ECE6450 Homework #6 Solution

1.) A 1000 liter/sec turbo pump is used to pump a process chamber. It is connected to a large vacuum chamber (infinite conductance) through a tube that is 2 feet long and has an inner diameter of 4 inches. What is it's effective pumping speed in liters/sec.

A turbopump is a high or ultrahigh vacuum pump. Thus the worst case vacuum is 10^{-4} torr. Thus, the mean free path between collisions is,

$$\lambda = \frac{kT}{\sqrt{2}\pi d^2 P} = \frac{(1.381e-23\ JK^{-1})300K}{\sqrt{2}\pi(3e-10)^2(1e-4\ Torr\ x\ 133\ Pa/Torr)} = 0.78\ meters = 78\ cm$$

Thus, the Knudsen number is 78/(2.54 cm per inch x 4 inchs)=1.28 which is greater than 1 indicating molecular flow. Thus,

$$\frac{1}{S_{effective}} = \frac{1}{1000\ liters/Sec} + \frac{1}{11.6\frac{(4"x2.54)^3}{(24"x2.54)}} = \frac{1}{1000\ liters/Sec} + \frac{1}{200\ liters/Sec} = 166\ liters/\text{sec}$$

2.) A process gas is to introduced into the chamber from problem 1 and the chamber must be maintained at 1e-4 torr. A.) What is the maximum flow rate (in sccm) of gas the pumping system can handle? B.) Repeat the problem for the pump connected directly to the chamber.

Use Q=SP: Q= (166 liters/S)(1e-4 Torr) = 0.0166 Torr Liters/Sec or 1.31 sccm (see your conversion chart)

If the pump were connected directly to the chamber, Q=(1000 liters/second)(1e-4 torr)=>7.9 sccm.

Homework #6:

3.) A wet chemical etch is desired that will etch a via hole through a silicon wafer for integration into a low inductance, high frequency circuit. If a 482 um/min etch rate is desired, what is the volume ratios of hydrofluoric, nitric and acetic acids required?

Many possible solutions exist. From the etching triangle, one solution is; ~65% HF, ~25% Nitric, and ~10% Acetic. Two lines are freely drawn parallel to the counterclockwise adjacent triangle side. The third line is constrained to the vertex of the previous 2 lines.

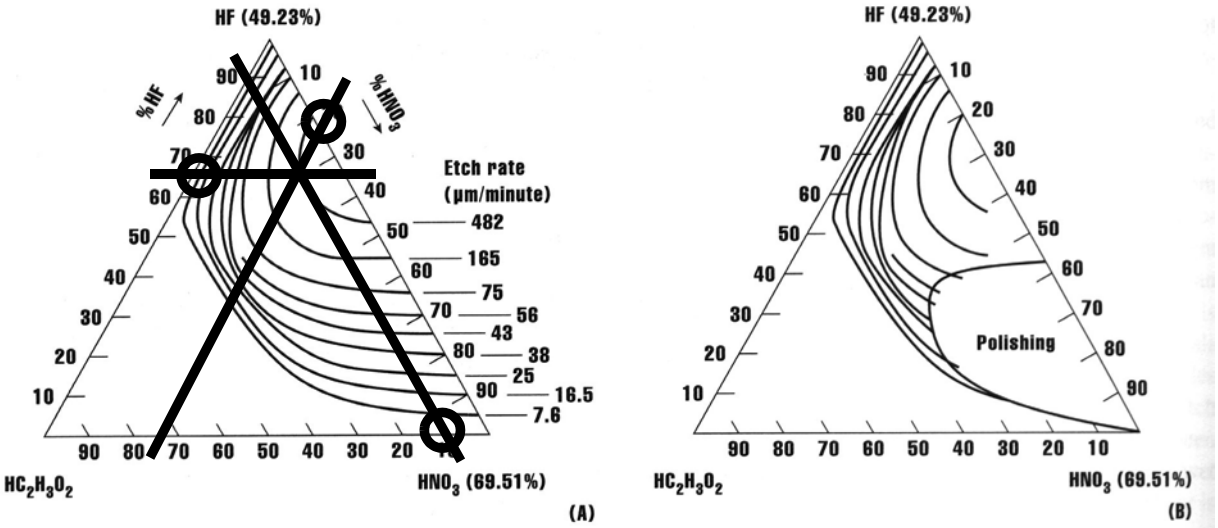

Figure 11-5 The etch rate of silicon in HF and HNO_3 *(after Schwarz and Robbins, reprinted by permission of the publisher, The Electrochemical Society Inc.).*