One Dimensional DC Mercury-Argon Fluorescent Lamp model

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Introduction
Mercury-Argon discharge: high efficiency UV radiation
- used widely as commercial fluorescent lamp
- We need plasma properties to improve lamps
- Data is not enough both in experimental and theoretical way
- We develop a 1 dimensional model and calculate radial distribution of Hg excited atoms to investigate plasma properties in DC Hg-Ar fluorescent lamp

Model

• DC model
  • We consider excitation and ionization for Ar. These processes are not considered in past models.

• Collisional-radiative model
  • Assumption
    1. Lamp is cylindrical in enclosure.
    2. The positive column is axially uniform.
    3. The positive column is radially symmetric.
    4. Electron energy distribution function is Maxwellian.
    5. The number of considered excited levels are 6 for Hg and 2 for Ar

• Basic equation

  Continuous equation
  \[ \frac{\partial N_e}{\partial t} + \frac{\partial (N_e v)}{\partial r} = \frac{\partial}{\partial r} \left( D_e \frac{\partial N_e}{\partial r} \right) + \frac{\partial}{\partial r} \left( \nu_e \frac{\partial N_e}{\partial r} \right) + S_e \]

  Ion current density \( J_i = \mu_i E N_i \)

  Excited atom density \( N_i = \frac{N_e}{k_B T_e} \)

  Energy conservation equation
  \[ \frac{\partial \varepsilon}{\partial t} = \frac{1}{2} \left( k_B T_e \frac{\partial N_e}{\partial r} \right) + \frac{3}{2} \frac{\partial}{\partial r} \left( \nu_e \frac{\partial N_e}{\partial r} \right) + S_i \]

  \( k_B \): Boltzmann constant
  \( D_e \): ambipolar diffusion coefficient
  \( \nu_e \): electron mobility
  \( k_B \): thermal conductivity
  \( E \): ambipolar electric field
  \( S_i \): generation-loss term of \( i \)

Comparison of simulation results and references

Lamp diameter: 14 mm
Ar pressure: 3 Torr
Lamp current: 0.27 A
Wall temperature: 323 K

Conclusion
- Developed the model which has a good agreement with experiment and show difference of excited atom distributions and of meta-stable and resonance level atom distribution dependence on wall temperature.