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Explorer 14 Magnetron Sputterer (PVD-05) Standard Operating Procedure

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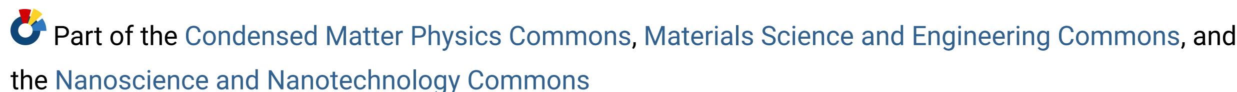
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Explorer 14 Magnetron Sputterer (PVD-05) Standard Operating Procedure

Summary/Description

Standard Operating Procedure for the Explorer 14 Magnetron Sputterer (PVD-05) located at the Quattrone Nanofabrication Facility within the Singh Center for Nanotechnology at the University of Pennsylvania

Keywords

sputtering, physical vapor deposition

Disciplines

Condensed Matter Physics | Materials Science and Engineering | Nanoscience and Nanotechnology

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Standard Operating Procedure (SOP)

Explorer 14 Magnetron Sputterer

(PVD-05)

In case of fire or injury, please call 911 (511 from Penn phones)

Please report errors on IRIS, and the staff will take care of it.

Please *DO NOT* run diagnostics without the supervision of a staff member.

General safety tips and common mistakes

1) If the system is not running, make sure you are logged into the tool on IRIS.
2) Do not exceed the maximum sputtering power (material specific; see next page).
3) The Ag target must cool down for 15 min in vacuum before venting. All other targets must cool down for 5 minutes.
4) You MUST stay logged in until the pump-down recipe is complete.
5) If neither voltage, current nor power reaches the desired setpoint, check if the power supply is on. If it is, contact staff.

Last modified 10/25/2022 by Jason A. Röhr
Last Revied 10/25/2022 by Jason A. Röhr

Maximum sputtering power

Material name	Target	Max allowed power [W]	Power type
Silver	Ag	600	DC
Aluminum	Al	600	DC
Gold	Au	140	DC
Chromium	Cr	560	DC
Copper	Cu	600	DC
Iron	Fe	350	DC
Germanium	Ge	140	DC
Indium tin oxide	ITO	140	RF/DC
Manganese	Mn	140	DC
Molybdenum	Mo	600	DC
Nickle	Ni	350	DC
Palladium	Pd	140	DC
Platinum	Pt	140	DC
Silicon - doped	Si (doped)	280	DC
Silicon - undoped	Si (undoped)	140	RF
Silicon dioxide	SiO2	210	RF
Titanium	Ti	350	DC
Titanium oxide	TiO2	140	RF
Tungsten	W	600	DC
Yttria stabilized zirconia	YSZ	140	RF

- Ensure that the deposition power does not exceed the values on the spreadsheet.
- Failure to adjust the deposition power can destroy the targets and will be considered tool misuse.
- Contact staff if you wish to deposit materials not on this list.

Sputtering rates/master recipes

Material	Power [W]	Pressure [mTorr]	Rate [nm/min]	Rate [A/sec]	Base pressure [Torr]	Recipe name
Al	450 (DC)	3	18.0	3.0	$\sim 5 \times 10^{-6}$	Al-master recipe
Ti	350 (DC)	3	12.0	2.0	$\sim 5 \times 10^{-6}$	Ti-master recipe
Au	140 (DC)	3	27.5	4.6	$\sim 5 \times 10^{-6}$	Au-master recipe
Cu	400 (DC)	3	38.5	6.4	$\sim 5 \times 10^{-6}$	Cu-master recipe
Pt	140 (DC)	3	15.4	2.5	$\sim 5 \times 10^{-6}$	Pt-master recipe
Ag	140 (DC)	3	44	7.3	$\sim 5 \times 10^{-6}$	Ag-master recipe

Explorer 14 Magnetron Sputterer

- Primary tool owner: Jason A. Rohr
- For processing-related questions: jarohr@seas.upenn.edu
- ***Issues must be reported on IRIS. Do not contact primary tool owner directly with tool issues.***

Tool Overview

The *Denton Explorer-14* (**PVD-05**) is a magnetron sputter deposition tool for depositing metallic and dielectric films. Sputter deposition is achieved by bombarding a source material (the target) with energetic ions, typically ionized Ar. Atoms at the surface of the target are knocked loose, and transported to the surface of the substrate, where deposition occurs. Sputter deposition tends to give smooth, uniform films; the films tend to be more conformal than what is achieved with thermal or e-beam evaporation, which might have complications for certain lift-off procedures.

The tool is an open load system in sputter-down configuration with one dedicated DC gun and two guns that can use either a DC or RF power supply (three sputter sources in total). Co-deposition from two DC sources or one DC and one RF source is possible. The tool is equipped with a cryo-pump, with an automated interface, accepting substrate sizes from pieces through wafers with 150 mm diameters. The tool has platen rotation and cooling.

The Denton cannot deposit magnetic materials. See the **PVD-03** system for deposition of magnetics.

Tool policies

- Source #2 always contains the titanium (Ti) target. Source #1 and #3 rotate depending on target requests.
- You have to stay with the tool while active vent and pump recipes are running (unless there is an emergency, i.e., a fire alarm or toxic gas alarm).
    - As soon as the ‘A_Pump’ recipe is complete, the system will continue to pump down the system. You can leave the system as soon as the tool alarm rings telling you that the pump-down recipe is complete.
- You are allowed to leave the tool while a long deposition is running. If your deposition is less than 10 minutes, please stay with the tool.
    - Ensure that the plasma is stable at the desired deposition power.
- Do not adjust the deposition parameters in the master recipes beyond the deposition time. This includes processing gas pressure, the ramp up parameters, and the final dwell time. They all serve a purpose.
- Always leave the tool pumped down after you’re done; do not leave the tool or logout of IRIS before the pump-down recipe is complete.
- Stick to your schedule; if you run over time and someone else has booked the system after you, please let them know in a timely fashion.

1. **Before you begin** ... 6
2. **Venting the chamber** ... 7
3. **Loading your sample** ... 9
4. **Pumping down the chamber** ... 10
5. **Running a master recipe** ... 11
6. **Venting the chamber** ... 16
7. **Taking out your samples** ... 16
8. **Pumping down the chamber** ... 16
9. **Log out of IRIS** ... 16

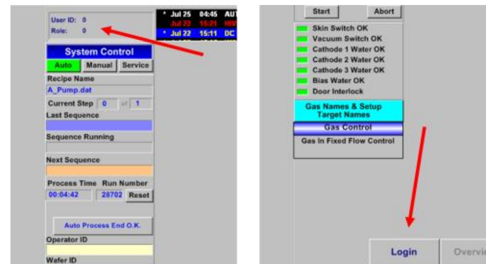
1. Before you begin

1.1. Login to the tool (PVD-05) on IRIS (https://iris.nano.upenn.edu/)

1.2. Ensure that the power supplies are on! The power supplies can be found at the bottom of the tool, underneath the computer (dashed orange boxes).

1.3. Make sure that you're logged into the tool as a basic user. If you're not logged in, the 'user ID' will say "0" in the top left corner.

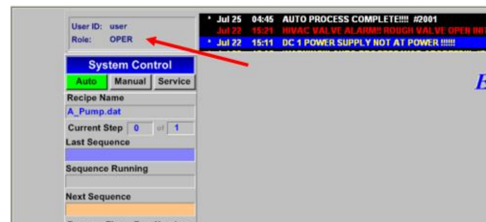
1.4. To log in, please click **Login** at the bottom of the screen.



1.5. Click **Log In**;

Username: user
Password: user

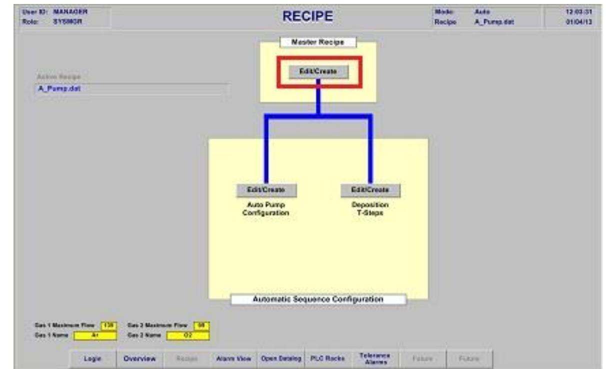
1.6. The User ID will now say "user" instead of "0".



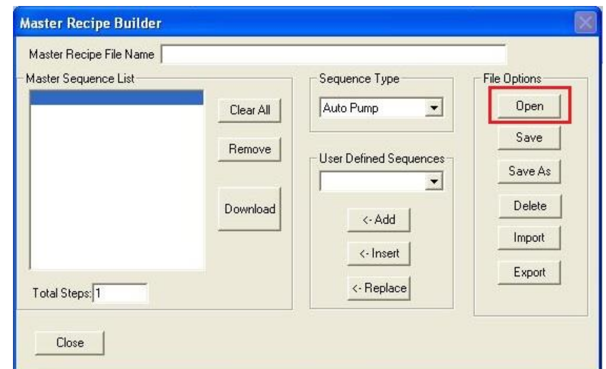
2. Venting the chamber

2.1. Click **Recipe** at the bottom of the overview screen to open the recipe screen.

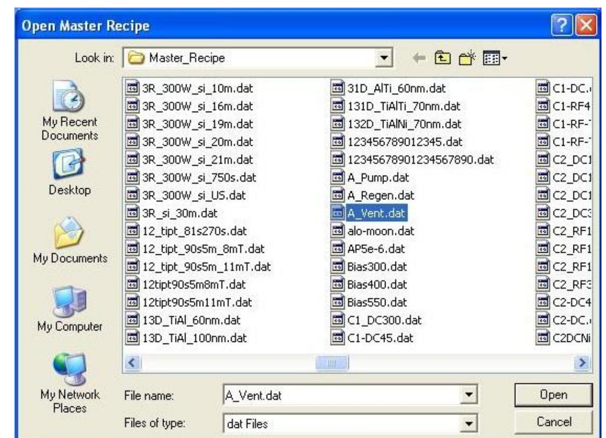
2.2. Click **Edit/Create** under the Master Recipe box to open Master Recipe Builder window (red box).



2.3. Set the “Sequence Type” to Auto Pump. Click **Open** under “File Options” to open the list of recipes.

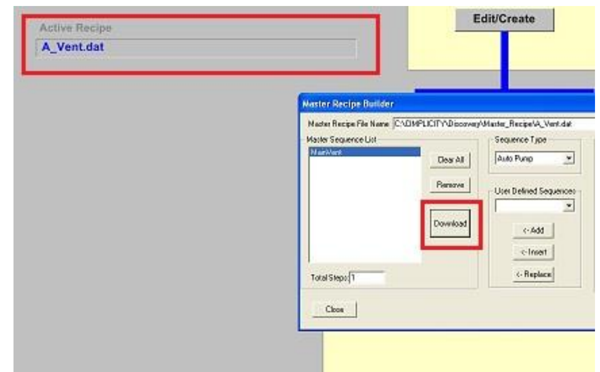


2.4. Choose “A_Vent.dat” and click **Open**.



2.5. Click **Download**. Make sure that the recipe name appears in the top left corner of the screen.

2.6. Click **Close**; your recipe has now been loaded.



2.7. Click **Overview** to go back to Overview screen.

2.8. Click **Start** to begin the venting recipe. The start button will turn green when the recipe is running.

You will hear the venting gas being injected. When the chamber is fully vented, the gas injection sound will change slightly.

3. Loading your sample

3.1. Open the sputter chamber.

3.2. Place your sample on the rotatable stage underneath the sputter sources.

You can mount your sample to the stage with Kapton tape if needed.

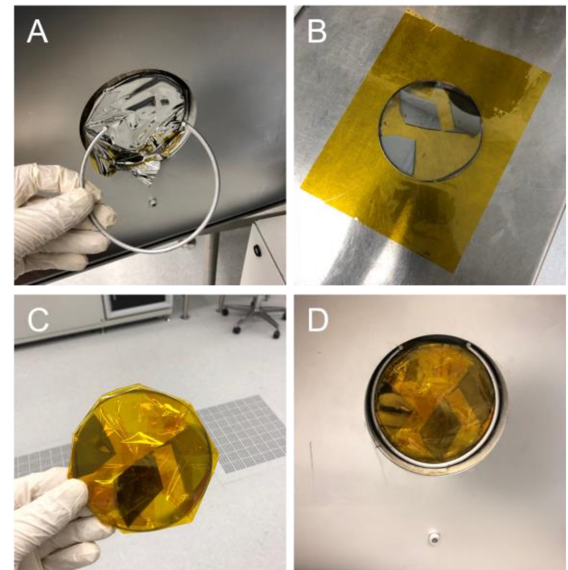
3.3. Replace Kapton on chamber window

A. Take off the metal clamp; take out the window; remove metal-covered Kapton.

B. Place glass window on Kapton sheet

C. Wrap the sheet; tape it in place.

D. Place the wrapped window in the door; ensure that the smooth Kapton surface is facing the inside of the chamber; mount the metal clamp.



3.4. Close the sputter chamber. Lock the chamber door slightly; just enough to keep the chamber door closed.

4. Pumping down the chamber

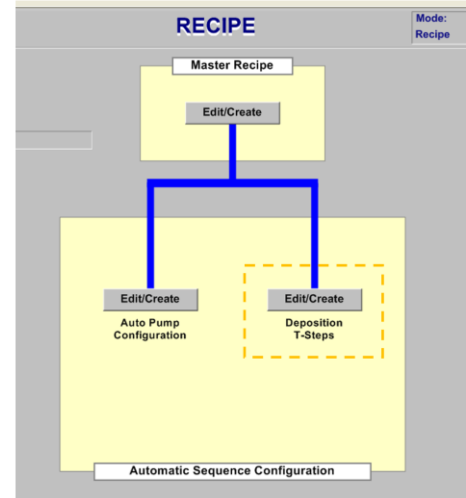
Follow the same procedure as for venting, but use recipe "A_Pump.dat".

See page 7-8.

5. Running a master recipe

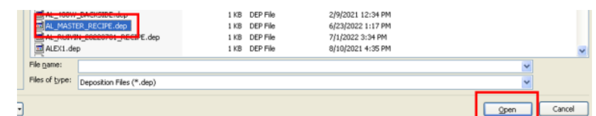
5.1. Click **Recipe** at the bottom of the screen.

5.2. Click **Edit/Create** as indicated.



5.3. An empty spreadsheet opens; click the green **Open** button

5.4. Pick a master recipe. There is a master recipe for each target (here “AL_MASTER_RECIPE.dep” for the aluminum target); click **Open**.



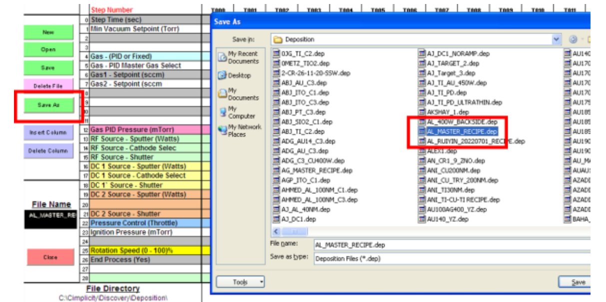
5.5. The master recipe name is now visible under "File Name".

Process parameters can now be changed

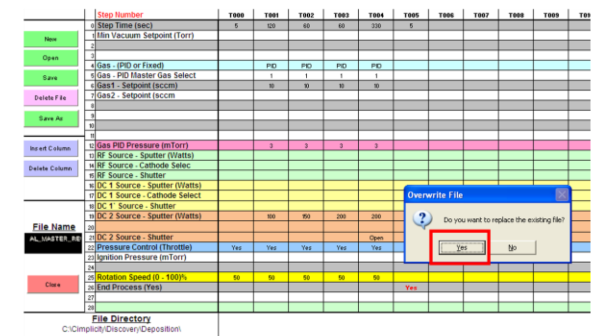
***Note:* You should not have to change any other process parameters besides the deposition time. Contact staff if you want to develop your own recipe.**

The column containing the "Open" statement for the specific sputter source is the actual deposition step. The deposition time can be altered under "Step Time (sec)".

5.6. Once the parameters have been set, click **Save as**. Find the same master recipe you opened (here AL_MASTER_RECIPE.dep). Click **Save**.

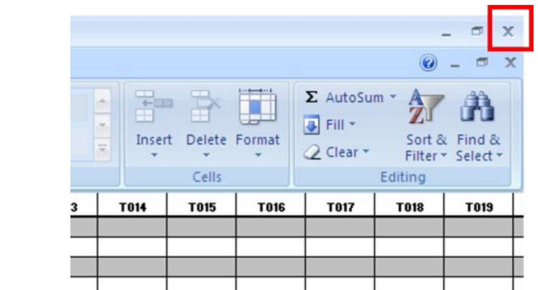


5.7. When it asks you whether you want to overwrite, click **Yes**.

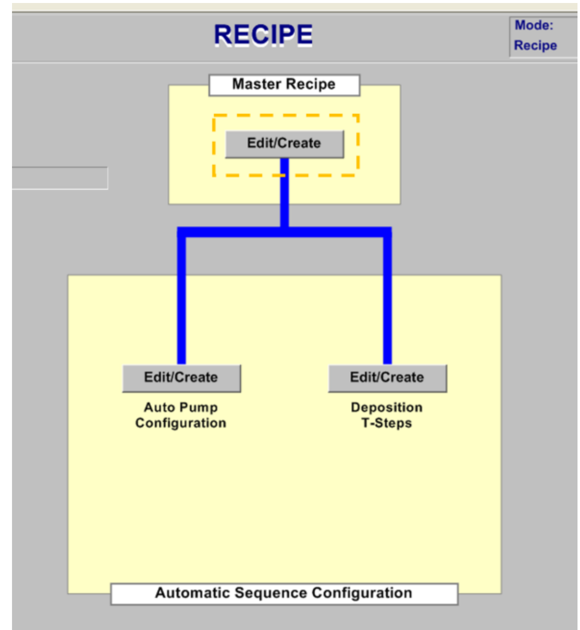


5.8. ***Optional:*** The spreadsheet can now be closed by clicking the outermost **x**.

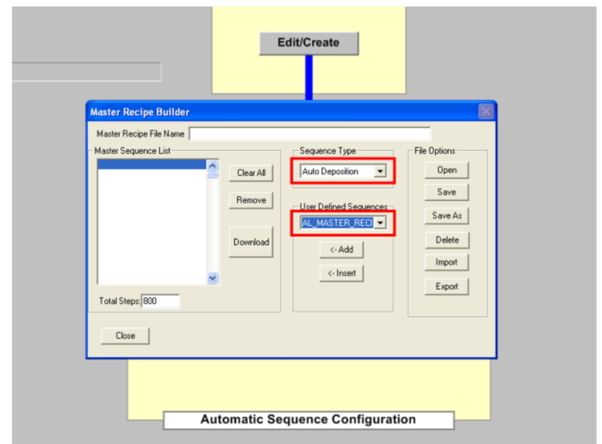
Alternatively, alt + Tab back to the main tool screen



5.9. Click **Recipe** at the bottom of the screen and click **Edit/Create** under “Master Recipe”.

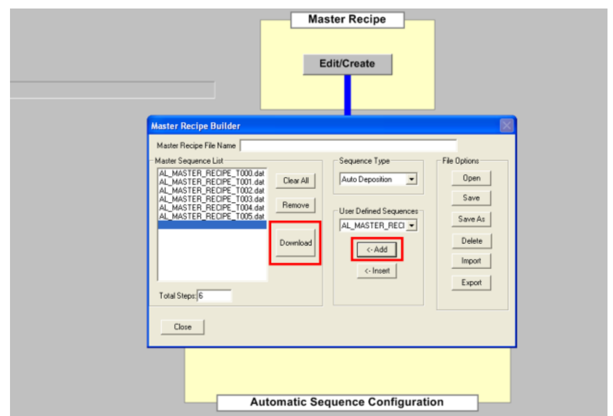


5.10. Under “Sequence Type”, pick Auto Deposition. Under “User Defined Sequences”, pick your edited master recipe (here “AL_MASTER_RECIPE.dep”)



5.11. Click **Add**. You will see several items in the “Master Sequence List”. This corresponds to each column in the editable spreadsheet.

5.12. Click **Download**.



5.13. It will now ask you to save your recipe, this time as a *.dat* file.

Critical: Save your recipe as “master_recipe_X.dat”, where X is the material name (here “master_recipe_Al.dat”). This file should already exist, and you need to overwrite it by clicking Save.

5.14. It will ask you whether you want to replace the existing file. Click **Yes**.

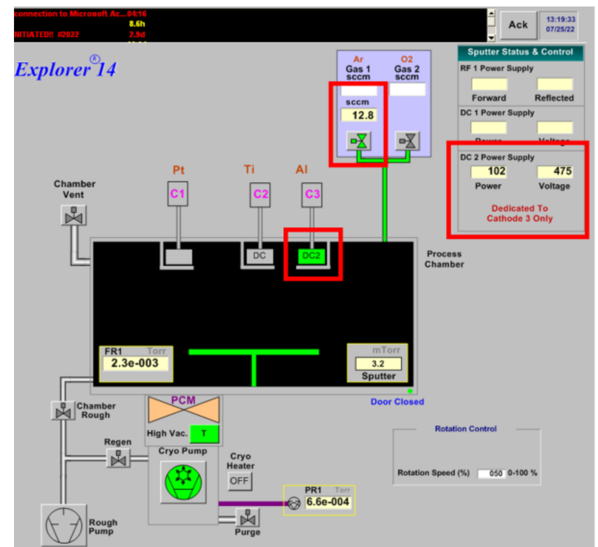
5.15. Once saved, click **Close**.

5.16. Click **Overview**. You can now see that your recipe has been loaded.

5.17. Click the **Start** button. It will turn green as the recipe begins. You can now follow along each step in your sequence list, which shows the process pressure, process power, time, etc.

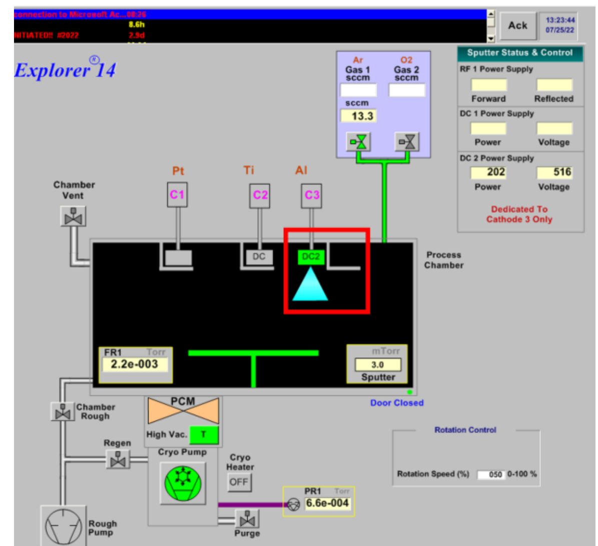
5.18. As the recipe is running, the chosen sputter source will turn green, the process gas injection will be visible and the power will increase to reach the desired setpoint. Pay attention to whether the process power matches the power set in the recipe.

Note: The power will ramp up in discrete increments in different ways depending on the material being deposited. It might take some time before the actual deposition power is reached.



5.19. You can observe the plasma through the Kapton deposition window. Make sure that it's steady and not flickering.

5.20. During the deposition step, the shutter graphic will be open, and a cone representing the emitted material is shown.



5.21. When the deposition is over, an alarm will notify you. You can now vent the system.

Note: All the master recipes have built-in dwell times at the end of the recipe to allow the target to cool. This cooling step prevents the build-up of oxides on the target surface.

6. Venting the chamber

Follow the procedure for venting.

See page 7-8.

7. Taking out your samples

7.1. Remove your samples from the chamber.

7.2. It is good practice to replace the Kapton tape on the chamber window after your deposition, especially if a long deposition was performed.

8. Pumping down the chamber

Follow the same procedure as for venting, but use recipe "A_Pump.dat".

Note: Do not leave the system until the chamber has been pumped down and until your hear the alarm.

9. Log out of IRIS

Do not log out of IRIS until the chamber is pumped down. If you do, the recipe will abort and the chamber will not be pumped down for the next user.