Chapter 6.03

Randex Sputtering System

1.0 Equipment Purpose
1.1 The randex sputtering system is an RF diode sputterer with two gas inputs. One is dedicated argon for sputtering, and the other is toggled between N2 and O2 for reactive sputtering.

2.0 Material Controls & Compatibility
2.1 Randex is a general metal deposition tool and has been exposed to several contaminants. Wafers entering randex are unlikely to ever achieve tystar-grade cleanliness again.

3.0 Applicable Documents
3.1 N/A

4.0 Definitions & Process Terminology
4.1 Sputtering: The process of using a plasma to bombard a material target which then redeposits onto a nearby substrate and the surrounding area, leaving a metal thin film
4.2 Reactive sputtering: the introduction of a reactive gas into the sputter plasma to make up or add constituents to the resulting film.

5.0 Safety
5.1 Substrates made of materials with high vapor pressure or with a mobile ion content should not be used in the Randex. Putting photoresist in the Randex should be avoided if at all possible. Consult the Process Engineering group if you have unusual substrate material or need for a new target material.
5.2 Use new gloves when you work within the chamber, or when handling parts entering the chamber.
5.3 The cryo temperature readout should read less than 15 K.
5.4 The high vacuum valve should be OPEN in standby mode.
5.5 Gas pressure feeds should be kept between 20 and 25 psi.
5.6 Sputtering power should never exceed 500 Watts. Reflected power should never exceed 50 Watts or 10% of the forward power.
5.7 The ion gauge filament and the ion gauge power should be off when sputtering. The ion gauge filament should be turned off when beginning pump down. It can be turned on after the high vacuum valve has opened.

6.0 Process Data
6.1 N/A

7.0 Available Processes, Gases, Process Notes
7.1 Cleaning Broken Wafer Pieces and Debris
7.1.1 Always use a vacuum hose to clean wafers or flaking metal. Never use an N2 gun.
7.2 Operation Theory and Available Recipes For Some of the Targets

7.2.1 The deposition source is generated by bombarding the target material with high-energy ions from plasma. The film deposited by this method is uniform in thickness and capable of covering areas usually shadowed by other deposition methods.

7.2.2 The Randex system consists of three parts:

7.2.2.1 The deposition chamber and control panel

7.2.2.2 The vacuum system

7.2.2.3 The ENI OEM 12A RF power supply.

7.2.3 Inside the deposition chamber are three targets, a substrate table, and an etch station circulating system. The control panel selects the target and substrate position and controls the sputtering power. The vacuum system contains a mechanical pump, a cryopump, throttle valve, automatic valve controls and chamber. An ENI OEM 12A RF power supply provides the RF power needed to generate plasma in the deposition chamber.

7.2.4 Refer to Table 1 in Appendix 11.1 for process parameter set up and the estimated deposition rate for various targets.

7.3 Target Inventory

7.3.1 Ag
7.3.2 Al
7.3.3 Al₂O₃
7.3.4 Cr
7.3.5 Cu
7.3.6 Flint Glass
7.3.7 Ge
7.3.8 InSb
7.3.9 ITO
7.3.10 LiF
7.3.11 MgF
7.3.12 MgO
7.3.13 Nickel (Ni)
7.3.14 Ni/Ti
7.3.15 Ni/Fe
7.3.16 PZT
7.3.17 Si
7.3.18 Si₃N₄
7.3.19 SiO₂
7.3.20 Sn
7.3.21 SnO₂
7.3.22 Ta
7.3.23 Tantalum Oxide
7.3.24 Ti
7.3.25 TiW
7.3.26 V
7.3.27 W
7.3.28 WSiX
7.3.29 Yttrium Alumunous Neodymium (YO₃-Al₂O₃-Nd₂O₃)
7.3.30 Zr
7.3.31 7059 Glass

8.0 Equipment Operation

8.1 A large inventory of targets exists for the Randex. Should you require a target changed, please observe the following target change policy.

8.2 Target Changes

8.2.1 Target changes are made by staff and superusers. Labmembers trained on randex are not immediately qualified to change targets.

8.2.2 To request a target change, send email to randex@eecs.berkeley.edu, stating what target(s) you would like and when you need them. Staff will add your requested targets to the target change queue in the order they were received and do whatever is possible to meet your schedule. Staff will enter the target change schedule into equipment comments and send a copy to labmembers qualified to use randex.

8.2.3 Anyone wanting to purchase a new target should contact the Process Engineer in charge of randex.

8.2.4 Targets will stay in place for a week at a time unless users indicate that they are done sooner and others are waiting. If there is no request, targets will not be changed.

8.3 Loading a Sample – Pumpdown

8.3.1 Enable the system on Mercury. Make sure to enter the material you’re depositing in the header prompt when the enable messages come up.

8.3.2 Check the cryo pump readout to confirm that the temperature is less than 15K. If not, STOP, and report a problem on Mercury.

8.3.3 Turn on the ion gauge power and filament and confirm that the pressure is less than 3x10⁻⁶ Torr. If not, report a problem on Mercury.

8.3.4 Turn off the ion gauge.

8.3.5 Push the VACUUM button to terminate pump cycle. This will close the high vacuum valve.
8.3.6 Vent the chamber by pushing the VENT button. (The system has a 10 second time delay relay to assure the gate valve has closed.) Vent until an N₂ breeze can be felt around the baseplate. Turn off the 2 VENT.

8.3.7 Put on clean vacuum gloves available in the center of the bay.

8.3.8 Raise the top plate. Be prepared to catch the O-ring if it sticks to the top plate.

8.3.9 Load the sample onto the substrate plate of your choosing.

8.3.10 Make sure the o-ring sits properly in the groove of the bell jar. Then lower the top plate.

8.3.11 Before starting pumpdown, confirm that the ion gauge is off.

8.3.12 Push the VACUUM button. The roughing valve should open and the chamber should pump down. When the pressure falls below 150 mTorr, the roughing valve should close and the high vacuum valve should open. If the crossover does not occur, push the VACUUM button to close the roughing valve, and report a problem on Mercury.

8.3.13 After the hi-vac valve opens, turn on ion gauge filament.

8.3.14 When the system achieves a pressure in the mid 10⁻⁶ range, turn on the cooling water (both knobs to the left) and the power supply (see Section 9.3).

8.3.15 Turn off the ion gauge filament.

8.3.16 Turn on Ar, N₂, and/or O₂ shutoff valves as appropriate.

8.3.17 Push gas controller toggle down to SET to set desired flow. Set to READ to read flow. Position 4 is Ar, position 2 is O₂ and N₂. (Note: There are only two mass flow controllers - Number 2 is used for both nitrogen and oxygen. Only one gas can be ON at a time.)

8.3.18 Typical sputtering pressures are 5 - 8 mTorr.

8.4 Operating Instructions for ENI OEM 12A RF Generator

8.4.1 Power Up Procedure

8.4.1.1 Turn on the ENI OEM 12A generator.

8.4.2 Operation

8.4.2.1 Increase the power setting on the ENI generator to 100 watts reflected.

8.4.2.2 Push IGNITE button to ignite the plasma on your target - this is essential for proper tuning.

8.4.2.3 Tune matching network for maximum forward power and minimum reflected power using load and tune knobs.

8.4.2.4 Adjust output level for desired power. Read watts on forward power meter. Reflected power should not exceed 10% of forward power.

8.5 Sputtering

8.5.1 Do not apply more than 300 watts of power to a dielectric target because the poor thermal conductivity of dielectrics heat is not effectively transferred to the coolant and the target may crack when cooling down due to differential cooling.

8.5.2 To sputter clean a target, place the system in the following position:
8.5.3 Turn on the ENI OEM 12A generator.

8.5.4 Increase the power setting on the ENI generator to 100 watts reflected.

8.5.5 Push IGNITE button to ignite the plasma on your target - this is essential for proper tuning.

8.5.6 Tune matching network for maximum forward power and minimum reflected power using load and tune knobs. The tune knob has a greater effect on reflected power than the load knob.

8.5.7 Adjust output level for desired power. Read watts on forward power meter. Reflected power should not exceed 10% of forward power.

8.5.8 Allow target to stabilize for 2 minutes, then rotate substrate into position.

8.5.9 After desired sputtering time, turn the power to adjust to zero.

8.5.9.1 Reduce power for dielectric targets by no more than 300W/Min to reduce chance of cracking.

8.5.10 Toggle the RF power off.

8.5.11 Cool down the system (~5 to 10 minutes depending on sputtering power used);

8.6 Vent and substrate removal

8.6.1 Turn power off on the power supply. Turn off gas toggle valves. The mfc controller should be left on. **DO NOT SHUT OFF THE GASES AT THE TANKS.**

8.6.2 Close the hi-vac valve. Wait 10 seconds. Press the vent button.

8.6.3 Wait until the chamber is at atmosphere.

8.6.4 Unload the sample and substrate plate with fresh vacuum gloves.

8.6.5 Turn off the cooling water.

8.6.6 Place the randex in the standby mode by:

8.6.7 Pump down system.

8.6.8 Check HV valve (ON), Roughing valve (OFF), Gas valves (OFF). You may leave the ion gauge power and filament on.

9.0 **Troubleshooting Guidelines**

9.1 Problem: Failure to pump down to crossover

9.1.1 Cause: Gross leak across seal. Open chamber and wipe o-ring for chamber lid down.

9.2 Problem: Plasma won’t ignite

9.2.1 Cause: Impedance mismatch. Try increasing pressure or slowly turning the tune/load knobs and ignite again.

10.0 **Figures & Schematics**
10.1 Figures, including the equipment front view, parts, and panels can be displayed in this section. Include figures and schematics of control panels.

11.0 Appendices

11.1 Process Recipes (parameter set up)

<table>
<thead>
<tr>
<th>Target</th>
<th>Ar (sccm)</th>
<th>O2* (sccm)</th>
<th>P (mTorr)</th>
<th>RF Power (W)</th>
<th>Rate**(Å/min)</th>
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* Process parameters for mixture of 90% Ar + 10% O2 are listed above (original process).
** Deposition rates are only for reference and will drift based on recent chamber use. It is recommended to run a test wafer before your device wafer.

Table 1 - Process Parameters for Various Targets and Their Estimated Deposition Rates

Other gas mix ratios can be used to optimize a particular process, as an example: 22 sccm of O2 and 22 sccm of Ar is equivalent to (1:1) O2:Ar mix (a mixture bottle of 50% O2 and 50% Ar was used in the old lab, before the tool was moved).