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A comparative study on characterization of fluorine-containing plasma with different reactors in micro atmospheric pressure

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Over the past few decades, due to the ability to produce reactive species at low gas temperature, a micro atmospheric pressure plasma have been widely explored for industrial processing. As a result, it has been growing in importance in materials treatment. Especially in the field of material fluorination applications under extreme conditions, a thorough study on specific species contributing to fluorine-containing plasma effect is yet unknown. Therefore, we used the experiments to study the plasma behaviors in a micro atmospheric arc, dielectric barrier discharge (DBD) and radio frequency (RF) reactors to identify the production pathways of various reactive species and their characteristics.

Three dedicated plasma sources including arc, DBD and RF have been developed. With these applied different type of technologies, a wider range of plasma densities can be obtained, as well as each types of electron impact reactions, such as electron attachment, excitation and ionization. Meanwhile, the active plasma volume has been formed with jet (arc plasma), torus (DBD plasma) and cylinder (RF plasma) to evaluate the fluxes of reactive and energetic species affected by each reactor. Optical emission spectroscopy and microwave interferometer have been employed to characterize plasma performance. For the study, a series of experiments have been set up in which focus on the electron properties, atom/ion energy and distribution, and etc. The results demonstrate that enhanced plasma control can be realized by plasma formation and customized driving mode. Dependence of active particle characteristics of fluorine-containing plasma on main control parameters (frequency, power, duty cycle and etc.) was investigated respectively. Plasma-assisted decomposition of CF_4 could offer a cost-effective and energy-efficient method for cracking CF_4/F_2 into fluorine atom even fluorinion. For different Ar/CH_4 gas mixtures and driving power, it shows that a more efficient and tailored production of active species densities such as fluorine atom can be achieved. Additional, further investigations into the role of both electron-induced and thermally induced reactions on the decomposition of CF_4 through a temperature-dependent plasma-chemical process are studied. It believes that the findings of this research will generate significant interest in addressing current limitations and will contribute to the advancement of plasma-assisted material fluorination technology.

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