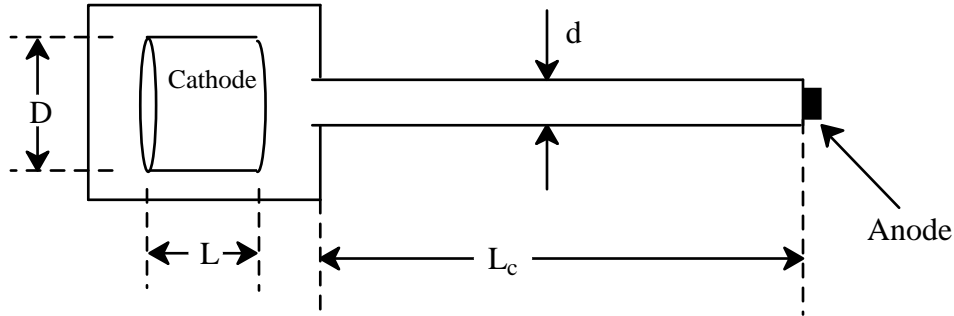


## EECS 517 / NERS 578 FALL 2010 HOMEWORK #7

In this assignment, we will design a positive column glow discharge as might be used in a display sign. We have a discharge tube with dimensions as shown:



The cathode is a hollow cylindrical shell of length  $L$  and diameter  $D$ . (Note: Consider the cathode as simply a cylindrical shell that is otherwise equivalent to a planar cathode. We are not talking about a current amplifying *hollow-cathode discharge*.) All of the useful light from the lamp comes from a long narrow tube housing the positive column. The tube emitting light has diameter  $d$  and length  $L_c$ . Using the ideal molecule cross sections with a Maxwellian electron energy distribution, find the a) power of the light that is emitted (Watts) and b) total voltage drop (cathode-to-anode) as a function of gas pressure (1-100 Torr). Please plot and comment on the results. Use the following assumptions.

- Discharge is a normal glow.
- Plasma covers only the inner surface of the cathode.
- The inelastic processes for the ideal molecule are excitation and ionization.
- Every excitation process results in emission of a photon with wavelength  $5000 \text{ \AA}$ .
- The discharge consists only of the cathode dark space and positive column of length  $L_c$ . You can ignore any voltage drop across the negative glow.
- Electron loss in the positive column is dominated by ambipolar diffusion.
- $L_c = 1.5$  meters,  $D = 3$  cm,  $d = 1$  cm,  $L = 10$  cm
- $T_{\text{gas}} = 400^\circ \text{K}$
- $\gamma$  (secondary electron emission coefficient by ion bombardment) = 0.15
- $M_{\text{gas}} = 28$  AMU
- Ion mobility  $\mu_I = \frac{1 \text{ cm}^2}{\text{V-s}}$  at 1 atm (760 Torr)
- $\alpha$  (First Townsend Coefficient in cathode fall) =  $A p \exp(-Bp/E) \text{ cm}^{-1}$   
 $A = \frac{10}{\text{cm-Torr}}$ ,  $B = 200 \frac{\text{V}}{\text{cm-Torr}}$ ,  $p = \text{gas pressure (Torr)}$ ,  $E = \text{Electric Field (V/cm)}$
- Light comes only from the positive column.