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kHz電源駆動大気圧He+O_2プラズマジェット中の活性種の時空間分布

Spatio-temporal distributions of reactive species in a kHz-driven atmospheric-pressure He+O_2 plasma jet

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1. Introduction

Atmospheric pressure plasmas can easily generate reactive species, which have used in medical and biological application. A kHz-driven atmospheric pressure plasma jet(kHz-APPJ) has been used in Queen's university Belfast [1]. Here, helium gas is used for a carrier gas, and a small amount of oxygen is added. To reveal the detailed of reactive oxygen species (ROS) behavior, we focused on spatio-temporal distribution of the ROS in the kHz-APPJ with He +O_2 gas by using time-depended one-dimensional numerical simulation.

2. Modelling

To describe the plasma-dynamics in the kHz-APPJ, a time-depended one-dimensional numerical simulation combined with a detailed chemical kinetic model [2] has been developed. We considered 341 reactions among 23 particles (e^-, He, He(2^3S), He(2^1S), He_2^*, O, O(^{1}D), O(^{1}S), O_2, O_2(vib), O_2(rot), O_2(^{1}D), O_2(^{1}S), O_3, He^+ He_2^+, O^+, O_2^+, O_4^+, O^-, O_2^-, O_3^-, O_4^-). O_2/He+O_2 is set to be 0.001~1%. The boundary conditions include 19 wall reactions and secondary electron production. The momentum conservation for electrons, the electron energy conservation, Maxwell-Stefanh equation for heavy particles transport and Poisson equation for plasma potential are solved. Fluid convection term is not considered.

3. Results

Fig. 1 shows an example of the numerically obtained results, i.e. one-dimensional distribution of ROS number density ((a) O, (b) O_2(^{1}D), (c) O_3) as a function of O_2 admixture after 10ms calculation. It is shown from Fig 1. that the number density of ROS sharply decreased near the cathode side rather than anode side as the O_2 admixture increases. In the bulk region, O, O_2(^{1}D) and O_3 density are order of 1・10^{20}[1/m^3], 2・10^{19}[1/m^3] and 5・10^{19}[1/m^3].

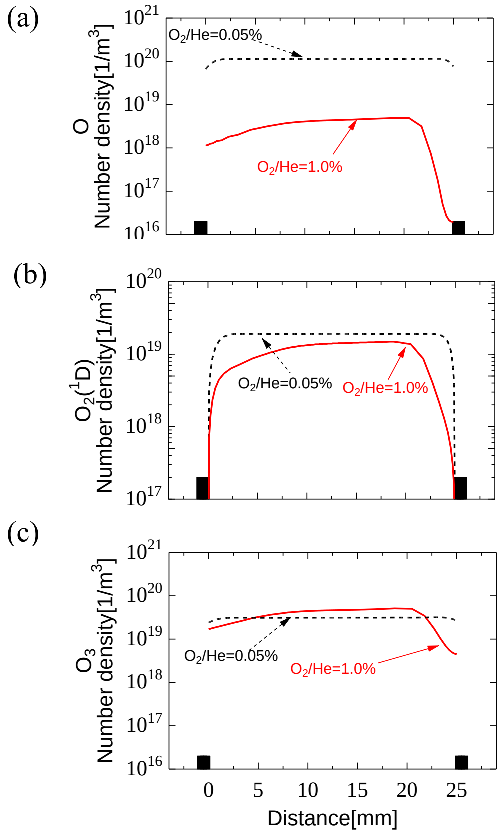

Fig.1 Spatio-temporal distribution of Reactive oxygen species ((a) O, (b) O_2(^{1}D), (c) O_3)

4. Conclusion

We have explored the influence of O_2 rate on spatio-temporal distributions of reactive species in a kHz-APPJ by using a one-dimensional time-depended global model. It was revealed that the ROS density become significantly lower near cathode side when the O_2 rate is high, that is, O_2 addition rate affects the plasma structure.

Reference

[1] Q. T. Algwari and D. Connell, Appl. Phys. Lett., Sep 2011.J.S.Sousa et al., Journal of applied physics 109, 123302 (2011)
[2] T.Murakami et.al plasma Sources. Sci. Technol. 22(2013)015003(29pp)