuum in 10^{-9} Torr range for deposition of films for quantum devices
- One 6″ and two 3″ diameter sputter guns
- Substrate holders for accommodating small chips up to 6” diameter wafers
- Substrate heating up to 1000 ^{o}C
- DC and HiPIMS power supplies
- Substrate rotation
- Z-axis motion for adjusting source substrate distance
- Substrate bias for cleaning or assisting deposition
- Load-lock with turbo pump backed by a dry roughing pump
- Cryo pump for main chamber