

Spatial diagnostics of reactive species

in AC-excited atmospheric pressure Ar plasma jet generated in open air

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Non-equilibrium atmospheric pressure plasmas have attracted much attention in medical and biological fields because it is enable us to do plasma irradiation without any thermal damage in atmosphere. Recently, many interesting results have been reported in the plasma applications [1,2]. It is considered that reactive species such as atomic and molecular radicals generated in the plasma play important roles in achieving these results. Non-thermal atmospheric pressure plasma jets (APPJs) are frequently used for treatments of biomedical samples. In the treatments, the samples are typically located in the effluent region far from the main discharge of plasma jet. In atmosphere, the reactive species instantly react with other gas-phase species because the collisions between species occur with higher frequency at atmospheric pressure condition. The gas-phase reactions generate many different species and affect the composition of the reactive species supplied to the sample. As results, the reactions on the sample surface become complex and make it difficult to understand the reaction mechanisms of plasma treatment. Therefore, spatial diagnosis of the reactive species generated by plasma jet is required to clarify the gas-phase reactions and understand the reaction mechanism.

In our group, an AC-excited APPJ with Ar gas as has been developed [3], and applied to the selective killing of cancer cells over normal cells [1] and the inactivation of *Penicillium digitatum* spores [2]. The plasma treatments in the applications are carried out in open air conditions. Therefore, in order to understand the reaction mechanism, the spatial behaviors of reactive species generated by the APPJ in open air condition have been measured using spectroscopic methods in this study.

In this study, spatio-temporal measurement of OH radical in gas-phase was performed by LIF spectroscopy. In the experiment, the AC excited APPJ with Ar discharge gas was generated between two metal electrode tips supplied a high voltage of 9 kV with a frequency of 60 Hz under the Ar gas flow of 2 slm. The distance between the electrodes was approximately 20 mm. The plasma jet was generated along the gas flow direction from the square-shaped gas outlet slit (20 mm long and 0.3 mm wide) of plasma source. We have measured spatial distribution of OH radical using LIF spectroscopy. The OH radical excited by a nanosecond optical parametric oscillation laser radiation with a wavelength of 281 nm pumped by the third harmonic radiation of a pulsed Nd:YAG laser. The laser light beam was expanded vertically as a sheet beam using

cylindrical optics. And the fluorescence signals of OH radical around 310 nm wavelength were captured by an ICCD camera equipped with a 310±5 nm optical bandpass filter. Temporally resolved measurements have been performed by time resolving between 0 to 8.2 ms. which is one cycle of the discharge.

Figure 1 shows (a) photograph of the plasma jet, (b) spatial distribution of LIF signal due to OH radical at 5.5 ms after the plasma ignition, and (c) the localized position of OH radical as a function of elapsed time from 3.0 to 6.5 ms after the plasma ignition. From the results, the highest LIF signal intensity of OH radical was observed at the front edge of plasma jet. Moreover, the localized position of the LIF signal moved toward the direction of gas downstream with the progress of discharge as shown in Fig. 1(c). The average shift speed of the localized position from 3.0 to 6.5 ms is found to be about 1.3 mm/ms.

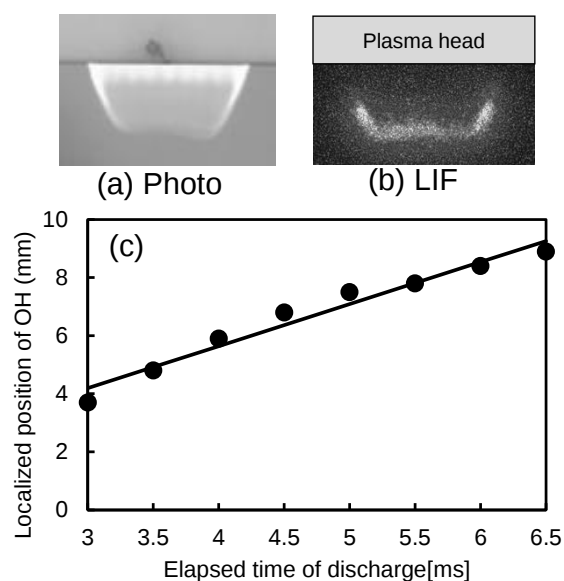


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References

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