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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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

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 Sillicon Etching System
(Oxford PlasmaPro 100 Estrelas)

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

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, N$_2$, O$_2$) supports reactive sputtering

- The Ending Point Detection system(SIMS) allows users to define etch end point and mount of over etch
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

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

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, CF₄, C₄F₈, CHF₃, O₂, SF₆
- 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 (SF₆: 40sccm, O₂: 5.5sccm)
Etch rate: 3.6um/min, Etch time: 5min, Selectivity: 28:1,
Reactive Ion Etching (RIE/ICP) System

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)

<table>
<thead>
<tr>
<th></th>
<th>Wafer size</th>
<th>Temperature range</th>
<th>Working gases</th>
<th>Etch capability</th>
<th>Restrictions</th>
<th>Chamber cleaning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Up to 4”(100mm)</td>
<td>25°C</td>
<td>Ar, O₂, N₂</td>
<td>All type of materials</td>
<td>Low etch rate</td>
<td>Scrubber and Vacuum</td>
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<tr>
<td></td>
<td>Up to 4”(100mm)</td>
<td>-140°C to 60°C</td>
<td>Ar, CF₄, C₄F₈, CHF₃, O₂, SF₆</td>
<td>Polymers, Si and Si based Semiconductors</td>
<td>Limited etch capability</td>
<td>O₂ plasma</td>
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<tr>
<td></td>
<td>Up to 12”(300mm)</td>
<td>25°C to 400°C</td>
<td>Ar, BCl₃, Cl₂, CF₄, O₂, SF₆</td>
<td>Polymers, Metals and Si based semiconductors</td>
<td>Poor temperature control and uniformity</td>
<td>O₂ plasma</td>
</tr>
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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: 0.8µm
- Overlay accuracy: ~ 1 µm
- 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: 0.6µm
- Overlay accuracy: ~ 0.2 µm
- Max wafer size: 6 inch (150mm)

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**Nano channel**
**SET device**
**Josephson Junction array**
**MTJ device**
**Hall bar**
NCMN Nanofabrication clean room facility: Focused Ion Beam

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

TEM image of L1$_0$ (Fe,Co)Pt-based magnetic films deposited by AJA sputtering system

AJA Sputtering System
**ATC 2000-F (AJA International)**
- Base pressure $\sim 5 \cdot 10^{-8}$ Torr
- Gas environment: Ar & O$_2$
- 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
Optic microscope (Nikon L200)
Reflective Film Thickness Measurement System (Filmetrics F40)
Stylus Profliometer (Dektak XT)
Four-probe Resistivity Measurement Stand (Lucas 302)

MTJ device optic image
Alq$_3$ film thickness measured by Filmtrics
SiN film thickness measured by Dektak
Thank You!