Low Pressure Nonequilibrium Plasma for Topdown Nanoprocess: its structure and function

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The collisional plasma sustained in each of feed gas molecules has distinct characteristics induced by the quantum structure of the molecule activated through collisions with electrons or heavy particles. That is, there exists the proper characteristics to produce dissociated radicals, short- and long-lived excited molecules, and radiations based on the molecular quantum structure through a short-ranged interaction mainly with electrons. It differs from collisionless plasmas controlled by the long-range Coulomb interaction. Generally, the degree of ionization will be less than 10^{-3} in the collisional plasma. The quantum structure in the form of the collision cross section between the electron and the feed gas molecule is first essential quantity to investigate the collisional plasma structure and to predict the function. In a plasma interacting with surface, the energy and the angle of incident particles, especially ions are basic quantities as well as the flux in order to estimate the surface plasma process. Then, the flux velocity distribution of ions in the sheath in front of the wafer is estimated by using the set of cross section as a function of relative energy between the ion and the feed gas molecule.

In this talk we will discuss the nonequilibrum characteristics of electrons in the bulk plasma and ions in the passive sheath in the two-frequency capacitively coupled plasma for dielectric etching. The structure of the velocity distributions of the electron and ion in the nonequilibrium collisional plasma will be demonstrated by using VicAddress[1][2].

[1] T. Makabe and Z. Petrovic, “Plasma Electronics: Applications in Microelectronic Device Fabrication”, Taylor & Francis (2006).
[2] T. Shimada, T. Yagisawa, and T. Makabe, Jpn. J. Appl. Phys. 45, 8876(2006).

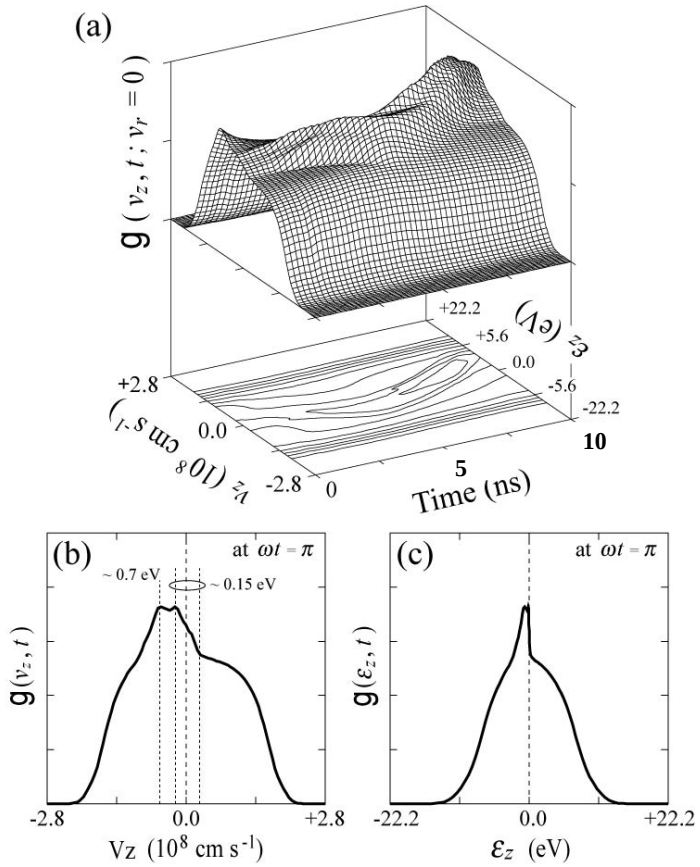

Figure: Time varying velocity distribution of electrons in the bulk plasma in collision dominated 2f-CCP, maintained at VHF(100MHz, 300V) and biased at LF (1MHz, 700V) at 50 mTorr in CF_4(5%)/Ar. $g(v_z, t)$ (a), $g(v_z, \omega t=\pi)$ (b), and $f(\varepsilon_z, \omega t=\pi)$ (c).