IONIC PLASMAS IN ROOM-TEMPERATURE ATMOSPHERIC-PRESSURE GASES

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Ionic plasmas or negative ion plasmas, which have been observed in negative ion sources and in dry etching reactors with fluorinated gases, includes different transport processes from conventional plasmas composed of positive ions and electrons. In comparison with the previous studies, we predict and examine ionic plasmas at atmospheric pressure in the gases very similar to the ambient air, in which electrons should almost diminish and ions suffer from heavy collisions against neutral atoms and molecules.

Starting from momentum balance equations for positive and negative ions, we can successfully derive dielectric properties of such ionic plasmas; they are expressed in a tensor in general, and the tensor turns into a nonlinear dielectric constant in a certain condition. When we can assume that their fluid velocity is nearly an electric-field drift one, it becomes a linear dielectric constant similar to that in the Drude model.

Experimental verification was performed by detection of dielectric responses in a kHz range in two different atmospheric-pressure plasmas, one of which was reported previously. In the downstream region of the plasmas, the dielectric constant indicated smooth frequency dependences, and their curves were well fitted to the Drude model. The detected ion densities on assumptions of their hypothetical mass numbers were roughly consistent with the data measured in other methods. These facts mean that ionic plasmas in such situations certainly exist.