Exercises DC and RF discharges

Exercise 1: Paschen curve and guarding ring

In a DC or RF discharge we want the plasma to be contained between the electrodes. To prevent the discharge to strike between the side of the powered electrode and the cylinder wall of the reactor, a so-called guarding ring is placed around the powered electrode. This ring is grounded. The geometry is sketched below. The question to be answered now is at what distance this ring should be placed.

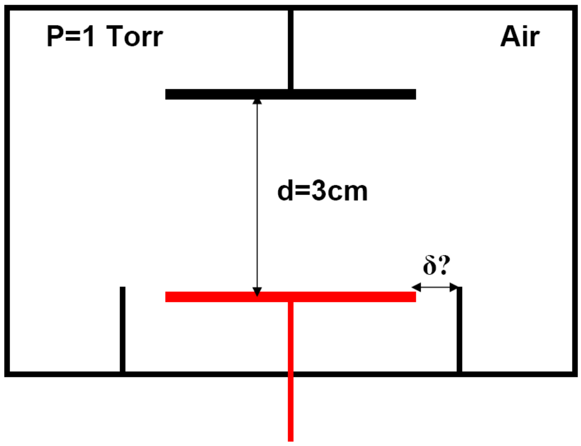

Figure Ex1.1: Discharge geometry with grounded top electrode, grounded cylinder wall, and grounded guarding ring. The bottom electrode is powered.

Suppose the electrode distance is 3 cm, the pressure is 1 Torr, and the gas is air, so assume that the the Paschen curve given in figure 1.2 of the lecture notes applies. For convenience it is reproduced below.

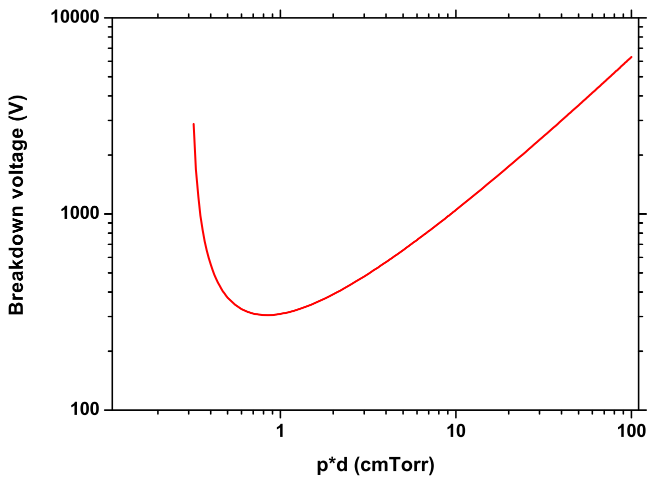

Figure Ex1.2 Paschen curve for breakdown in air. The secondary electron emission coefficient is set to 10^{-2}.

(a) What is (approximately) the voltage needed to create a plasma in between the electrodes?

(b) At what other product of $p \times d$ would this be the right voltage for the generation of a discharge?

(c) How must we choose the distance δ between the powered electrode and the guarding ring to make sure that the conditions for discharge generation are never met.

Exercise 2: DC discharge with unequal electrodes

In the lecture notes the potential distribution in a DC discharge is discussed for electrodes with equal areas. We actually looked at the current densities, and thus took 1 m^2 for the size of the electrodes. In the discussion of the RF reactor the electrodes were not assumed to be equal in size, mainly because the grounded cylinder wall also acts as grounded electrode. Of course this will also hold for a DC discharge in the same geometry. In this exercise we will look at the influence of the size of both electrodes. The grounded electrode has area A_{grnd}, the powered electrode A_{pow}, and the ratio $A_{pow}/A_{grnd}=\alpha$. As in the lecture notes, the powered electrode is at a large negative potential, and he electron current contribution to that electrode can be neglected.

(a) What is the current to the powered electrode and to the grounded electrode, expressed in the electron density, electron temperature, area, and plasma potential?

(b) The currents must be equal and opposite. This condition gives an expression for the plasma potential.

(c) Check that α=1 gives the expression from the lecture notes.

(d) What happens when α goes to zero?