Paschen's Law Plasma Demonstration Chamber

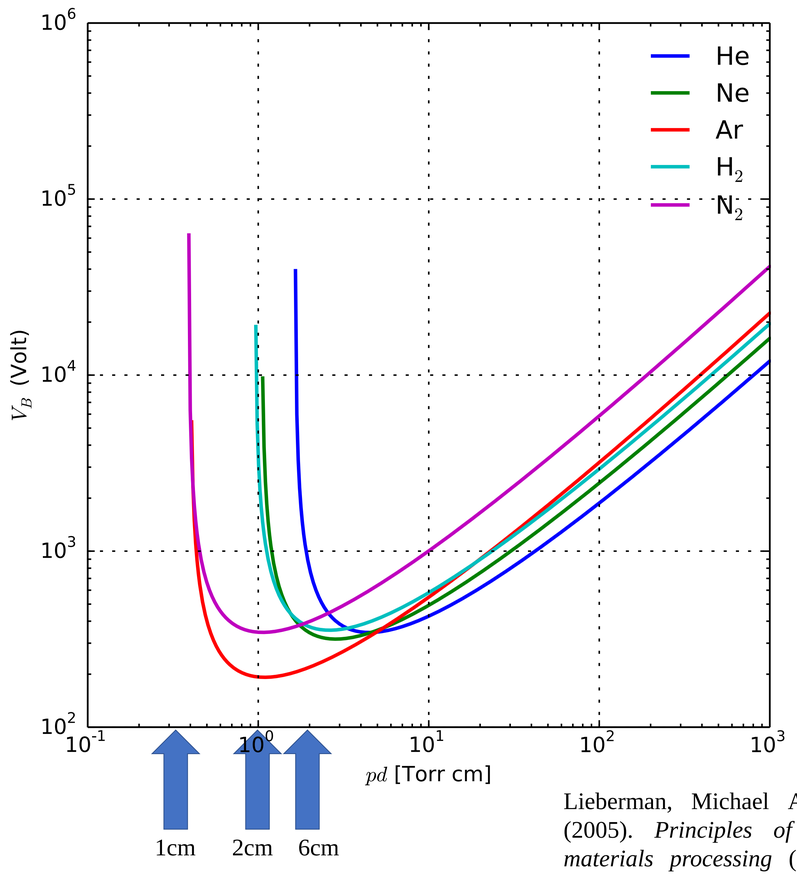
Vizma A. Leimanis, Dr. James G. McLean
SUNY Geneseo

Abstract

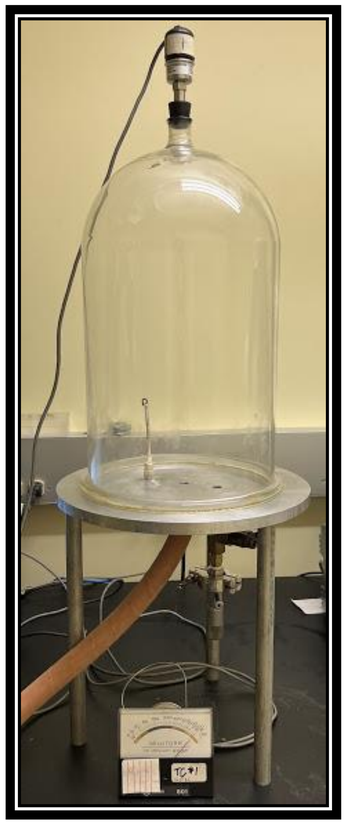
I am building a plasma chamber apparatus to demonstrate Paschen's Law by showing plasma arcs between electrodes in a vacuum chamber. A minimum breakdown voltage is needed to spark a plasma between two electrodes in a gas. Paschen's Law relates this breakdown voltage to the pressure p of the gas and the length d of the gap between the electrodes. There exists an optimal product p×d which minimizes the breakdown voltage, which is roughly (7.5 cm)×(10–4 atm) in air. Three pairs of electrodes with different gap lengths will be shaped like a ladder. They will be connected in parallel so that the same voltage is applied across all of them. The gap lengths were chosen to contrast the optimal conditions, with two of the gaps corresponding to larger breakdown voltages. The vacuum chamber consists of a bell jar and raised base-plate to contain the electrodes. This chamber is connected to a vacuum pump, pressure gauge and regulator, and electrical contacts to the ground and high voltage. This plasma chamber will be usable for educational purposes and is portable.

Paschen's Law

The graph below shows the Paschen curves for several gases. The vertical axis shows the voltage necessary to spark a plasma, which is called the breakdown voltage. The curves always have a minimum breakdown voltage value at a certain multiplication of pressure and gap distance (shown on the horizontal axis), and the reason for this depends on the properties of the gas in different situations. On the left side of the minimum, higher voltages are required to spark a plasma. This is because at very low pressures electrons are less likely to bump into (and then ionize) any gas particles, and at very low distances electrons only can travel a short distance and can't bump into very many particles on the way. On the right side of the minimum, higher voltages are required because at higher pressures electrons can't gain enough energy to ionize a particle before bumping into it, and at larger distances electrons can't accelerate enough to ionize the particles they encounter.



Lieberman, Michael A.; Lichtenberg, Allan J. (2005). *Principles of plasma discharges and materials processing* (2nd ed.). Hoboken, N.J.: Wiley-Interscience. 546. ISBN 978-0471005773.



Thermocouple pressure gauge

Glass bell jar

Base plate

Vacuum pump

High voltage power supply

Future Purpose

This apparatus will be used as an educational tool by the local chapter of the AVS (Science and Technology Society) at the Rochester Museum and Science Center and other regional demonstration fairs. Audiences will include children from kindergarten through high school.