

University of Minnesota Nano Fabrication Center

Standard Operating Procedure

Equipment Name: Ion Mill

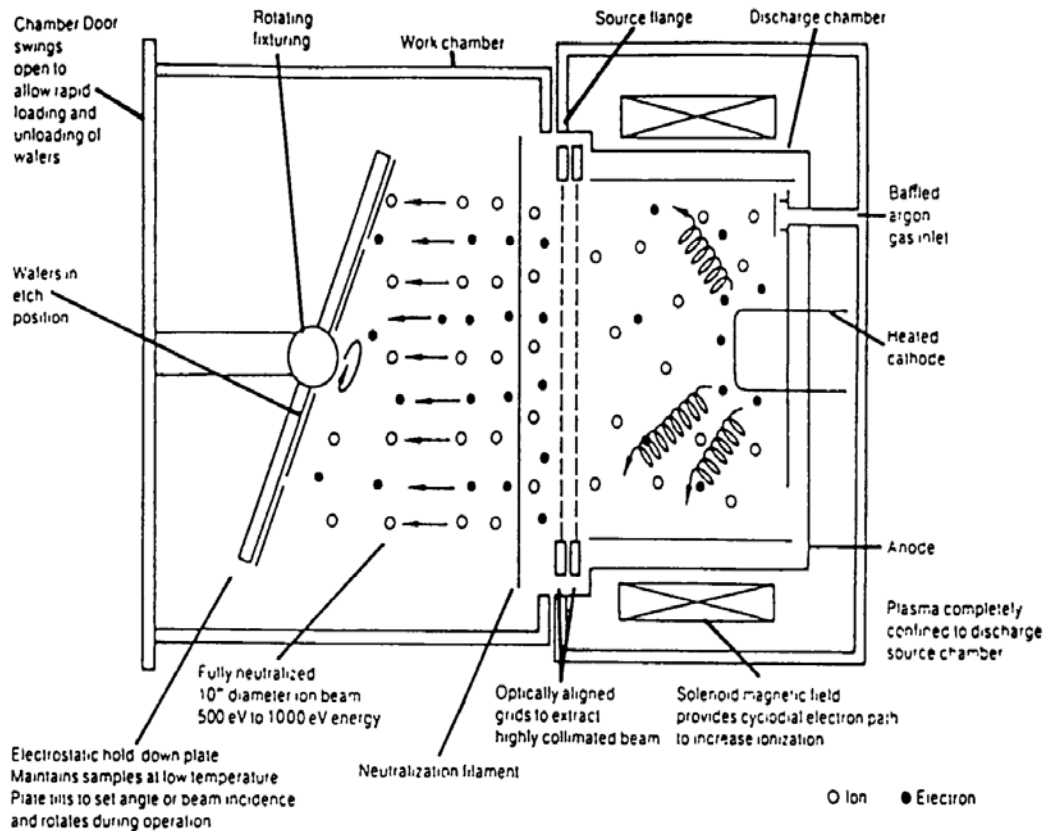
Coral Name: ionmill
Model: Technics
Location: Bay 3

Revision Number: 2
Revisionist: K. Roberts
Date: 9/24/09

1 Description

The Technics Ion Mill is used for non-chemical etching of thin films. To accomplish this, the chamber is first pumped down to low pressure and then back filled with Argon gas. The Argon is then ionized and accelerated by an electric field toward the substrate. This kinetically energized Ar "sputters" or removes the film from the substrate (see Figure 1).

Figure 1 - An Ion Mill Etching System:



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2 Safety

- a Make certain the door is latched to avoid having it fall down when the chamber reaches atmosphere. It is **very** heavy!

3 Restrictions/Requirements

- a Must be a qualified user on the Ion Mill.

4 Required Facilities

- a Compressed air, 75 psi
- b Argon, 14 psi
- c Nitrogen, 10 psi
- d Chilled water, 50/14 psi, 2.25 GPM

5 Definitions

- a Ion Beam Current – The amount of ions being accelerated toward the substrate.

6 Operating Instructions

- a Log in on bar code system.
- b CHAMBER VENTING:
 - 1 Push 'VENT' button. System will vent in 2-3 min. Door gap will widen when vented.
- c SAMPLE LOADING:
 - 1 Carefully lower the door by releasing the latch on top of the chamber.
 - 2 Remove the 3 piece cover plate setup by unscrewing the four thumb screws. Decide upon one of the given size templates provided by MTL (i.e. 1:6", 3:4", 4:3", etc.)
 - 3 Layer the stage in the following way: First, place the foam pad on the bottom. Next, put the copper-colored template of your choice on top of the foam pad. Then place your substrates in the assigned locations. Finally, screw in the silver-colored stainless steel cover on top. **Caution: Be sure to fill all open slots for the chosen template otherwise the argon beam will etch the foam pad away.**
 - 4 When the samples are ready, close the chamber lid and make sure that the latch has been properly secured atop the chamber.
 - 5 Adjust the angle of the stage (ranging from 0 to 40 degrees) by unscrewing the **set screw**, rotating the **lever** found on the right side of the chamber cover, and then tightening the **set screw**. **Caution: Adjusting the angle past 40 degrees may cause the stage to get stuck and possibly induce motor burn-out.**

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- d PUMP DOWN:
- 1 Push 'PUMP' button. Rough pumping will begin momentarily. At 50 mtorr, the cross-over to the cryo pump will be initiated and the ion gauge will be turned on. If for some reason 50 mtorr is not reached within 4 minutes, the roughing pump will shut itself off automatically. If this should happen, check to make certain the door o-ring is seated correctly, press the door firmly against the chamber, and try pumping down again by pressing "START" a second time, or contact MTL staff for assistance.
 - 2 Optimally, you should wait until a base pressure of 8.0×10^{-6} torr is reached (~20 min.) until proceeding to the next section. However, this is not an absolute necessity--just make sure you're in high vacuum: $< \text{mid } 10^{-5}$ torr.
- e GAS FLOW:
- 1 Slowly turn the silver **gas line valve** parallel to the line (vertical).
 - 2 Flip the white **argon source flow switch** up to manual mode.
 - 3 Flip the **milling control switch** in the lower right hand corner to manual mode.
 - 4 Rotate the black **needle valve** dial counterclockwise until the pressure stabilizes at 8×10^{-5} Torr.
- f POWER SUPPLY SETTINGS:
- 1 Make sure that all power supply dials are off (turned counterclockwise).
 - 2 Flip the **power switch** on the Advanced Energy power supply to the "on" position.
 - 3 Flip the **left source beam switch** up momentarily to the "on" position. The NEUTRALIZER, CATHODE, SOURCE POWER, EXTERNAL INTERLOCK, EMISSION, BEAM, and ACCELERATOR lights should all be a constant red with only the DISCHARGE light flashing. **If any of the first seven are flashing, shut the system down and contact an MTL staff member.**
 - 4 Turn the **discharge control knob** clockwise until the displayed voltage is 140 volts.
 - 5 Slowly, turn the **cathode control knob** clockwise until the discharge light stops flashing, but do not go over 10 amps! If the discharge light is still flashing when you reach 9.5 amps, turn both the cathode control and the discharge control knobs completely counter clockwise. Then, repeat step 4 with 145 volts instead of 140.
 - 6 When the discharge light stops blinking, raise the **discharge voltage** to 50 volts.
 - 7 Raise the **beam voltage** to above 300 volts.
 - 8 Raise the **accelerator voltage** to 100 volts.

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- 9 Adjust the **neutralizer emission knob** so the ion current LCD in the lower left corner reads 000. This ensures that the beam striking your wafer is electrically neutral and will give you a much faster etch rate.
 - 10 Flip the **turntable switch** to manual for substrate rotation.
- g START YOUR RUN
- 1 Open the **chamber shield**. The etching of the substrate has now begun! Estimates of the etch rates of many common materials can be found at the end of these instructions (**see Table 1**).
 - 2 Record all your settings in the log book.
 - 3 When your run is finished, close the **chamber shield** and shut off the **turntable switch**.
- h SHUTDOWN
- 1 Turn all the **control knobs** on the power supply completely counterclockwise to off.
 - 2 Turn off the **power switch** found on the left of the power supply.
 - 3 Turn off the **milling control power** and then flip off the **argon source flow switch**.
 - 4 Rotate **argon source flow dial** clockwise to off.
 - 5 Wait a few seconds for the gas line to be pumped out and then close the silver **gas line valve** so it is perpendicular to the main line.
- i UNLOADING SAMPLES
- 1 Push 'VENT' button. System will vent in 2-3 min. Door gap will widen when vented.
 - 2 Carefully lower the door by releasing the latch on top of the chamber.
 - 3 Remove substrates.
 - 4 Return one of the cover plates, foam pad, and screws to system.
 - 5 Close the chamber lid and make sure that the latch has been properly secured atop the chamber.
 - 6 Push 'PUMP' button. Rough pumping will begin momentarily. At 50 mtorr, the cross-over to the cryo pump will be initiated and the ion gauge will be turned on. If for some reason 50 mtorr is not reached within 4 minutes, the roughing pump will shut itself off automatically. If this should happen, check to make certain the door o-ring is seated correctly, press the door firmly against the chamber, and try pumping down again by pressing "START" a second time, or contact MTL staff for assistance.
 - 7 Make certain system is in high vacuum before leaving.
 - 8 Complete log book entry if needed.
 - 9 Log out of bar code system.

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7 Problems/Troubleshooting

- a Avoid slamming the chamber shield to its 'open' position as this can cause a short to occur which causes the **ion current gauge** (lower left) to misread.
- b Often longer runs (greater than 15 min.) lead to overbaking of the photoresist. This can be alleviated somewhat by cycling of the chamber shield; 5 min. 'open', 5 min. 'closed' for instance. If overbaking of the resist does occur, a more expensive stripper, EBR PG, should be asked for. This will remove resist that has been baked at 180 °C.

Table 1 - Ion Mill Etch Rates

| Material | Rate (Ang/min.) | Material | Rate (Ang/min) |
|--------------------------------|-----------------|--------------------------------------|----------------|
| Ag | 100 | Nb | 20 |
| Al | 35 | Ni | 30 |
| Al/Cu | 5 | NiCr | 10 |
| Al ₂ O ₃ | 5 | NiFe | 20 |
| Au | 90 | NiFeCo | 5 |
| AZ 1350 J | 15 | No | 20 |
| Bi | 430 | Pb | 155 |
| C | 5 | PbTe | 150 |
| CdS | 50 | Pd | 50 |
| Co | 30 | PMMA | 20 |
| Cr | 20 | Pt | 45 |
| CrSi | 5 | Rb | 200 |
| Cu | 50 | Re | 25 |
| Er | 45 | Ru | 30 |
| Fe | 25 | Sb | 160 |
| FeO | 35 | Si | 20 |
| GaAs | 115 | SiC | 15 |
| GaP | 70 | SiO ₂ | 25 |
| GaSb | 85 | Si ₃ N ₄ LPCVD | 5 |
| Ge | 45 | Sn | 70 |
| InSb | 60 | Th | 35 |
| Ir | 30 | Ti | 10 |
| LiNbO ₃ | 25 | V | 20 |
| Mn | 45 | W | 15 |

Note: This table uses ~80mA Ion Beam Current and 100 accelerating volts.
 Values rounded to nearest 5 A/min.