A 2D Inductively Coupled Plasma Chamber Model

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Introduction: Inductively Coupled Plasma (ICP) has been widely used as it provides high plasma densities, uniform plasma distribution and room temperature working condition[1]. The goal of this work is to get a better understanding of the effect of conditions of the cathode plate on the plasma electric potential distribution in a ICP chamber. An Argon-based ICP chamber model was developed, as shown in figure 1.

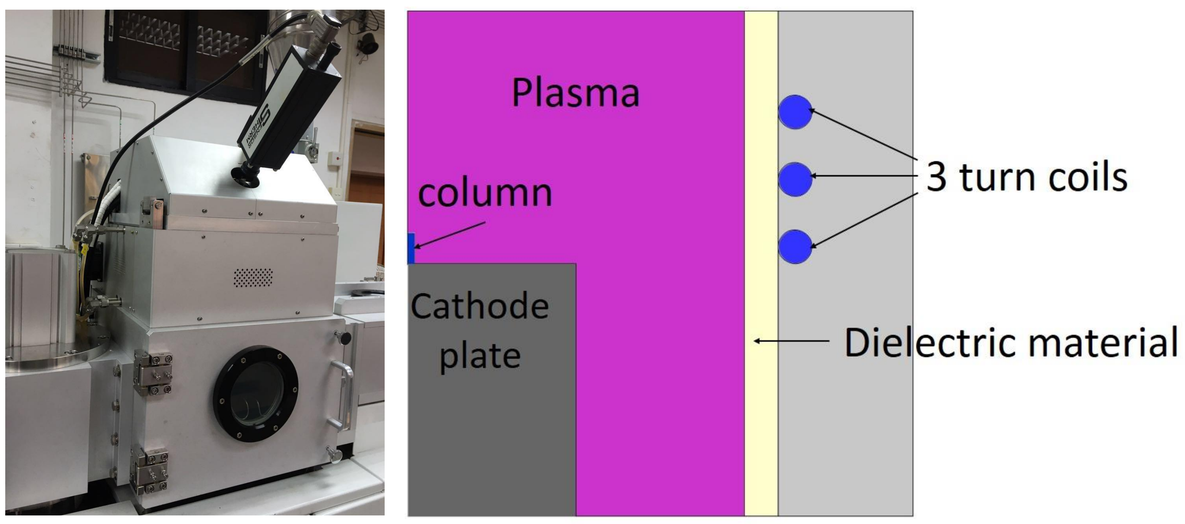

Figure 1. geometry of the ICP chamber model

Model details:

- 2D axisymmetric plasma model using Plasma module in COMSOL Multiphysics®
- 4 species Ar, Ars, Ar+ and e;
- 7 reactions including electron impacted reactions and non-electron particles collisions;
- 3 surface reactions considering different secondary emission coefficients in cathode surfaces or non-cathode surfaces;
- Power supple in coils: 13.56MHz and 1100W; Gas pressure in the chamber: 0.058Torr; Temperature: 1173K;
- A column was set up in the cathode plate;
- The electric potential of the cathode plate varies from 0V (grounded), -100V to -200V;
- 4 physics interfaces, as shown in table 1.

Drift Diffusion interface	electron density and mean electron energy
Heavy Species Transport interface	transport of the non-electron species
Electrostatics interface	potential distribution in the plasma
Magnetic Field interface	magnetic field and induced current distributions in and around coils

Table 1: physics interfaces used in the model

Result: The peak electric potential occurs at the center of chamber, the potential decreases slightly in the space of the chamber and decreases rapidly near the cathode surface, as illustrated in figure 2a-2c. In the case that the cathode plate is negatively charged (-100V or -200V), the negative potential is limited near the cathode, which is termed debye sheath[2].

The contours of the potential is parallel to the cathode plate but distorted above the irregular structure, in our case, the column. Since the direction of the electric field is the direction in which the potential decreases, The electric field is distorted above these structure as well.

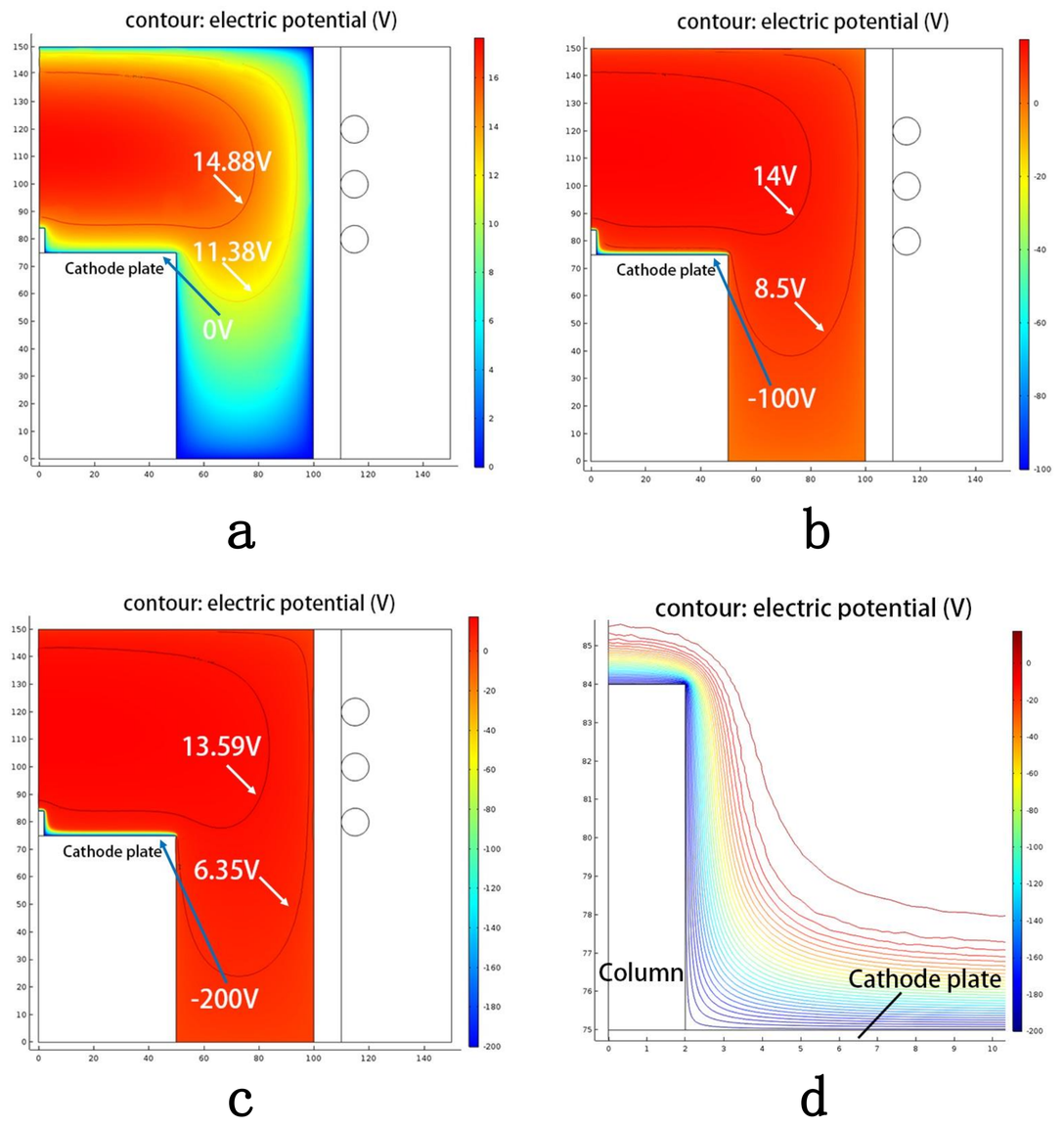

Figure 2. a-c: electric potential distribution of plasma with various potential of cathode plate. d: electric potential distribution near the irregular structure when the cathode plate is -200V charged.

Conclusions: The model successfully describes the electric potential distribution of the plasma in a ICP chamber with various cathode plate conditions. The result is helpful for understanding the ICPCVD process.

Reference:

1. Frischmuth, T., et al., Sensors and Actuators A: Physical.
2. Zhang, Y., et al., Carbon, 2013. **56**: p. 103-108.