Lab 1
Familiarization with the MKS PPTS-1A Plasma Trainer

Name: ______________________________

Purpose

The purpose of this lab is to:

1. Familiarize the student with the structure and components of the MKS PPTS-1A Plasma Trainer
2. Teach the student how to safely set up and operate the system through a complete process cycle including:
    a. Instrument set up
    b. Pump down
    c. Generating a plasma and sputter coating a substrate
    d. Properly bring the system back to atmospheric pressure

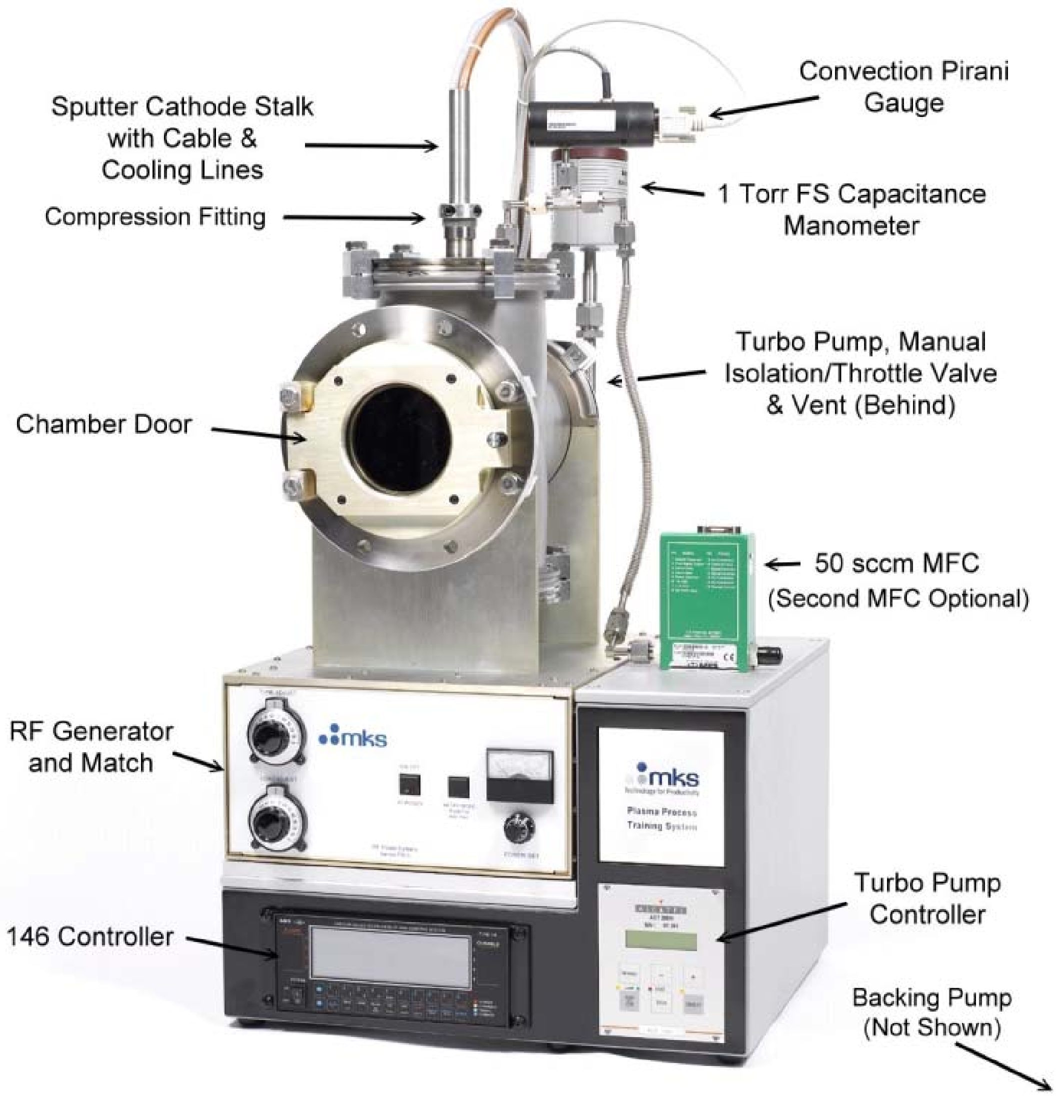
Required Equipment and Tools

1. PPTS-1A Plasma Trainer
2. Equipment Manuals including:
    a. PPTS-1A Manual
    b. PB-3 RF Power Supply manual
    c. Magnetron cathode manual
    d. Vacuum pump manuals (high vacuum turbo pump and mechanical backing pump)
3. Safety glasses
4. Wafer tweezers
5. Substrates (glass or silicon)

Part 1: Equipment Familiarization

The MKS PPTS-1A is a complete plasma deposition (sputtering) system that includes a process chamber, magnetron sputter cathode, upstream PID pressure control system, high vacuum pumping system and 300 watt 13.56 MHz power supply with a manual matching network.

The illustration below is a picture of the PPTS-1A with the major components identified.



1. Describe the function of each of the following components. Be specific as to how each relates to the proper functioning of the PPTS-1A and the deposition process:

    a. RF Generator:

    b. Matching Network:

    c. Magnetron cathode and target:

    d. Mechanical backing pump:

    e. High vacuum turbo pump:

    f. Chamber:

    g. Manual isolation/throttle valve:

    h. Convection Pirani gauge:

    i. 1 Torr full scale capacitance manometer:

    j. Mass Flow Controller (MFC):

    k. 146 Controller:

2. For the following situation, in what position should the manual isolation/throttle valve be in and why? Answers may be expressed in terms like “fully closed,” “barely open,” “fully open,” etc.

    a. When pumping the chamber down and when at base pressure

    b. When running at process pressure during deposition

    c. When venting the chamber

    d. When the system is shut down

3. The system has a base pressure below 10^{-4} Torr. During deposition the pressure is in the range of 10 to 80 milliTorr.

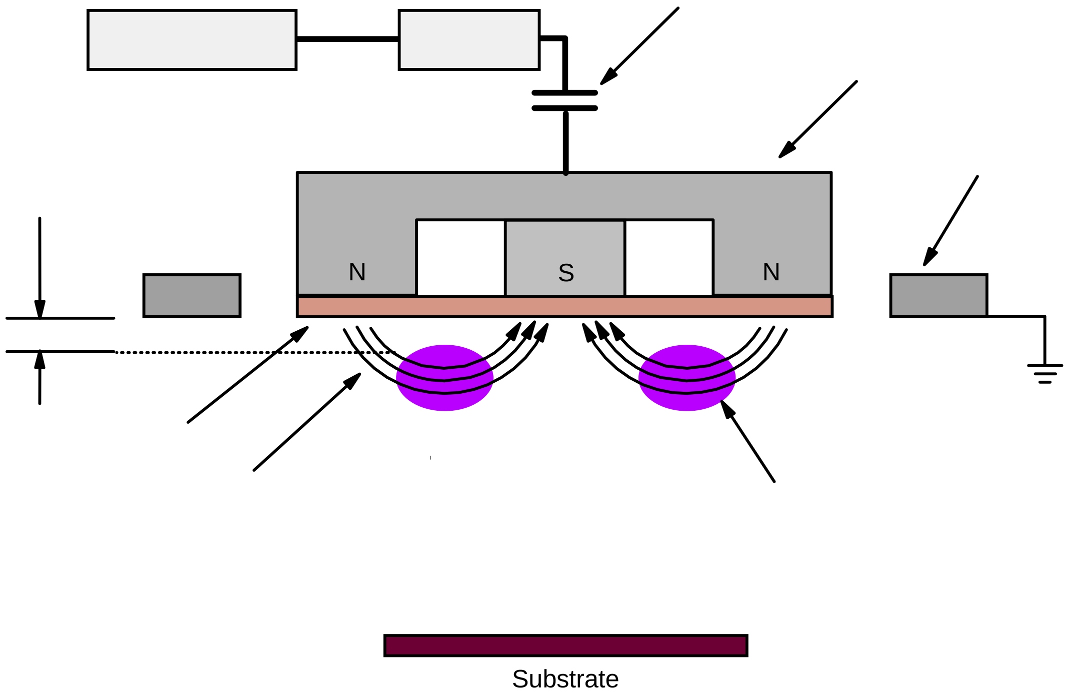
    a. What are the purposes served by the low base pressure?

    b. What factors influence the process pressure? (State in terms of mean free path and other properties of vacuum.)

4. Describe the operation of the upstream pressure control system. Include the functions of the components and factors such as pressure set point and PID tuning parameters.

Part 2: The Sputtering Process

To answer the questions in this section, please refer to the figure below.



1. Identify the following items by labeling the diagram and briefly describe the function of each:

    a. Magnet and pole pieces

    b. Magnetic field lines

    c. Shield

    d. Cathode region

    e. Plasma (glow discharge)

    f. Target

    g. Process gas

h. RF generator

i. Matching network

j. Blocking capacitor

k. 50 ohm line

l. Process gas

2. Describe the motions of the process gas atoms, process gas ions and target atoms

3. The illustration shows a radio frequency power supply.

    a. Would this setup work with a direct current supply?

    b. What would have to change?

    c. What types of targets (materials) could be used with a direct current supply? Could they also be used with an RF supply?

    d. What types of targets (materials) could not be used with a direct current supply? Would they also not work with an RF supply?

4. Does current pass between the cathode and the shield? Why?

5. Does the substrate have to be made of a conductive material? Explain.

6. Why is argon used as a standard sputtering gas?

7. What might be expected if the following gases were used:

    a. Xenon

    b. Helium

    c. Oxygen

    d. Nitrogen

    e. SF_6

8. Reactive sputtering involves mixing a reactive gas with the inert sputtering gas. This can be used to deposit a chemical compound using an elemental target. Describe a process whereby a capacitor could be fabricated in a single process sequence.

Part 3: Setting up the PPTS-1A and Pumping to Base Pressure

For this section, follow the appropriate procedures in the PPTS-1A manual. Apply the following conditions in the set up:

- Single gas sputtering with argon (MFC on Channel 4)
- Pressure set point of 40 milliTorr
- Lead – 1.0, Gain – 40
- RF forward power: 100 watts

1. With the pumps and RF generator off and the chamber at atmospheric pressure, set up the 146 unit for each of the instruments that are connected to it. You may either use the front panel keys or the Windows software.
2. Set up the recipe for the process conditions described above. Make sure that the control mode is upstream ("reverse") and that when you finish the set up the valve mode (control signal to the MFC valve) is "Close."
3. Following the Operation Procedure in the manual, place a substrate in the chamber, start up the system and pump it down.
4. Monitor the convection Pirani gauge. The pressure should decline quickly. When the convection Pirani gauge has reached its lower reading limit (a few milliTorr) or, if the system is equipped with an auxiliary ion gauge, the pressure has reached the low 10^{-4} range, zero the capacitance manometer.
5. Record the base pressure here:

Part 4: Deposition

Following the sequence of steps in the manual, prepare the system to deposit a film on your substrate. Set the conditions as follows:

- Pressure: 30 milliTorr
- Gas: Argon
- Power: 100 Watts
- Time: 5 minutes

Before applying RF power, check your pressure control tuning settings (Lead and Gain) and adjust as necessary to optimize (best set point acquisition time and stability at the setpoint). This will require several cycles to and from the base pressure.

Record your final settings here:

- Manual isolation/throttle valve position (turns from closed):
- Set Point:
- Lead:
- Gain:

Following the procedure in the manual, start up the RF generator and apply power. Check to be sure that cooling water is flowing to the cathode. After initially optimizing the match settings at low power, ramp the power quickly to 100 watts and make any final adjustments to the tuning. Deposit at 100 watts for 5 minutes. Record your settings here:

- Forward power:
- Reflected power:
- Tune Adjust setting
- Load Adjust setting

Bring the system back to atmospheric pressure, remove your substrate and note your qualitative assessment of the film here: