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Low Pressure Nonequilibrium Plasma for Topdown Nanoprocess

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Abstract

Maxwellian velocity distribution of charged particles states the internal plasma parameters as usually described in a high temperature plasma. In a low temperature plasma subject to thermally non-equilibrium condition, however, the velocity distribution of electrons will differ from Maxwellian under a strong influence of the two-body collison (short-range interaction) subject to the quantum property of the feed gas molecule [1].

In almost all applications of the low temperature plasma, the knowledge of the two or three dimensional (2D or 3D) plasma structure will be requested to control and design the optical, physical, or chemical function. In this sense it will be essential for us to identify the multidimesional plasma structure in space and time. 2D (or 3D) structure will be estimated by a numerical simulation in the limited case that the set of cross sections and the transport of charged particles in a feed gas are available. In a plasma process, dissociated molecules, which are physically unstable and chemically reactive, are employed for the surface interaction in addition to ions. In order to enhance the surface efficiency, the plasma density may be increased and then the initial feed gas will change to a mixed-gas phase including a large percentage of the dissociated molecules. At present, it will be difficult to have a set of cross sections of most of the dissociated molecules. It is one of the reasons to prevent a quantitative numerical simulation of a high-density reative plasma for material processes. On the other hand, optical emission spectroscopy(OES) will be a powerful tool to investigate the spatial distribution of plasmas and the temporal behavior of electrons. Urgent issue in dry plasma etching will be the technological conquest of the micro-loading effect at extremely shallow pattern and the plasma molding at extremely wide profile[2]. Plasma process is a competitive process among charging, etching, and deposition on the material surface exposed to the reactive plasma. In particular, the time and space-resolved-OES is very effective to investigate the surface interaction.

We proposed vertically integrated computer aided design for device process (VicAddress) in 2000[3]. In this talk, some of interesting phenomena of reactive plasma interacting with surface for topdown nanoprocesses will be demonstrated and discussed by both VicAddress and the space- and time-resolved OES.

Reference

[1] T. Makabe and T. Yagisawa, 2009 Plasma Sources, Science and Technology 18, 14016.
[2] F. Hamaoka, T. Yagisawa, and T. Makabe, 2009 J. Phys.D: Appl. Phys. 42, 075201.
[3] T. Makabe and Z. Petrovic, 2006 Plasma Electronics: Applications in Microelectronic Device Fabrication (New York, Taylor & Francis).