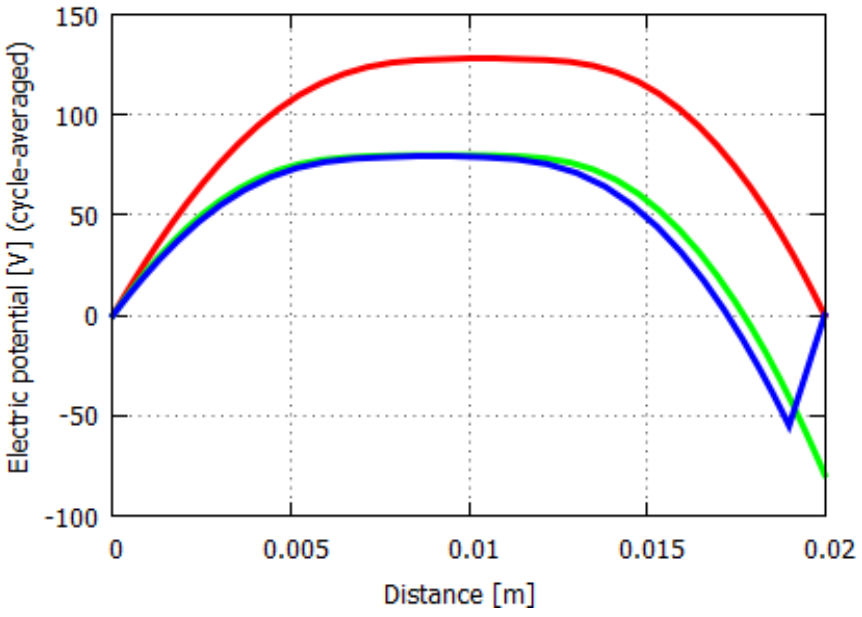
— TECHNICAL COLUMN —

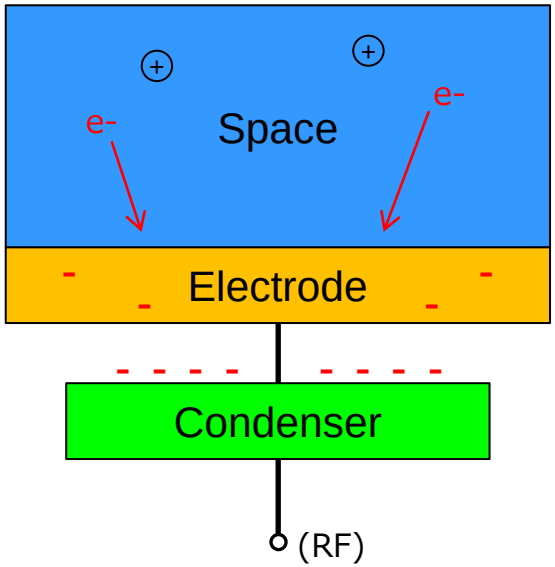
Self-Bias Effect

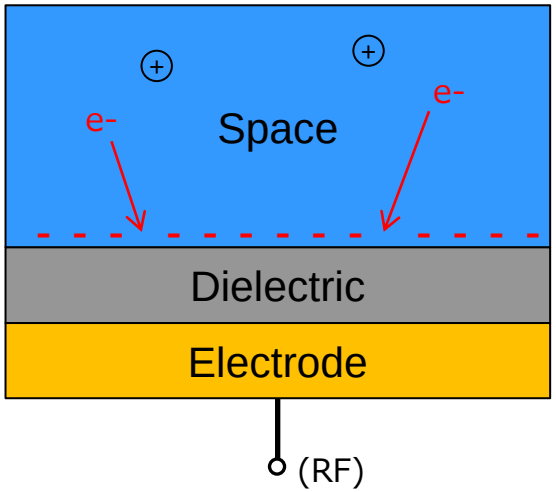


Abstract

In general CCP chamber, a blocking condenser is connected to an RF electrode. Because the electron mobility is very large than ion in space, the negative charge accumulated to the condenser forms negative potential. It is called as "self-bias effect". Self-bias forms on a surface of dielectric, because electric charge is accumulated there as well as condenser.

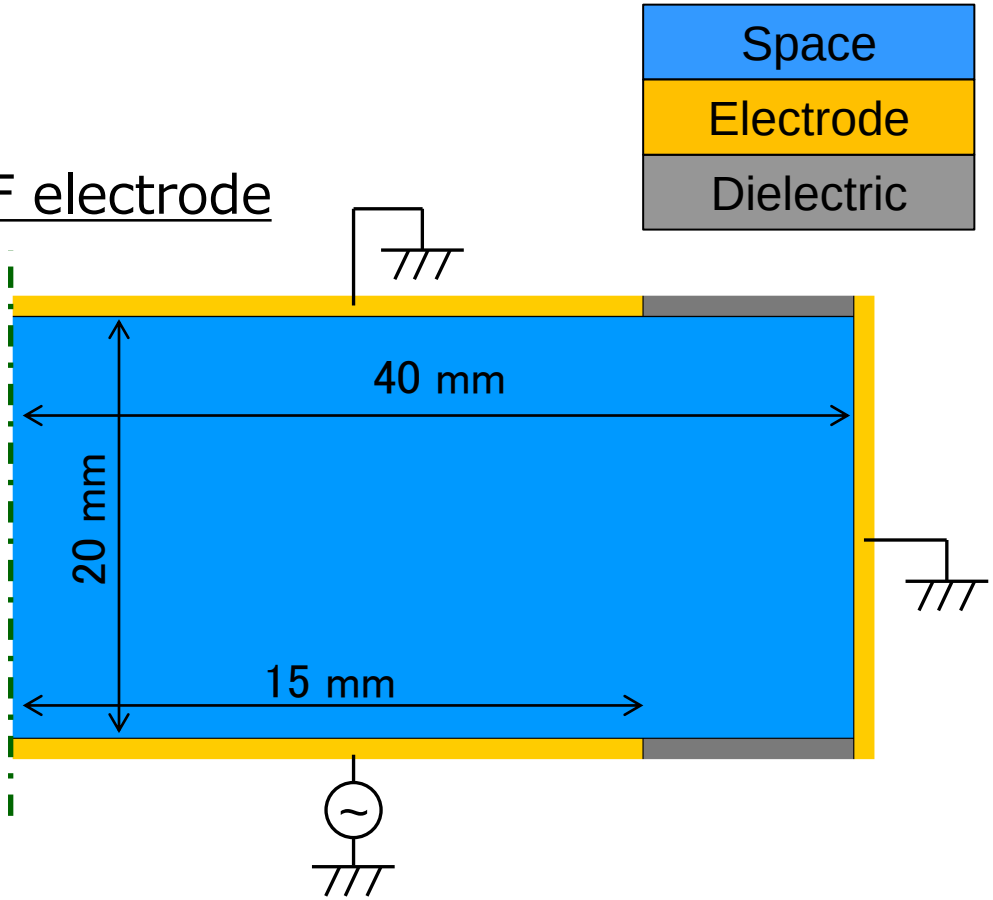
We tested it in Particle-PLUS simulation using simple CCP model and a little change.





Simulation Model (A)

- ✓ 2D-axisymmetric model
- ✓ Ar 30 mTorr
- ✓ RF電圧 500 V（13.56 MHz）
- ✓ No condensers
- ✓ No dielectric layers on RF electrode

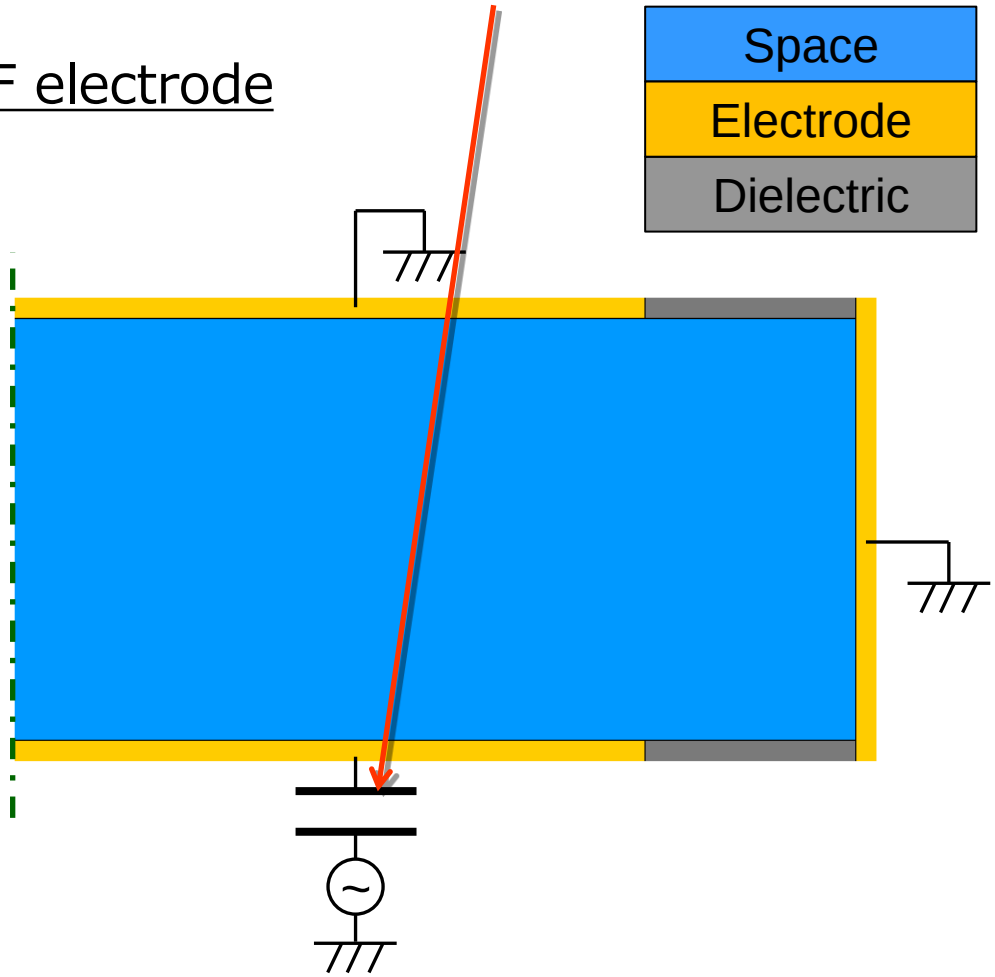


[Simple RF Heater]

Simulation Model (B)

- ✓ A blocking condenser (100 pF) connected with a RF electrode
- ✓ No dielectric layers on RF electrode

The other conditions are the same as model (A).

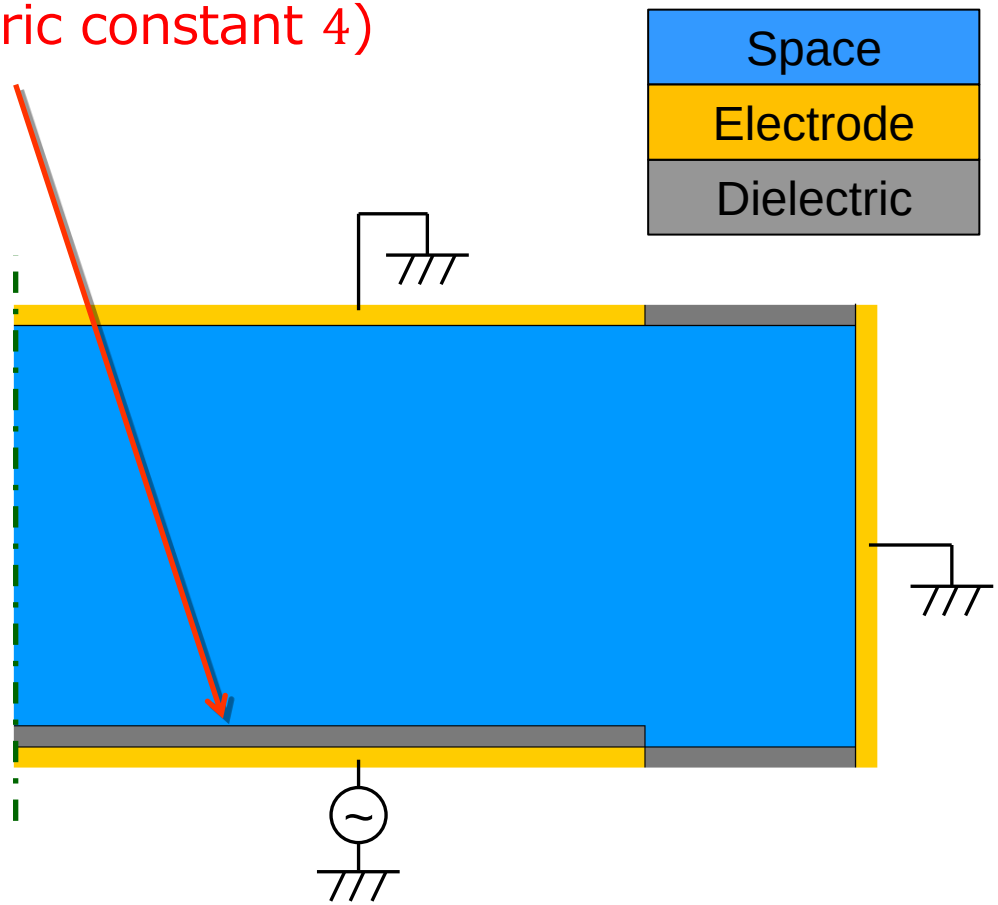


[Typical CCP Chamber]

Simulation Model (C)

- ✓ No condensers
- ✓ A dielectric layer (dielectric constant 4) on RF electrode

The other conditions are the same as model (A).

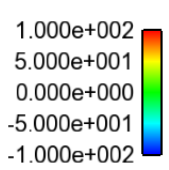


[RF Heater with Dielectric]

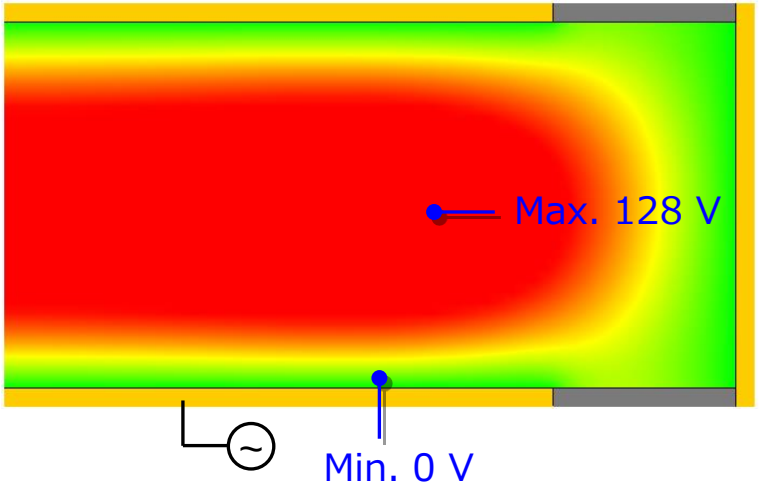
Results: Electric Potential

* Cycle averaged

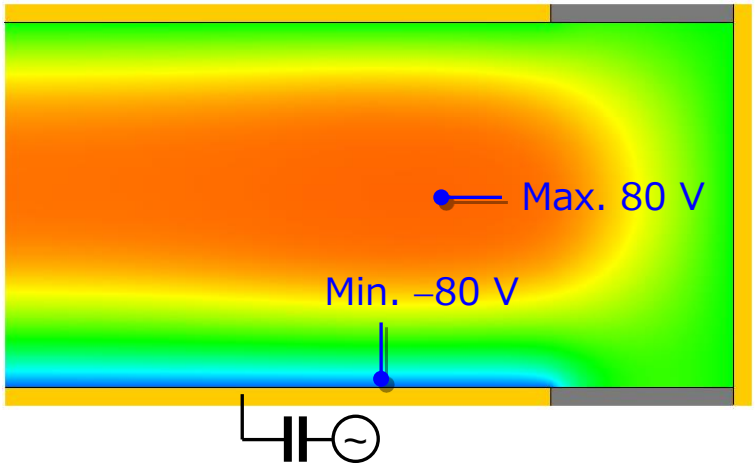
In model (C), the Cycle-averaged potential is negative on surface of a dielectric layer. It is the same qualitative result as an electrode connected with a condenser in model (B), that means self-bias effect.



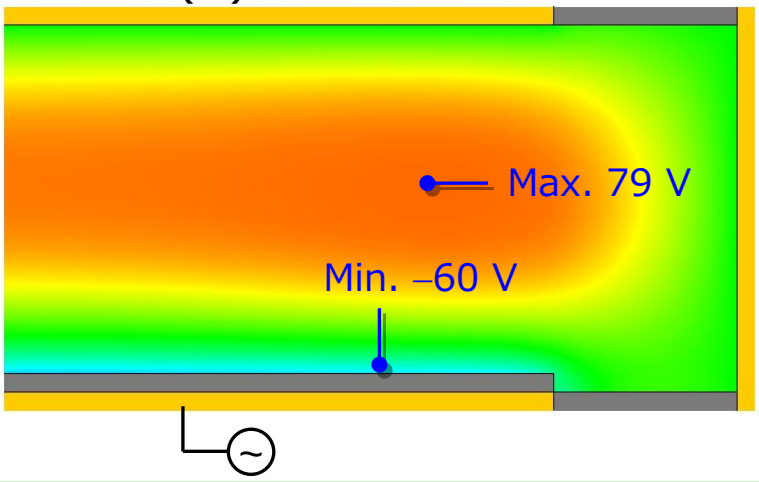
Model (A)



Model (B)



Model (C)

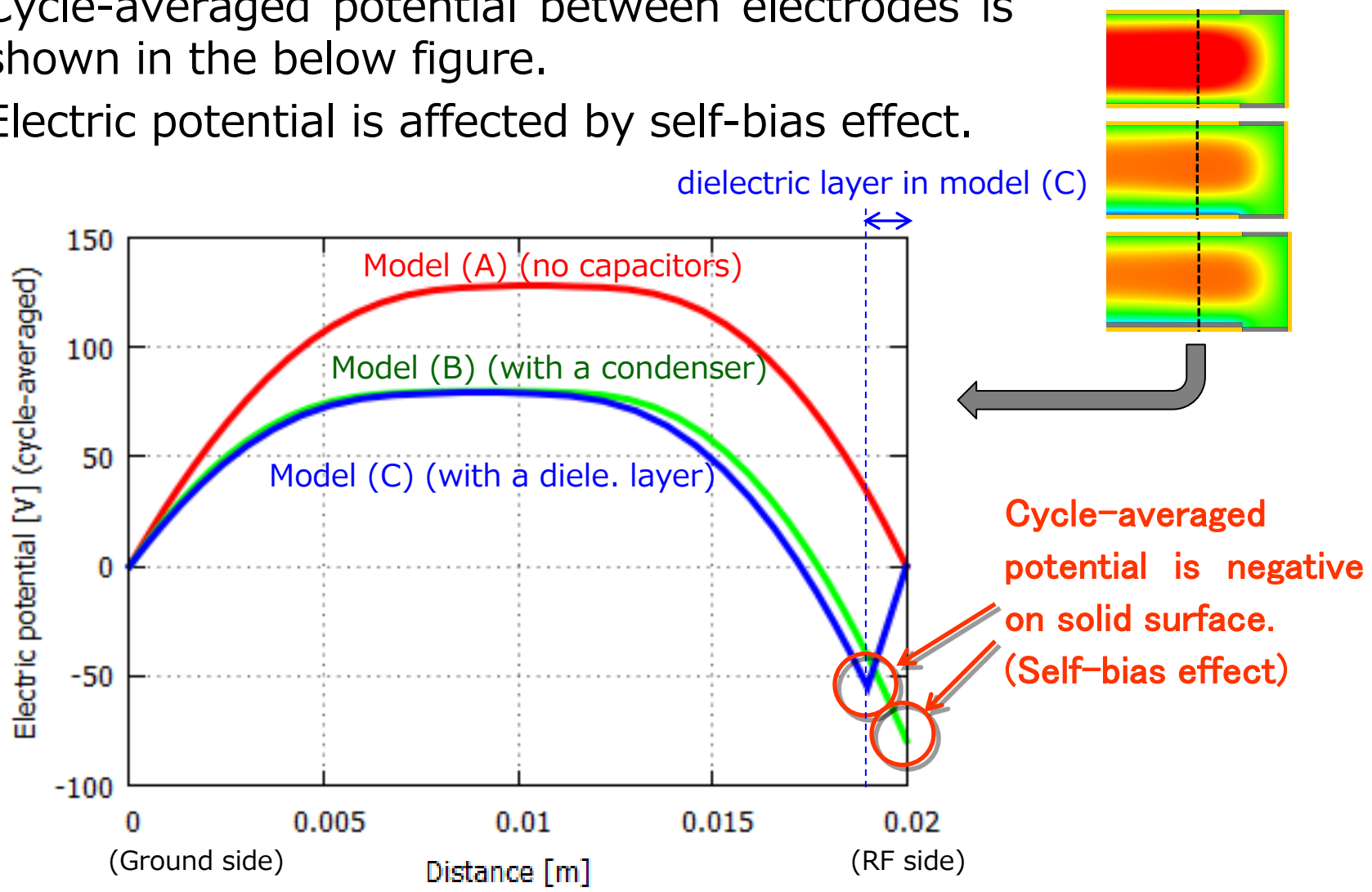


Results: Electric Potential

* Cycle averaged

Cycle-averaged potential between electrodes is shown in the below figure.

Electric potential is affected by self-bias effect.

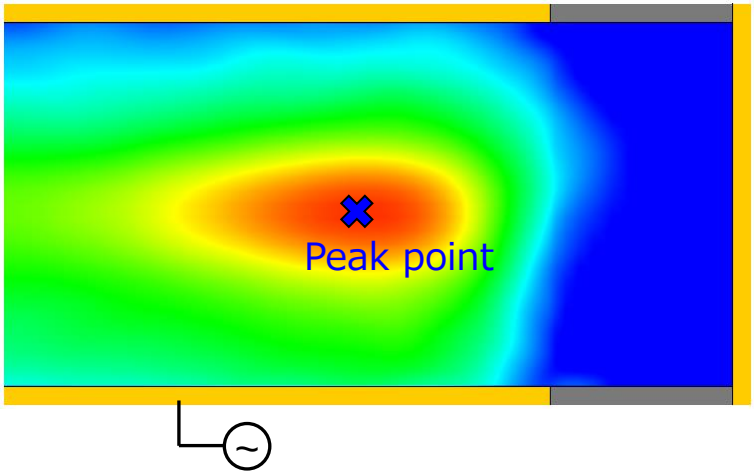


Results: Ion Density

* Cycle averaged

Plasma profile such as ion density is affected by self-bias effect. Plasma peak shifts to the right side in model (B) and (C).

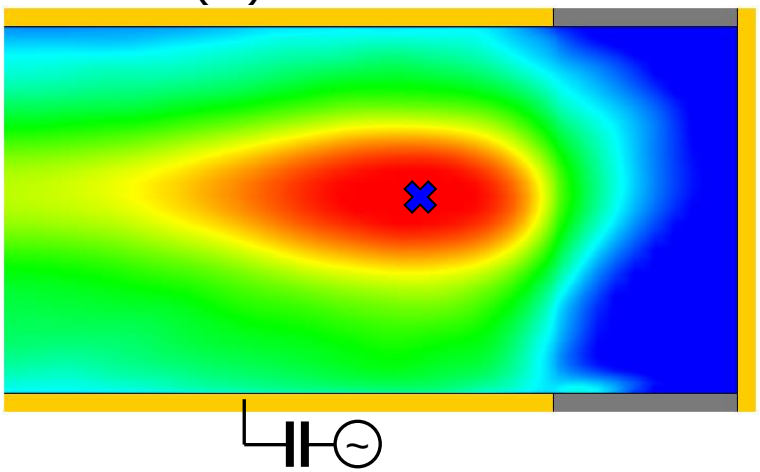
Model (A)



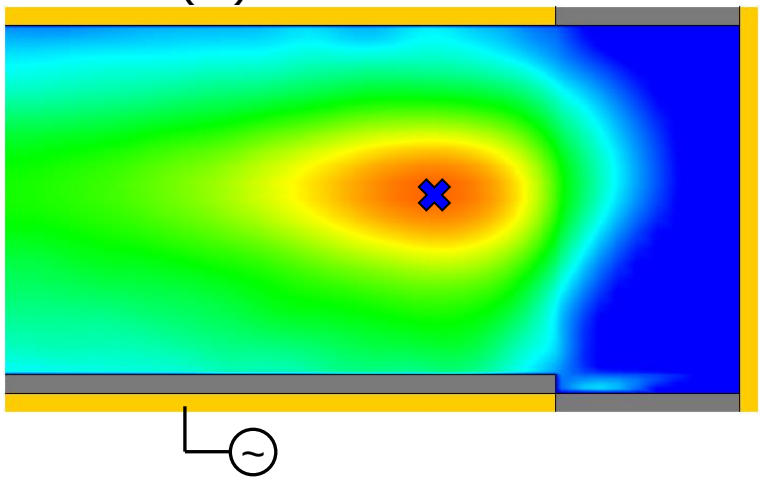
ave_density_Ar_p [#/m3]

5.000e+015
2.812e+015
1.581e+015
8.891e+014
5.000e+014

Model (B)

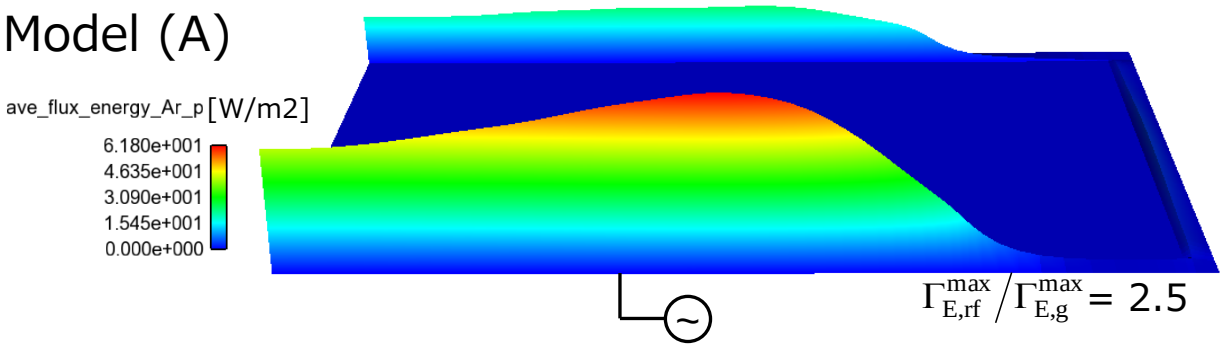


Model (C)

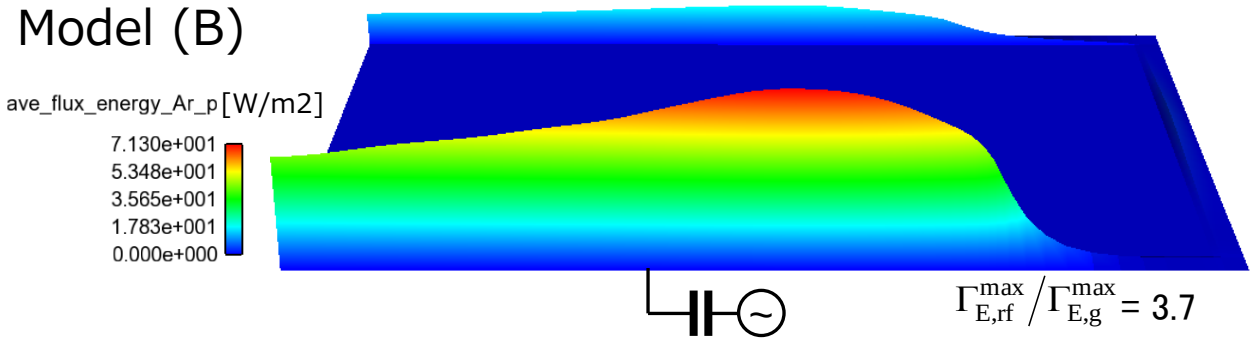


Results: Ion Energy Flux * Cycle averaged

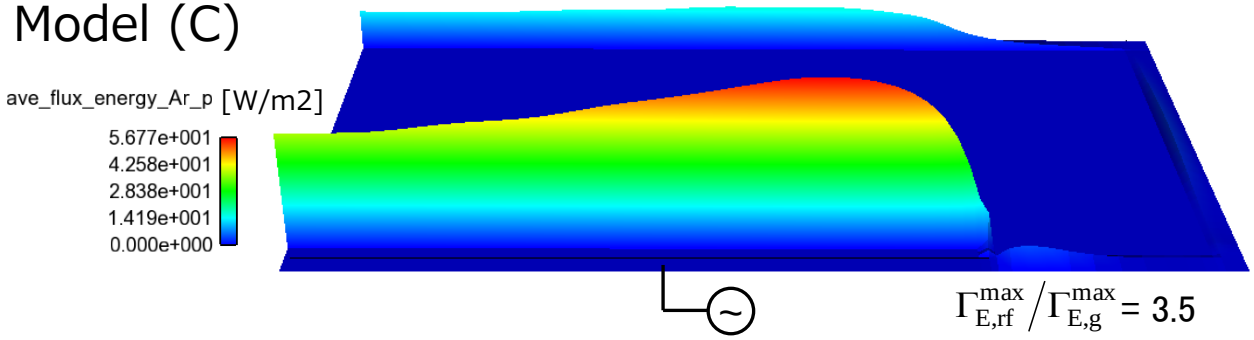
Model (A)



Model (B)



Model (C)



The energy flux ratio at the RF electrode side to the grounded one in model (B) or (C) is larger than model (A) .The peak of energy flux shifts as well as ion density.

Summary

- ✓ Particle-PLUS can simulate plasma considering self-bias effect by capacitor (such as condenser and dielectric)

- ✓ Self-bias affects electric potential, ion density, ion energy flux, and so on.