針対水面型 He DBD ジェットの時間空間分解発光分光

Time- and Space-resolved OES on Pin-to-Water-Surface He DBD Jet

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Plamsa in contact with liquid has attracted much attention because of its various potential applications including biology, medicine, and agriculture. We have proposed three-dimensionally integrated micro solution plasma which can be used large volume materials processing in liquid [1]. We have also conducted diagnostics, modeling, and simulation on plasma/liquid interface region for understanding basic physics and chemistry involved in plasma in contact with liquid [2]. Previously, we have reported results of time-resolved OES on the DBD on water surface, and shown that dissociative recombination of electrons and H_3O^+ ions may contribute to longer lifetime of OH(A) in an afterglow period. In order to understand details of the plasma in contact with liquid, we have started time- and space-resolved OES using an ICCD detector and band-pass filters, and applied this technique to diagnostics of He DBD in contact with water.

In this work, we have performed OES on the He DBD between a metal syringe and planar surface of water in glass petri dish because He DBD shows quite nice stability on water surface and is suitable for time- and space- resolved OES. Figure 1 shows delay-time dependence of spatial profile of optical emission by He (587 nm), OH(A) (309 nm) (including partial bands of N_2 SPB emission), Hα (656 nm), and N_2 SPB (337 nm) when positive potential (1.2 kV) is applied on the syringe. Flow rate of He was 1.22 L/min. The top- and bottom- horizontal lines in each photo indicate the positions of the syringe nozzle and the water surface. The gas gap between them was 3 mm. In the initial stage of discharge, we can see evolution of a streamer from the top electrode down to water surface. After that, we can recognize formation of glow-discharge structure composed of a positive column, Faraday dark, and negative glow, which has been observed in DC discharge in a similar configuration [3]. In contrast to conventional glow discharge, emission intensity of negative glow is not so intense than of positive column, which may be caused by electron attachment on water vapor distributed on the water surface. In the case of negative polarity although it is not shown in this figure, we have observed up-side-down discharge structure in the initial stage of discharge. However, spatial profiles of optical emission become almost similar to those for positive polarity after establishing plasma region between the electrode and water surface. This suggests that the spatial profiles of active species are not governed by discharge structure but by gas-phase composition of He, H_2O, and N_2 on water surface. We will discuss these results together with numerical simulation results.

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[2] T. Shirafuji et al: Jpn. J. Appl. Phys. **54**, 01AC03 (2015).
[3] N. Shirai et al: Jpn. J. Appl. Phys. **48**, 036002 (2009).

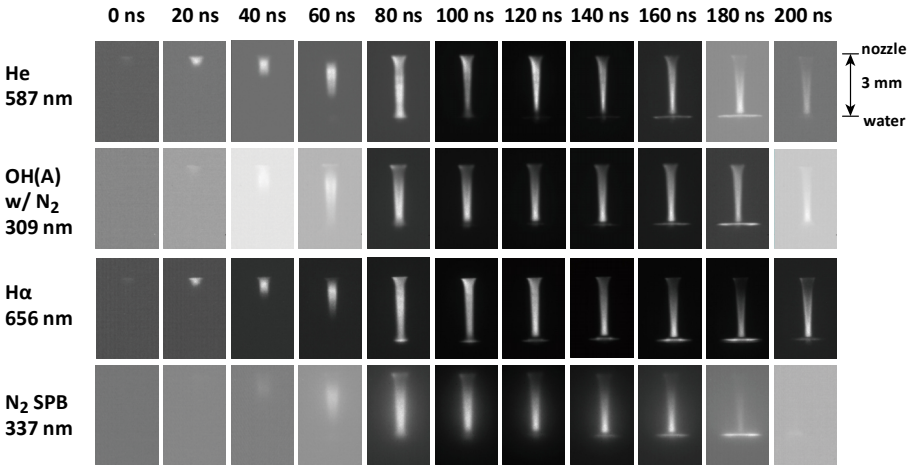

Fig. 1 Time- and space-resolved OES profiles on a He plasma jet on water.