Characteristics of Broad-Band Frequency Low Pressure Inductively Coupled Plasma Used for Nanostructured Carbon Deposition

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Low pressure plasmas driven at very high frequency (VHF) have recently attracted considerable attention [1] because they might have higher plasma density and lower electron temperature compared with those of conventional 13.56 MHz radio frequency (rf) plasma. These characteristics are considered to be appropriate for plasma process, e.g. deposition of thin films or etching. There are up to now many reports on capacitive VHF discharge, however there is few on inductive VHF discharge.

We have recently developed a broad-band frequency (10-60 MHz) low pressure inductively coupled plasma system used for nanostructured carbon deposition by properly adjusting a helical antenna and an impedance matching network. The reflected power was always maintained at less than 10% of the forward power. We report on the plasma characteristics {plasma potential (Vp), electron temperature (Te), plasma density (Ne), and electron energy distribution function (EEDF)} measured with an optical emission spectroscopy (OES) and an rf compensated Langmuir probe [2,3] in this study.

The OES profiles of Ar and H_2 plasma as a function of frequency exhibit that the relative intensities of ArI[$4s(1/2)^0_1$-$4p(1/2)_0$] at 750.4 nm and Hβ at 486.1 nm become strong with an increase of frequency. These features reveal that the excited states levels of chemical species in plasma largely depend on plasma driven frequency.

Figure 1 shows the Vp, Te, and Ne of Ar plasma at 13.6, 27, and 40 MHz with 500 W in plasma power as a function of pressure. With an increase of pressure, the Ne also increases while the Vp and Te decrease. With an increase of frequency, the Vp and Ne also increase, whereas the Te tends to be saturated in higher frequency. It was reported on a capacitive VHF plasma that the Vp decreases with an increase of frequency [4]. The opposite tendency in this study is presumably due to inductive discharge.

Figure 2 shows the EEDF of Ar plasma with 50 mTorr in pressure and 500 W in plasma power. The almost straight line at lower frequency indicates Maxwellian distribution. The profiles at higher frequency imply that the deviation from Maxwellian distribution occurs with an increase of frequency.

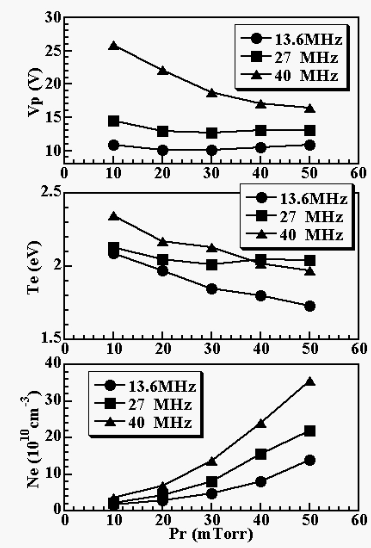

FIG. 1. Variation of Vp, Te, and Ne with pressure at 13.6, 27, and 40 MHz.

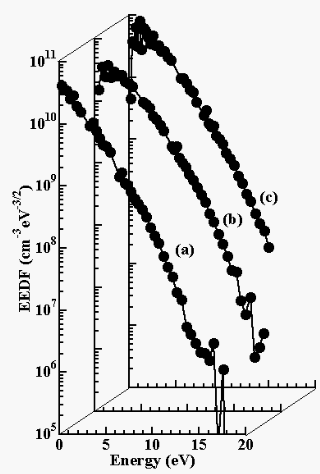

FIG. 2. EEDFs of Ar plasma as a function of frequency: (a) 13.6 MHz, (b) 27 MHz, and (c) 40 MHz.

References

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