PLASMA PROPAGATION ALONG THE LONG POSITIVE COLUMN PLASMA: II. PLASMA WAVE ANALYSIS

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The observations of light propagation along the long positive column plasma have been found first in the history of fluorescent lamps. The propagation has been explained as the electron plasma-wave propagation in Ref.[1] . However, the electron plasma wave has not been described completely whether the wave can propagate a long distance of about 100~1,000 *mm* and a long time of a few μs, since the damping time of an electron plasma wave is very short.
For the interpretation of experimental results, our models for the analysis are listed below as: (i) Plasma is generated at high voltage side and diffused toward the ground electrode. The gradient of plasma density in a steady state is formulated by the continuous generation of plasma at the high voltage side. (ii) Perturbation is generated at the high voltage side by the high voltage $V(t)=V_o\sin\omega_o t$ with the frequency $f_o=\omega_o/2\pi$. The wave is generated initially at the high voltage side with the frequency $\omega=2\pi(2f_o)\sim10^5\ s^{-1}$ for the operation frequency f_o. In this analysis we will show the wave always propagates along the z-direction with the propagation velocity and the decay length. (iii) The wave cannot be observed with naked eyes. It means that the wave length is sub-millimeter. Then the phase velocity is determined with the wave frequency $\omega\sim10^5\ s^{-1}$. The group velocity of propagation should be $\sim(10^5\text{-}10^6)$ *m/s* according to the experimental data. For the presentation of wave decay along the tube, we have the characteristic decay length, which should be about the lamp length according to the lamp current.
The fatal results of previous report[1] are that the electron plasma waves are dependent of the electron drift velocity whose direction is changed with the voltage polarity. Therefore, they do not explain the direction of propagation observed in the experiments where the observed waves always propagate from high voltage side to the ground. Contrary to the electron plasma waves, the observation results have been explained completely with the ion plasma waves.

1. G. S. Cho, J. H. Kim, J. M. Jeong, B. Hong, J. Koo, E. H. Choi, J. P. Verboncoeur, H. S. Uhm, “Electron plasma wave propagation in external electrode fluorescent lamps”, Appl. Phys. Lett. Vol. 92, No. 2, 2008, p. 021502.