Ambient mass spectrometric study of atmospheric-pressure micro-plasma jets: Effect of metastable atoms on the creation of short-living species

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Non-thermal atmospheric-pressure plasma jets are well-known plasma tools to generate and to deliver plasma generated reactive oxygen species (ROS) and reactive nitrogen species (RNS). Number of studies reported that ROS and RNS are strongly link to the biological and medical effects e.g. killing bacteria, wound healing, cancer treatment etc. [1-3]

In this work, we focused on the generation of oxygen and nitrogen atoms, and OH and NO radical molecules in outflow plasma jet. He (or Ar) gas with a low frequency high voltage used for the operating plasma jets. A commercially available ambient mass spectrometer (HPR60-EQP300, Hiden Analytical Ltd) was used to detect the reactive species. The mass spectrometer was operated in the RGA (residual gas analysis) mode with an internal ionizer, which generates positive ions by electron-impact ionization, especially in low electron-energy range (up to 30 eV) with a high resolution (0.1 eV). Using micro-stages in figure 1, we carefully aligned the plasma jet and the mass spectrometer as real-time monitoring of an ionic signal (O^+) to be maximized. Figure 2 shows the measured atomic nitrogen signals with and without He plasma. The difference indicates atomic nitrogen generated by the interaction between plasma and N_2 in ambient air. Interestingly, the intensity peak of atomic nitrogen was measured at around 20 eV and similar peak of atomic oxygen was also observed. We speculated a large number of atomic species generated at the specific energy due to the collisional reactions between the metastable He (19.80 and 20.62 eV) and air species via a dissociative excitation and ionization of N_2. To clear these phenomena, we have investigating the effect of different energy level of metastable Ar at 11.55 and 11.65 eV.

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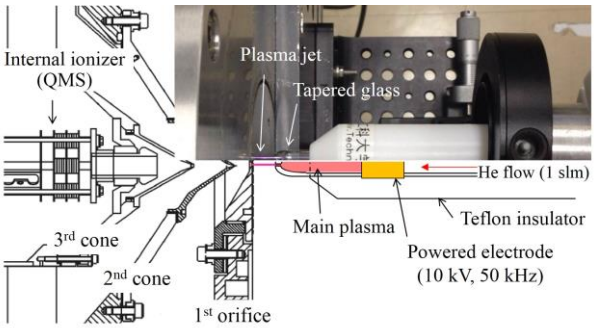

Fig. 1 Alignment of the HPR60-EQP system and an atmospheric-pressure He plasma jet.

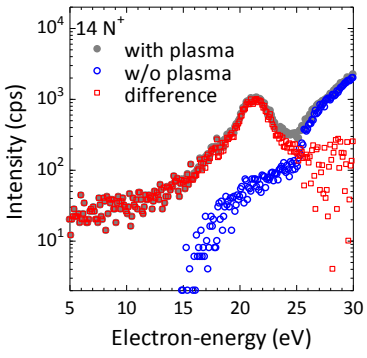

Fig. 2 Electron energy scan for N^+ ions (m/z = 14) measured with and without He plasma. Difference indicates that the atomic nitrogen generated in outflow plasma jet.