PHTN1432 Final Exam Material

1. ***Procedures to utilize vacuum systems***

Operating procedures such as "Which valve to turn when"

- Roughing, foreline, hi-vac valves
  - e.g. "describe the procedure to pump a cryopumped deposition system, currently at atmosphere, to high vacuum"

Key pressures (e.g. crossover)

- e.g. "Given a system consisting of a diffusion pump with a maximum tolerable foreline pressure of 100mTorr and a speed of 1000 l/s at $1*10^{-3}$ torr, and a forepump of 12 l/s, calculate the crossover pressure for the system"
  (Answer: 0.0012 torr, see test #1)

Diffusion, Turbo, and Cryo systems

- Roughing procedures for all three (valves, when)
- When to open Hi-Vac for all three (valves, when)
- "Roughing through" procedures for diff & turbo systems
  - e.g. "A diffusion pump system has a chamber pressure of 50 mTorr and is to be brought to high vacuum by completing roughing through the diffusion pump itself. Describe the procedure"
    (Answer: review your lab #5 procedure)

Start-up, Pump-down, Vent, shutdown cycles

- How to start a diff or cryo pump (rough pump body 1st, etc)
  - e.g. "Describe the procedure to start a cryo pump, the body of which is currently sitting at atmosphere"
    (Answer: see the text on cryopump-based systems)
- When to fill a cryotrap on a diff pump system

2. ***Deposition procedures***

Thermal, sputtering, and eBeam

- Procedures (details, ramp/soak, power control, shutter usage)
  - e.g. "describe the procedure, including key values, to bring a filament up to deposition temperature"
    (Answer: review lab #5 procedures)
  - e.g. "describe the procedure, including key parameters such as times and powers, to bring a sputtering target up to a full power of 300W and start a deposition"
- Filament ramp (why), shutter usage
- Ramp and soak on a sputtering target
- Rates of materials (from the lab, and why)

Deposition monitor usage

- Programming, parameters
  - e.g. "Aluminum (with parameters in the appendix) is to be deposited. Describe the parameters to be programmed into the deposition monitor"
- Usage procedures (zero, rate control, thickness)

Analysis using spectrum

- Full- and Half- wave peaks (interferometer basics)
  - e.g. "The transmission spectrum of an MDM filter using MgF_2 (n=1.38) shows a transmission peak at 500nm as well as another at 333nm. Assuming the phase shift is zero at the metal-dielectric interface, what is the thickness of the dielectric layer?"
    (Answer 3623 A)
  - e.g. "If the 500nm peak was observed but the 333nm was NOT, what is the likely thickness of the layer?"

(Answer 1812A – this is a half-wave peak)
e.g. "In the above design what is the wavelength of the next observed peak ?"
(Answer 250nm – this is a full-wavelength peak)

Tooling Factor and correction

e.g. "The monitor shows a deposit of 3700A was made with a 100% tooling factor but the main transmission peak for an MDM filter using MgF_2 was seen at 650nm. Assuming the phase shift is zero at the metal-dielectric interface, what is the tooling factor?"
(Answer: Actual layer is 4710 Actual so Tf=127%)

3. ***Pumps and Systems***

Diff Pump
- Principles of operation
- System configuration (valves and traps)
  - e.g. "Describe the function of each valve in the system"
- Calculating proper crossover pressure (using P, S)
- Fluids

Cryo Pump
- Surfaces and gases trapped at each
  - e.g. "Describe the gases trapped at each of the three stages in a cryopump and name the process employed with each stage"
  - (Answer: Review class notes from the lecture on Cryopumps)

Turbo Pump

4. ***Thermal Deposition***

Filament usage (ramp, degas)
- e.g. "What is emitted from a filament kept at atmosphere which is first heated ?"

eBeam principles (scanning, gun configuration)
- e.g."Why must the electron beam be scanned on an eBeam system ?"

5. ***Sputtering***

Basic and reactive sputtering
- Gases, pressures

Stoichiometry
- Expected film chemistry
  - e.g. "What is the expected ratio of Zn-to-O when zinc oxide is sputtered in both pure argon (non-reactive), and oxygen (reactive)
  - (Answer: Review notes on reactive sputtering)
  - e.g. "What is the expected film stoichiometry from an aluminum sputtering target both in argon and oxygen"
  - (Answer: Al_2O_3, See the notes on reactive sputtering and your assignment)

Target usage (power sources DC/RF, ramp, soak)

Mass flow control basics

6. ***Optical structures***

Basic design for A/R, MDM, Quarter, V, Mirror
- e.g. "Calculate the reflectivity of a single A/R coating using MgF_2 on glass"
- (Answer 1.4%)

Calculating reflectivity for a basic device with up to four layers
- Use of Fresnel equations, small r, phase (add/subtract ?)

e.g. "Calculate the reflectivity for a ¼-¼ coating using Air|SiO(n=1.7)|ZnO(n=2.1)|Glass (n=1.5)"
(Answer: 0.016%)
e.g. "A Quarter-Quarter coating is designed with Glass(n=1.52)|ZnO(n=2.1)|SiO(n=1.6)|Air. (a) Draw a diagram of the coating showing all reflections, (b) Calculate the reflection coefficients (not the magnitudes) of each reflection, (c) Determine the phase of each reflection (same or 180-degrees), and (d) Calculate the overall reflectivity of the coating"
(Answer: 0.231, 0.135, 0.160, 0.4% overall reflection)
e.g. "Fabricate the above design in reverse, with SiO against the glass, and calculate the reflectivity"
(Answer: 0.355, 0.135, 0.0256, 21.6% overall reflection)

FilmStar models