$$\frac{\partial n_i}{\partial t} + \nabla \cdot \boldsymbol{\Gamma}_i = (S - L)_i$$

$$\frac{\partial n_e}{\partial t} + \nabla \cdot \boldsymbol{\Gamma}_e = (S - L)_e$$

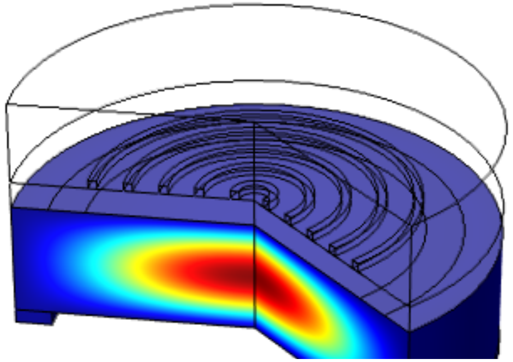
$$\frac{\partial \boldsymbol{\Gamma}_i}{\partial t} + \nabla \cdot (\boldsymbol{v}_i \boldsymbol{\Gamma}_i) = -\frac{Z_i e n_i}{M_i} \nabla V - \frac{1}{M_i} \nabla (n_i T_i) - \nu_{iN} \boldsymbol{\Gamma}_i$$

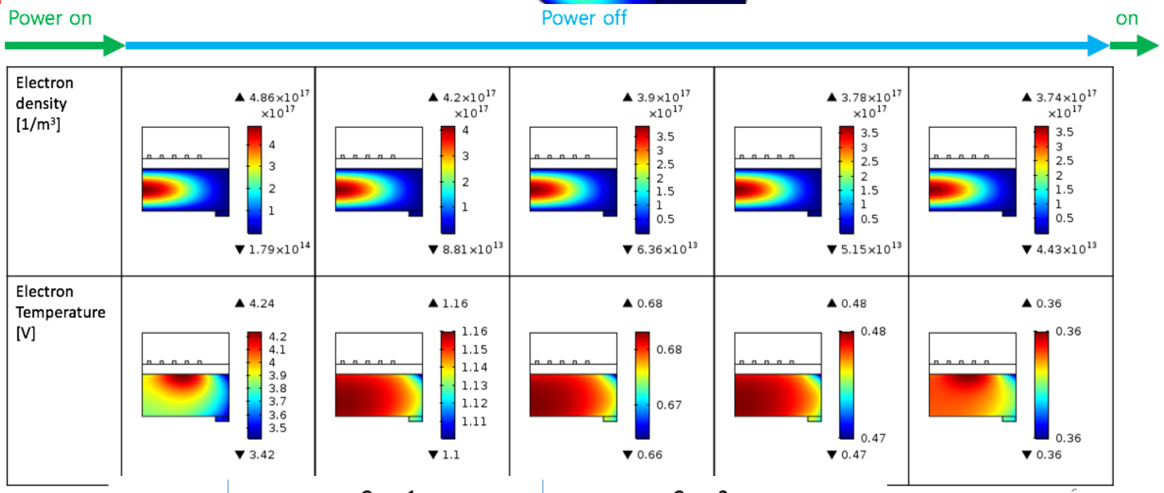
$$\frac{\partial \boldsymbol{\Gamma}_e}{\partial t} + \nabla \cdot (\boldsymbol{v}_e \boldsymbol{\Gamma}_e) = \frac{e n_e}{m_e} \nabla V - \frac{1}{m_e} \nabla (n_e T_e) - \nu_{eN} \boldsymbol{\Gamma}_e$$

$$\frac{\partial}{\partial t}\left(\frac{3}{2} p_e\right) + \nabla \cdot \left(\frac{5}{2} \boldsymbol{\Gamma}_e T_e - \frac{5}{2} \frac{e n_e T_e}{m_e \nu_{eN}} \nabla T_e\right) - e \nabla V \cdot \boldsymbol{\Gamma}_e + P_{e,loss} = P_{abs}$$

$$\nabla^2 V = -\frac{e}{\varepsilon_0} (Z_i n_i - n_e)$$

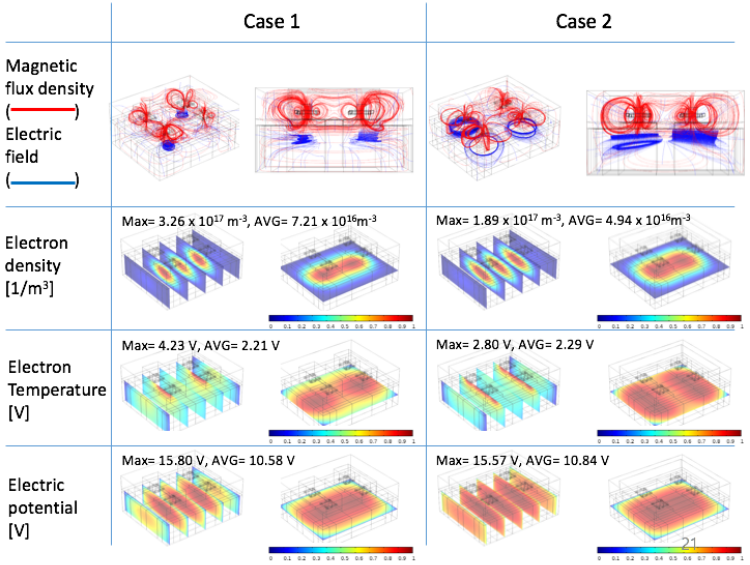
Equation name	Equations, boundary conditions and notations
Laminar Flow	$\rho (\vec{u} \cdot \nabla)\vec{u} = \nabla \cdot [-p\vec{I} + \mu(\nabla\vec{u} + (\nabla\vec{u})^T - (^2/_3)\mu(\nabla \cdot \vec{u})\vec{I}]$ $\nabla \cdot (\rho\vec{u}) = 0$
	Boundary conditions: $Inlet: -\int_{\partial\Omega} \frac{\rho}{\rho_{st}} (\vec{u} \cdot \vec{n}) d_{bc} dS = Q_{sccm}, \quad \rho_{st} = \frac{M_n}{V_m}, \quad Q_{sccm} = 100\ [scccm]$ $Outlet: [-p\vec{I} + \mu(\nabla\vec{u} + (\nabla\vec{u})^T - (^2/_3)\mu(\nabla \cdot \vec{u})\vec{I}]\vec{n} = -\widehat{p_0}\vec{n}, \quad \widehat{p_0} \le p_0, \quad p_0 = 10\ [mTorr]$ $Wall: \vec{u} = 0$
	Notations: ρ: *the gas density* $[kg/m^3]$ $\vec{u}$: *the gas flow velocity* $[m/s]$ p: *pressure* $[Pa]$ μ: *the dynamic viscosity* $[Pa \cdot s]$ $\vec{n}$: *the normal unit vector* M_n: *Mean molar mass* $[kg/mol]$ V_m: *standard molar volume* $[m^3/mol]$





Equation name	Equation, boundary conditions and notations
Heat transfer	$\rho C_P \vec{u} \cdot \nabla T + \nabla \cdot \vec{q} = Q$
	Boundary conditions: $Inlet: T = 300\ [K]$ $Outlet: -\vec{n} \cdot \vec{q} = 0$ $Wall: -\vec{n} \cdot \vec{q} = -k \frac{16}{15\pi\lambda} \sqrt{\frac{T_{wall}}{T}} (T - T_{wall})$
	Notations: ρ: *the gas density* $[kg/m^3]$ C_P: *the heat capacity* $[J/(kg \cdot K)]$ $\vec{u}$: *the gas flow velocity* $[m/s]$ $\vec{q} = -\nabla T$: *the conductive heat flux* $[W/m^2]$ Q: *the heat source for gas* $[W/m^3]$ $\vec{n}$: *the normal unit vector* k: *the thermal conducitivity* $[W/(m \cdot K)]$ λ: *the mean free path* $[m]$ T_{wall}: *the wall temperature* $[K]$

Equation name	Equations and notations
Boltzmann Equation, Two-Term Approximation	$\frac{\partial}{\partial \varepsilon}\left(Wf - D\frac{\partial f}{\partial \varepsilon}\right) = S$ $W = -\gamma\varepsilon^2\sigma_\varepsilon - 3a\left(\frac{n_e}{N_n}\right)A_1, \quad D = \frac{\gamma}{3}\left(\frac{E}{N_n}\right)^2\left(\frac{\varepsilon}{\sigma_m}\right) + \frac{\gamma k_b T}{q}\varepsilon^2\sigma_\varepsilon + 2a\left(\frac{n_e}{N_n}\right)(A_2 + \varepsilon^{3/2}A_3)$ $a = \frac{q^2\gamma}{24\pi\varepsilon_0{}^2} ln\left(\frac{12\pi(2\varepsilon_0 q\bar{\varepsilon}/3)^{3/2}}{q^3 n_e^{1/2}}\right)\varepsilon^2\sigma_\varepsilon + 2a\left(\frac{n_e}{N_n}\right)(A_2 + \varepsilon^{3/2}A_3), \quad \gamma = (2q/m_e)^{1/2}\ [C^{1/2}/kg^{1/2}]$ $A_1 = \int_0^\varepsilon u^{1/2} f(u)du, \quad A_2 = \int_0^\varepsilon u^{3/2} f(u)du, \quad A_3 = \int_\varepsilon^\infty f(u)du$
	Notations: S: *The source term, energy loss due to inelastic collisions* $\gamma = (2q/m_e)^{1/2}\ [C^{1/2}/kg^{1/2}]$ ε: *energy* $[V]$ σ_ε: *the total elastic collision cross section* $[m^2]$ σ_m: *the total collision cross section* $[m^2]$ q: *the electron charge* $[C]$ T: *the temperature of the background gas* $[K]$ k_b: *the boltzmann constant* $[J/K]$ n_e: *the electron density* $[1/m^3]$ N_n: *the background gas density* $[1/m^3]$



Research Topic

-. 반도체 디스플레이 공정에 사용되는 plasma simulation

-. 연관된 modeling & integration

졸업생 진로

-. 반도체 또는 디스플레이 관련 회사/연구소

Plasma Lab.