MAGNETIZED MICROPLASMAS GENERATED IN A NARROW QUARTZ TUBE

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Recently, several microplasma sources have developed for gas chromatography detector, nanomaterial synthesis, localized etching and onsite deposition[1]. According to Paschen's law, microplasmas easily generate at atmospheric pressure because the smaller discharge gap, the higher gas pressure. However, low pressure operation is anticipated to open up a possibility of controlling plasma parameters and radicals in a plasma gas phase. For this purpose, capacitively coupled radio frequency (rf) He and Ar microplasmas generated in a narrow quartz tube having an inner diameter of 1 mm (referred to as capillary microplasmas) have been magnetized by applying the strong magnetic field, provided that the magnetic field is perpendicular to both the rf electric field and the tube axis and that the Larmor radius of an electron is sufficiently smaller than both the electron mean free path and tube inner radius. In this condition, a rf oscillating $\boldsymbol{E} \times \boldsymbol{B}$ drift motion seems to occur along the tube axis. When a magnetic field with a magnetic flux density of 0.4 T was applied, the magnetized capillary microplasma could be generated at gas pressure lower than 1.5 kPa because the electron cyclotron frequency exceeds the electron-neutral collision frequency. The dependence of atomic excitation temperatures on gas pressure for He and Ar microplasmas generated at a constant rf power of 4 W with and without a magnetic field of 0.4 T was studied[2]. Magnetized capillary microplasmas have generated at low gas pressure of below several kPa. The Ar atomic excitation temperature increased dramatically from 5000K to 15000K when the gas pressure was reduced from 4 to 0.2 kPa. This implies an increase in the electron temperature. In addition, plasma has not ignited without the strong magnetic field at gas pressures below 2 kPa, even at rf powers of 10 W or more. Furthermore, Ar ionic emission (Ar II) lines were clearly observed in the spectral range of 430-500 nm. It means that an increase in electron temperature enhances the ionization and excitation efficiencies. Therefore, magnetized capillary microplasmas have the potential to be used as miniaturized ion sources.

1. F. Iza, G. J. Kim, S. M. Lee, J. K. Lee, J. L. Walsh, Y. T. Zhang and M. G. Kong, "Microplasmas: Sources, Particle Kinetics, and Biomedical Applications", Plasma Processes and Polymers **5**, 2008, pp. 322-344.
2. H. Yoshiki, "Magnetized microplasmas generated inanarrow quartz tube", Applied Physics Letters **95**, 2009, pp. 021501-1-3.