



Nanofabrication clean room facility at Nebraska Center for Materials & Nanoscience

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National Nanotechnology Coordinated Infrastructure (NNCI)
Nebraska Nanoscale Facility (NNF)

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UNIVERSITY OF
Nebraska
Lincoln®





Supporting Infrastructure

* **Nebraska Center for Materials and Nanoscience**

- Founded 1988
- 100 faculty members in 12 departments
- Organizes collaborative research (MRSEC, Keck, etc.)
- Operates six Central Facilities
- Operates an Education-Outreach Program
- Runs weekly seminar series

* **New Nano Building (2012)**

- \$7M funding from NIST grant
- \$5M gift to UNL from Voelte-Keegan Family





Present Central Facilities at Nebraska Center for Materials and Nanoscience

Nanofabrication Cleanroom

Nanomaterials & Thin-Film
Preparation

Nanoengineered Materials &
Structures

Electron Microscopy

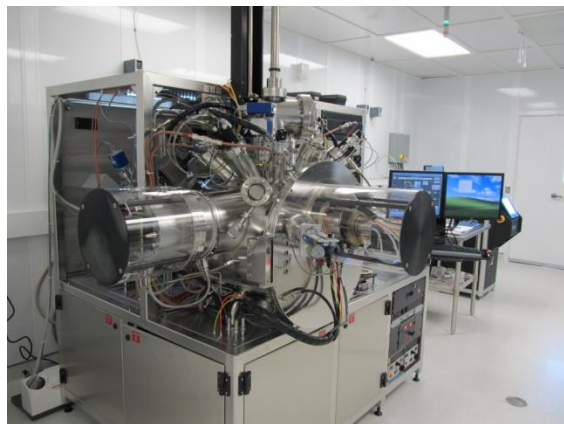
X-Ray
Structural Characterization

Scanning Probe and Materials
Characterization





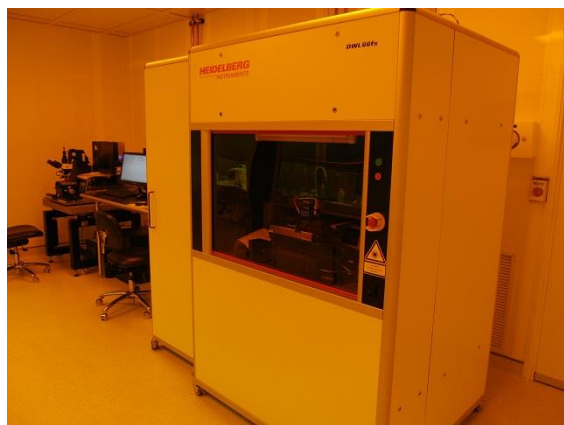
Nanofabrication Clean Room Facility



Dry etching



Wet etching



Lithography



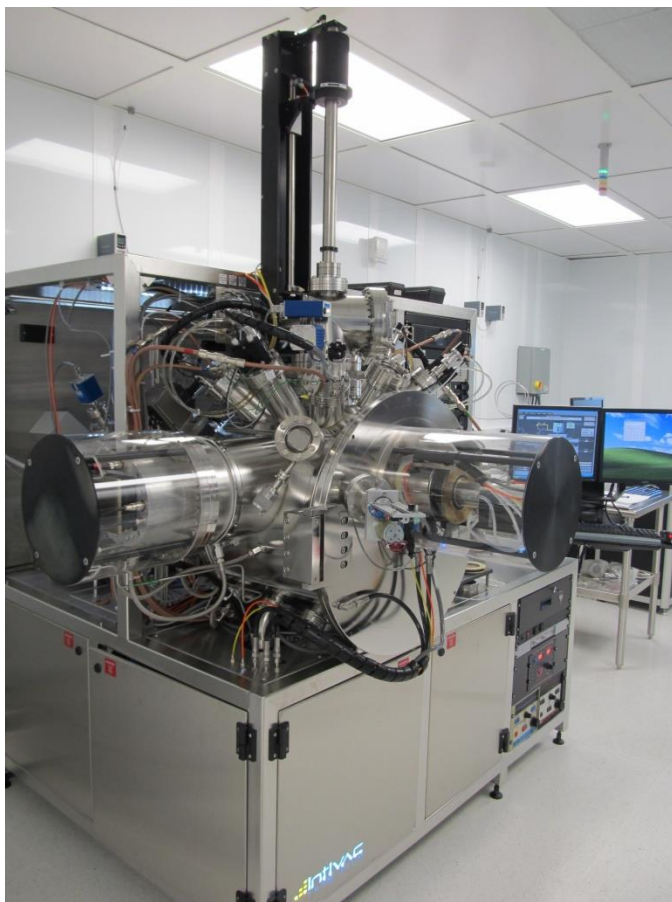
Metrology

Key features:

- Certified class 10,000 (ISO-7)
- 4,000 sq. ft. area with 2,500 sq. ft. workspace
- Four functional bays: **Lithography, Etching, Deposition, Metrology**
- Real time monitoring system on hazardous gases, airborne particle concentration, temperature, air pressure, etc.



NCMN Nanofabrication clean room facility: Dry Etching



Ion Beam milling/Sputtering System
(Intlvac Nanoquest-I)



Deep Silicon Etching System
(Oxford PlasmaPro 100 Estrelas)



Reactive Ion Etching (RIE/ICP) System
(Trion Minilock-Phantom III RIE/ICP)



Ion Beam Milling/Sputtering System



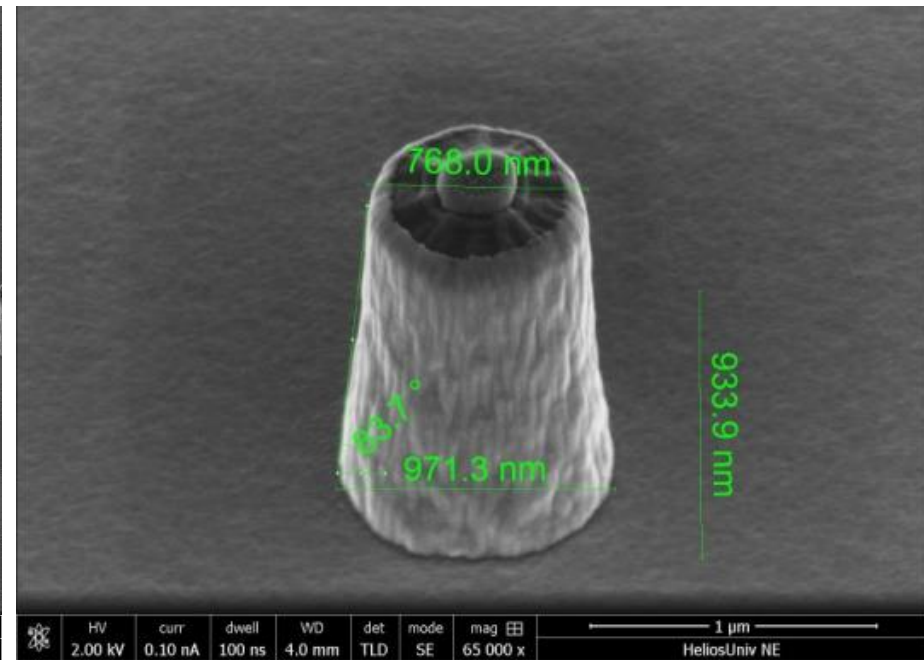
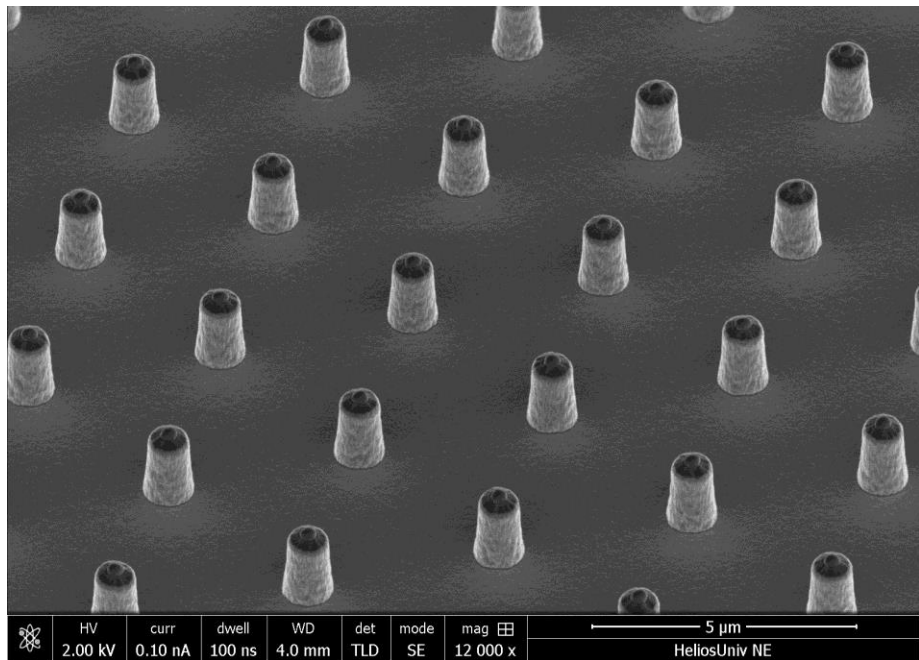
Ion Beam milling/Sputtering System
(Intlvac Nanoquest-I)

Key features:

- Versatile R&D ion beam development platform for both thin film milling and deposition
- **UHV chamber** with base pressure in 10^{-9} Torr range
- **One 14cm ion source** for ion beam milling (Beam current: 0-500mA at 1200V; Ion energy: 100-1200eV)
- **One 4cm ion source** for ion beam sputtering (Beam current: 0-150mA; Ion energy: 100-1200eV, 3x 4" targets;)
- **8x 2" magnetron sputtering guns** (1 RF and 2 DC power supplies) allowing co-sputtering
- Single axis motion stage supports **multi-incident angle operation** and the **maximum wafer size up to 4" (100mm)**.
- Three working gas (Ar, N₂, O₂) supports reactive sputtering
- **The Ending Point Detection system(SIMS)** allows users to define etch end point and mount of over etch



Ion beam milling application 1: Ti nano-pillars



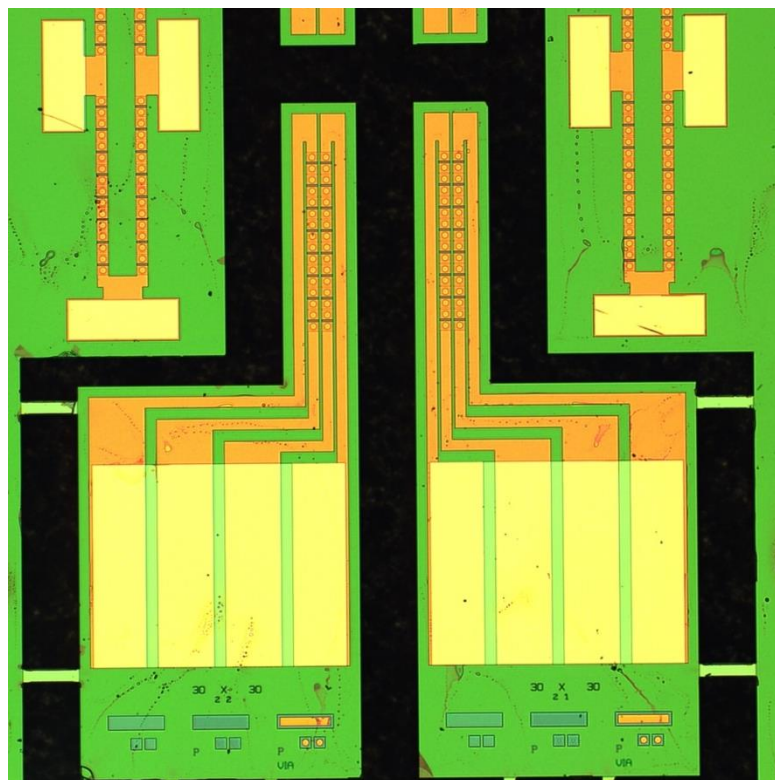
Ti nano-pillars fabricated with Ion beam milling

Condition: Ion energy: 1200eV, Beam current: 200mA

Mask: AZ1518(2um), Etch time: 10min

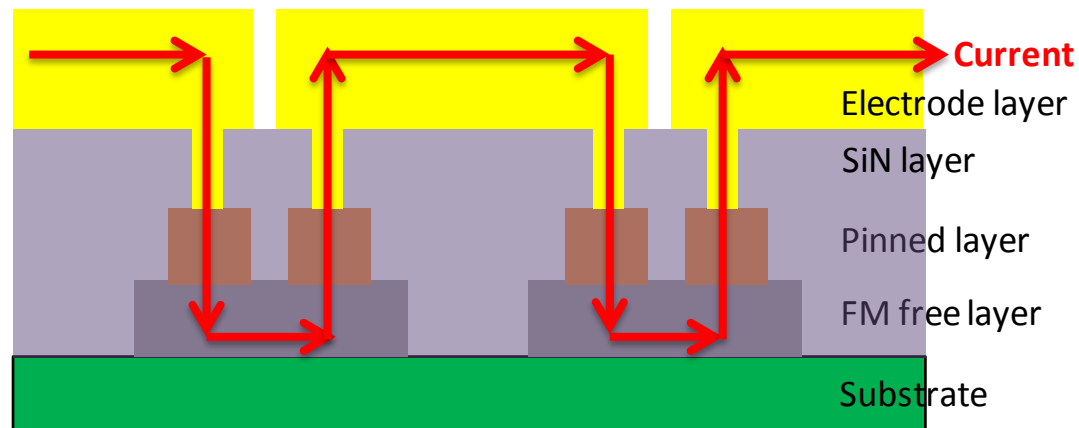


Ion beam milling application 2: MTJ Device

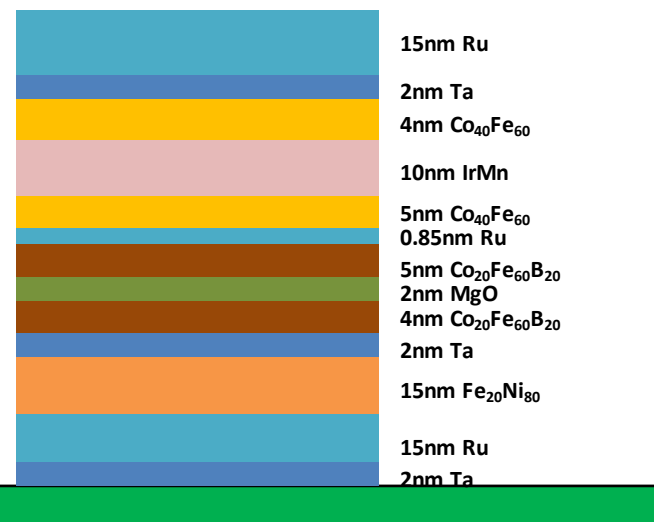


Picotesla Magnetoresistive Sensor

Side view:



MTJ Stack:



Condition: Ion energy: 200eV, Beam current: 50mA
Mask: AZ3312(1.2um)
Etch time: 3min



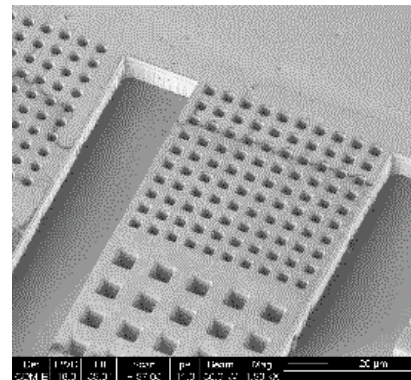
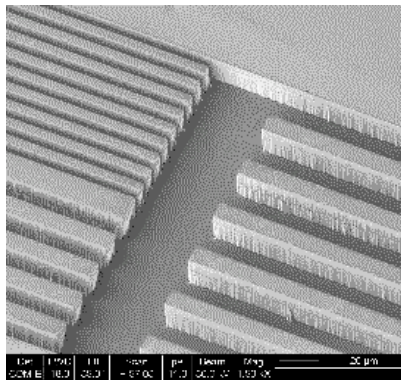
Deep Silicon Etching System



Deep Silicon Etching System
(Oxford PlasmaPro 100 Estrelas)

Key features:

- Offering high aspect ratio Si etch solutions for multiple applications
- Run Bosch and Cryo etch process (temperature range: -140°C to 60°C)
- Max RF power: 3000 W – ICP; 300W – RIE
- 6 Gas Channels: Ar, CF_4 , C_4F_8 , CHF_3 , O_2 , SF_6
- Wafer size: 4" (100 mm) and 3" (75mm)



Silicon templates for microfluidic channels

Condition: ICP: 700W, RF: 8W(30VDC), Temp: -110°C , Mask: Shipley S1813(1.5um)
Pressure: 10mTorr (SF_6 : 40sccm, O_2 : 5.5sccm)
Etch rate: 3.6um/min, Etch time: 5min, Selectivity: 28:1,



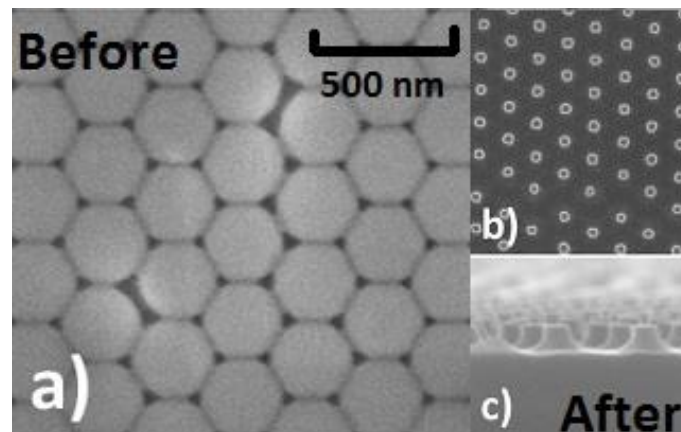
Reactive Ion Etching (RIE/ICP) System



Reactive Ion Etching (RIE/ICP) System
(Trion Minilock-Phantom III RIE/ICP)

Key features:

- Plasma etch system with ICP and RIE source
- Max power: 1000 W – ICP; 600W – RIE
- 6 Gas Channels: Ar, BCl₃, Cl₂, CF₄, O₂, SF₆
- Max wafer size: 12 inch (300 mm)






Polystyrene beads etching

Condition: RIE: 100W, Temp: 25°C, Pressure: 20mTorr (O₂: 50sccm)
Mask:N/A, Etch time: 2min



NCMN Nanofabrication clean room facility: Dry Etching (summary)

			
Wafer size	Up to 4"(100mm)	Up to 4"(100mm)	Up to 12"(300mm)
Temperature range	25°C	-140°C to 60°C	25°C to 400°C
Working gases	Ar, O ₂ , N ₂	Ar, CF ₄ , C ₄ F ₈ , CHF ₃ , O ₂ , SF ₆	Ar, BCl ₃ , Cl ₂ , CF ₄ , O ₂ , SF ₆
Etch capability	All type of materials	Polymers, Si and Si based Semiconductors	Polymers, Metals and Si based semiconductors
Restrictions	Low etch rate	Limited etch capability	Poor temperature control and uniformity
Chamber cleaning	Scrubber and Vacuum	O ₂ plasma	O ₂ plasma

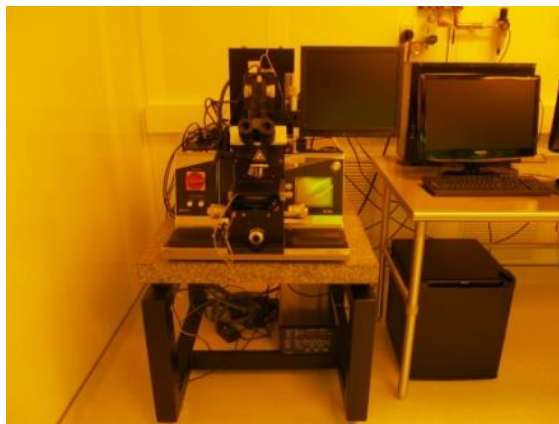


NCMN Nanofabrication clean room facility: Lithography



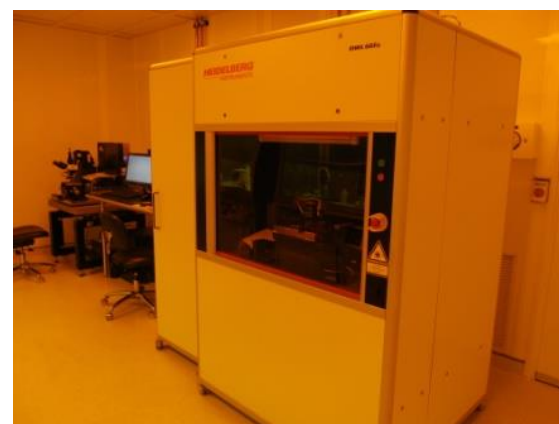
E-Beam Lithography System

- Composed with Zeiss SEM and Raith pattern generator
- Energy of electrons: 0.1 - 30 keV
- Minimum pattern feature size: ~ 20 nm
- Field stitching error ≤ 50 nm



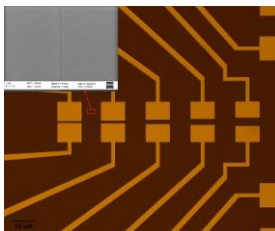
Mask Aligner System for Optical Lithography (SUSS MJB-4)

- Instrument for high resolution optical lithography
- Minimum pattern feature size: $0.8\mu\text{m}$
- Overlay accuracy: $\sim 1\mu\text{m}$
- Max wafer size: 4 inch (100mm)

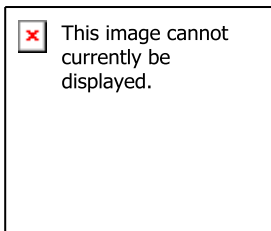


Maskless Laser Lithography System (Heidelberg DWL66)

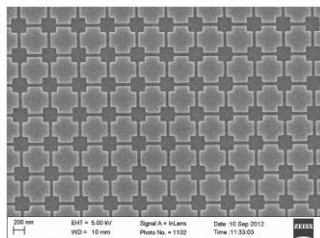
- high resolution pattern generator for direct writing on wafers
- Minimum pattern feature size: $0.6\mu\text{m}$
- Overlay accuracy: $\sim 0.2\mu\text{m}$
- Max wafer size: 6 inch (150mm)



Nano channel



SET device



Josephson Junction array



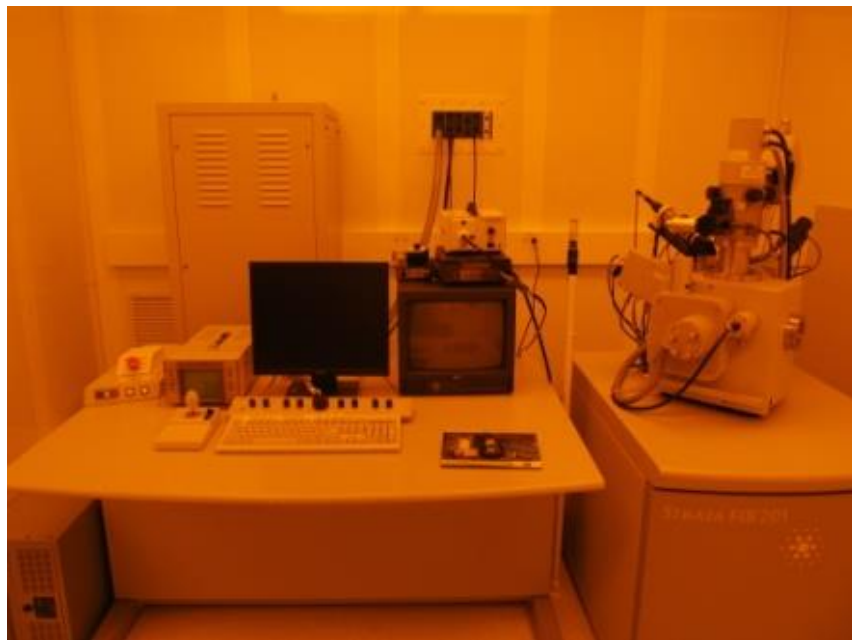
MTJ device



Hall bar

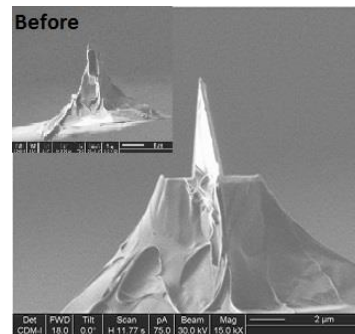


NCMN Nanofabrication clean room facility: Focused Ion Beam

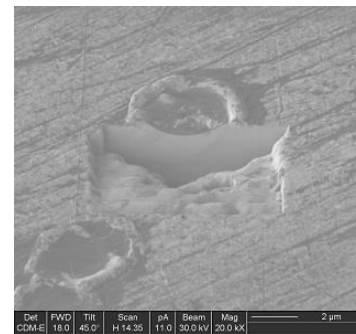


**Focused Ion Beam (FIB) workstation
(FEI Strata 200)**

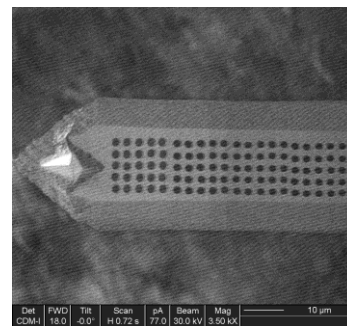
- Single Ga Ion beam system
- Accelerating energy: 5 - 30 keV
- Beam current range: 1 pA - 11.5 nA
- Pattern resolution: ~ 50 nm
- Two complimentary GIS: Pt deposition and selective carbon milling



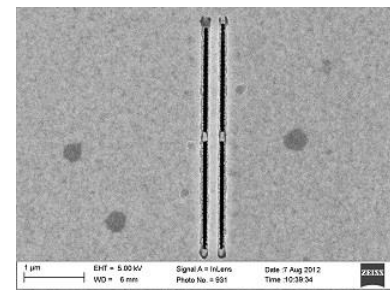
Sharpening Tips



**Crossing section
on stainless steel**



Hole-array on Tip



**Double-slit on SiN
membrane**



NCMN Nanofabrication clean room facility: Thin Film Deposition

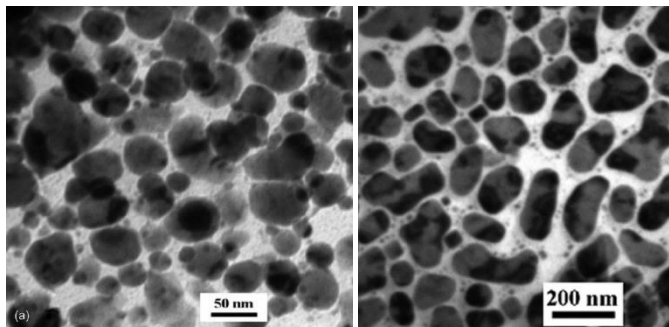


- Base pressure: $\sim 2 \cdot 10^{-9}$ Torr
- 4 evaporation sources
- Substrate heater: 850°C max
- substrate rotation
- Load lock 1 sample
- Quartz crystal thickness monitor

Electron beam evaporation system
ATC ORION 8000-E (AJA International)



AJA Sputtering System
ATC 2000-F (AJA International)

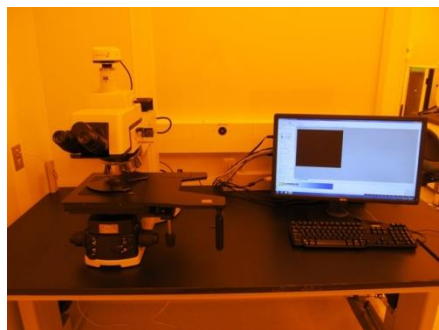


TEM image of L1₀ (Fe,Co)Pt-based magnetic films
deposited by AJA sputtering system

- Base pressure $\sim 5 \cdot 10^{-8}$ Torr
- Gas environment: Ar & O₂
- 2RF (300 W) and 2DC (750 W) supplies.
- Sputtering source: 5 in total.
- Substrates up to 4 inches in diameter
- Substrate heater: 850° C max
- Substrate rotation and RF bias
- Quartz crystal thickness monitor
- 6 sample Load lock



NCMN Nanofabrication clean room facility: Metrology



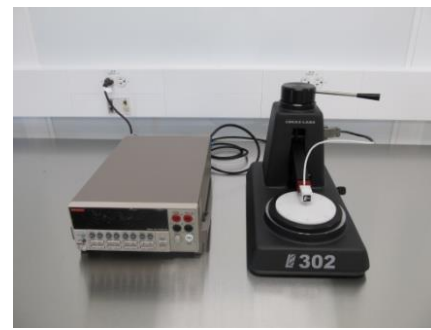
Optic microscope
(Nikon L200)



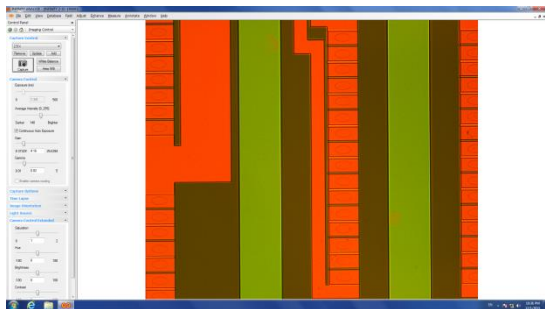
Reflective Film Thickness
Measurement System
(Filmetrics F40)



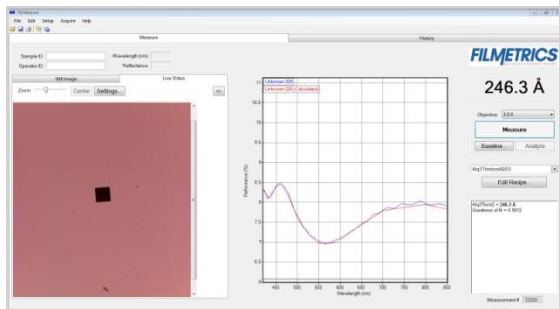
Stylus Profilometer
(Dektak XT)



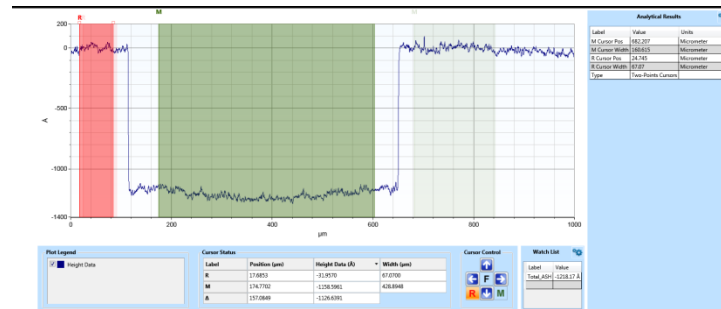
Four-probe Resistivity
Measurement Stand
(Lucas 302)



MTJ device optic image



Alq₃ film thickness measured by
Filmetrics



SiN film thickness measured by
Dektak



Thank You !