

电子-中性氩(氩原子)碰撞截面  $\sigma$ :

$$\sigma = \pi r_0^2 = \frac{e^4}{16\pi \epsilon_0^2 m^2 v^4}, \quad e \approx 1.602 \times 10^{-19} \text{ C}, \quad \epsilon_0 \approx 8.854 \times 10^{-12} \text{ F/m}, \quad m \approx 9.11 \times 10^{-31} \text{ kg},$$

$$v = \sqrt{\frac{2T}{m}} = \sqrt{\frac{2 \times 2 \text{ eV}}{9.11 \times 10^{-31} \text{ kg}}} \approx 8.387 \times 10^5 \text{ m/s}$$

$$\approx 4.07 \times 10^{-19} \text{ m}^2$$

中性氩原子的平均距离  $L_{Ar}$ :

$$n_{Ar} = \frac{P}{kT} = \frac{30 \text{ Pa}}{1.38 \times 10^{-23} \text{ J/K} \cdot 500 \text{ K}} \approx 4.348 \times 10^{21} / \text{m}^3$$

$$L_{Ar} = \left( \frac{1}{n_{Ar}} \right)^{1/3} \approx 6.127 \times 10^{-8} \text{ m}$$

电子运动平均自由程  $\lambda_e$ :

$$\lambda_e = \frac{1}{n \cdot \sigma} = \frac{1}{4.348 \times 10^{21} / \text{m}^3 \cdot 4.07 \times 10^{-19} \text{ m}^2} \approx 5.65 \times 10^{-4} \text{ m}.$$

$Ar^+$  运动平均自由程  $\lambda_{Ar^+}$ :

$$\lambda_{Ar^+} = \frac{1}{n \cdot b}, \quad b = \pi d^2 = \pi \cdot (0.364 \text{ nm})^2 \approx 4.162 \times 10^{-7} \text{ m}^2.$$

$$\approx 5.525 \times 10^{-16} \text{ m}.$$

电子德布罗意波长  $\lambda_d$ :

$$\lambda_d = \frac{h}{p}, \quad p = \sqrt{2mE} \approx 7.04 \times 10^{-25} \text{ kg} \cdot \text{m/s}$$

$$\approx 8.67 \times 10^{-10} \text{ m}.$$

腔管厚度  $a$ :

$$a \sim 0.2 \text{ m}$$

德布罗意波长  $\lambda_D$ :

$$\lambda_D = \sqrt{\frac{\epsilon_0 k_B T_e}{n e^2}}, \quad T_e = \frac{2 \text{ eV}}{k_B}$$

$$\approx 3.325 \times 10^{-5} \text{ m}.$$

鞘层厚度  $b$ :

$$b = \frac{k_B T_e}{e E} = \frac{2 \text{ V}}{E}$$

$$\lambda_{Ar^+} < \lambda_d < L_{Ar} < \lambda_D < \lambda_e < a$$