S5-P-019307

NUMERICAL STUDY ON THE EFFECT OF SECONDARY ELECTRON EMISSION PROCESS CONSIDERING THE SURFACE CHARGES ON THE ATMOSPHERIC PRESSURE DIELECTRIC BARRIER DISCHARGE*

JIAN WANG, DONG DAI

School of Electric Power, South China University of Technology, Guangzhou 510641, People's Republic of China

The ion-induced secondary electron emission (SEE) process is the fundamental physical process for low temperature plasmas[1, 2]. The surface charge on the dielectric plays an important role in the SEE process, thus influencing the dynamics of the plasma discharge[3]. In this work, compared to the previous model which simplifies the electronic structure and the parameter of surface charges, a more accurate method based on Auger neutralization and the density functional theory (DFT) model is applied to calculate the secondary electron emission coefficient (SEEC) of MgO with accumulated surface charge in the atmospheric pressure helium dielectric barrier discharge (DBD) with nitrogen impurities[4].Based on it, we explore the change of DBD spatiotemporal characteristics when the SEE is affected by the dielectric surface charges. The simulation results indicate that, the phase of discharge moment is advanced and the current amplitude illustrates the obvious reduction when the secondary electron emission process considering the dielectric surface charges. Furthermore, the result in the fluid model based on the accurate SEEC calculation method is compared with using the simplified SEEC calculation method[5]. It turns out that the model based on the simplified SEEC calculation method and the based on our accurate calculation of SEEC all illustrate the uniform discharge, our model shows the more uniform state and the lower electron density. Further analysis reveals that the surface charge influences the secondary electron emission rate on the dielectric surface, thus having an impact on the electron distribution and discharge uniformity. Enhancing the acknowledgment that the dielectric surface charge influences the dynamics of the plasma discharge, this study explores the relationship between the SEE on the surface charge and the evolution of the plasma characteristics with a more accurate theoretical method, and elucidate the impact of the SEE caused by the specific material on the plasma characteristics. It lays a theoretical foundation for further study about the physical process of DBD discharge in the future.

REFERENCES

[1] Haiyun Luo, Junkai Jiao, Kai Liu, Yang Yue, Xinxin Wang, "Characteristics of Shallow Traps in the Dielectric Surface and Their Effects on Diffuse Dielectric Barrier Discharge in Air," IEEE Transactions on Plasma Science, vol. 45, no. 4, pp. 749–753, December 2016.

[2] Gang-Hu Liu, Xiang-Yu Wang, Yong-Xin Liu, Jing-Yu Sun, You-Nian Wang, "Effects of secondary electron emission on plasma density and electron excitation dynamics in dual-frequency asymmetric capacitively coupled argon plasmas," Plasma Sources Sci Technol, vol. 27, no. 6, pp. 064004, June 2018.

[3] Congwei Yao, Sile Chen, Zhengshi Chang, Hai-Bao Mu, Guan-Jun Zhang, "Atmospheric pressure dielectric barrier discharge involving ion-induced secondary electron emission controlled by dielectric surface charges" J Phys D: Appl Phys, vol. 52, no. 45, pp. 455202, August 2019.

[4] HAGSTRUM H D, "Theory of Auger Neutralization of Ions at the Surface of a Diamond-Type Semiconductor" Physical Review, vol. 122, no. 1, pp. 83-113, April 1961.

[5] Shu Zhang, Guang-Yu Sun, Arnas Volˇcokas, An-Bang Sun, Unveiling the role of dielectric trap states on capacitively coupled radio-frequency plasma discharge: dynamic charging behaviors" Plasma Sources Sci Technol, vol. 30, no. 5, pp. 055007, May 2021.

*This work is supported by the Key Program for International S&T Cooperation Projects of China (Grant No. 2021YFE0114700)