Investigation of Fluorine Actinometric Coefficient in Capacitively Coupled SF_6/Ar Plasma

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Measurement of radical density is important for monitoring of etch process since chemical etching induced by uncharged etchant such as fluorine is relatively dominant process. [1] There are various methods to diagnose fluorine atom density such as Laser based methods (LIF, LAS and TALIF), Optical Emission Spectroscopy (OES), Residual Gas Analyzer (RGA) and Quadrupole Mass Spectrometer (QMS). [2] One of these methods, actinometry using OES, is widely-used, inexpensive and feasible for monitoring radical density in real-time. Actinometry is the method adding small amount of inert gas and obtain the radical density from atomic line emission intensity ratio. Actinometric coefficient, electron-impact excitation rate ratio of atomic species, is a proportional coefficient between emission line and atomic density ratio. Actinometric coefficient can be treated as a constant when selected lines have same electron-impact excitation threshold energy from ground state and linear cross sections. The coefficient is actually dependent on electron energy distribution function (EEDF), because of differences in threshold energies and cross section shapes. In previous studies, actinometric coefficients of fluorine and argon were calculated from theoretical excitation cross sections due to deficiency of experimentally obtained fluorine excitation cross sections. [3][4] Actinometric coefficient of CF_x/Ar plasma and inductively coupled SF_6/Ar plasma were empirically measured. [5]. Very-High-Frequency Capacitively Coupled Plasma (VHF CCP) have different EEDF shape comparing to inductively coupled plasma, because energetic beam-like electrons are generated by stochastic heating. [6] In this study, actinometric coefficients were measured for SF_6/Ar VHF CCP. Intensity ratio of fluorine to argon line and mole fraction of fluorine to argon were measured by OES and Appearance Potential Mass-Spectrometry (APMS), respectively. APMS can measure an amount of the species by ionizing neutral with specified electron energy. Experiments were progressed on following conditions; SF_6 mole fraction (over than 80 %), input power (100 W~ 500 W) and pressure (10 mTorr~100 mTorr). Actinometric coefficients were measured for varying molar ratio [F]/[Ar] and [SF6]/[Ar]. It is discussed about effects of EEDF on actinometry coefficients by comparing theoretical values to experimentally obtained values.

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