Investigation of Molecular-Impurity Decomposition in High-Pressure Low-Temperature Plasmas Using Laser Absorption Spectroscopy

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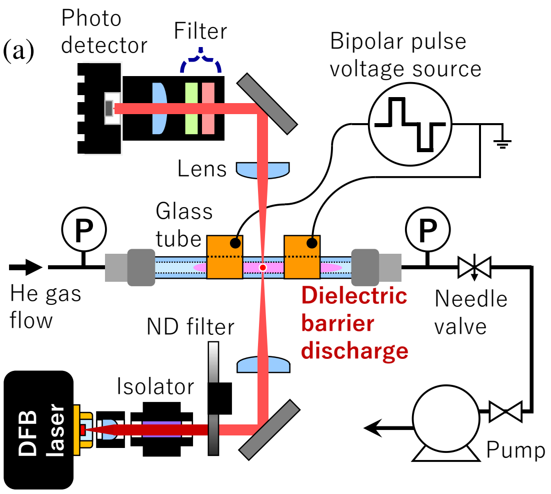
In experimental studies of plasmas, it is challenging to completely eliminate impurities incorporated into the gas flow between the gas cylinder and the discharge space. The small-fraction impurities impact the discharge behaviors in high-pressure low-temperature plasmas because of the frequent collision between electrons/ions/excited species and the impurities. When the impurity includes molecular species, they are decomposed in the plasma. The molecular-impurity decomposition changes the total fraction and reaction rates of the impurity, and spatiotemporal characteristics of plasma parameters. To precisely control reaction kinetics (e.g., selective generation of critical reactive species for applications) in high-pressure low-temperature plasmas, molecular-impurity decomposition is one of the key phenomena which must be quantitively evaluated.

This study investigates the molecular-impurity decomposition in a high-pressure dielectric barrier discharge (DBD) in high-purity helium (He) gas flow. We have revealed by optical emission spectroscopy (OES) that a major impurity species in our He-DBD system is water (H_2O) vapor [1], and the H_2O decomposition depends on the original impurity fraction and the discharge conditions [2]. To quantify the impurity fraction and analyze the decomposition, time-resolved laser absorption spectroscopy (LAS) of the He metastable 2^3S_1 (He^m) atom is installed in the system. (Fig. 1(a)) The dependence of He^m quenching frequency on the applied-voltage frequency (Fig. 1(b)) is analyzed in detail to achieve the quantitative investigation of H_2O decomposition in the He-DBD.



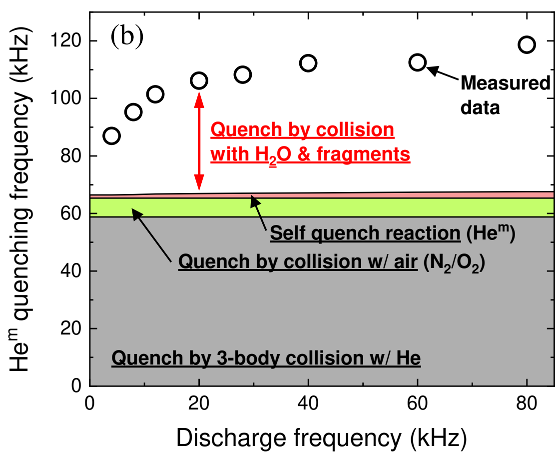


Figure 1. (a) Experimental setup of He-DBD and LAS used in this study. (b) Dependence of He^m quenching frequency on the discharge frequency measured by the LAS method. The contribution of gas species to the He^m quench is shown to investigate the influence of H_2O decomposition.

[1] K. Urabe *et al.,* Proc. 75th GEC / 11th ICRP, HW6.00048 (Sendai, Japan, 2022).
[2] M. Toyoda *et al.*, Proc. 25th ISPC, POS-3-114 (Kyoto, Japan, 2023).

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