

## Behavior of Electron and Negative Ion Density in Very High Frequency Capacitively Coupled Plasma

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### INTRODUCTION

A very high frequency (VHF), 30 - 300 MHz, capacitively coupled plasma (CCP) have proved to be useful plasma processing tool for semiconductor fabrication due to the enhanced process rates and lower plasma induced damage. Generally, higher plasma density and lower electron temperature are realized as increasing the driving frequencies. Moreover, a pulsed plasma is known to satisfy requirements such as charging-free plasma processes for high-aspect-ratio hole etching processes. In this study, we present experimental results for the measurement of negative ion densities in a CCP discharge driven at 60 MHz or 100 MHz frequency in both CW and pulsed mode.

### EXPERIMENTAL & RESULTS

Electron and negative ion densities in O<sub>2</sub> and Ar/O<sub>2</sub>/C<sub>4</sub>F<sub>8</sub> plasma were measured using a hairpin probe and pulse laser photo-detachment method. Wavelengths used in the photo-detachment were 532, 355 and 266 nm in order to measure negative ions (O<sup>-</sup>, F<sup>-</sup> etc) generated in the plasma. The effects of RF frequency, power, duty ratio for 1-kHz pulsed plasma on negative ion generation were examined as well as the gas pressure. In the CW O<sub>2</sub> plasma, the electron ( $n_e$  :  $2 \times 10^{10}$  to  $5 \times 10^{10}$  cm<sup>-3</sup>) and O<sup>-</sup> density ( $n$  :  $1 \times 10^{10}$  to  $3 \times 10^{10}$  cm<sup>-3</sup>) increased with an increase in the VHF power (100 to 500 W) and decreased slightly ( $n_e$  :  $3 \times 10^{10}$  to  $2 \times 10^{10}$  cm<sup>-3</sup>,  $n$  :  $1.3 \times 10^{10}$  to  $0.9 \times 10^{10}$  cm<sup>-3</sup>) with an increase in the gas pressure (1 to 10 Pa). In the CW Ar/O<sub>2</sub>/C<sub>4</sub>F<sub>8</sub> plasma, the total negative ion density increased and O<sup>-</sup> density decreased (~50%) percentages with an increase in power from 50 to 300 W because F<sup>-</sup> were mainly produced by the dissociative attachment of fluorocarbon radicals. The F<sup>-</sup> densities were further measured by performing photo-detachment at higher laser wavelength and observed a linear increase in F<sup>-</sup> density with the increase in power.

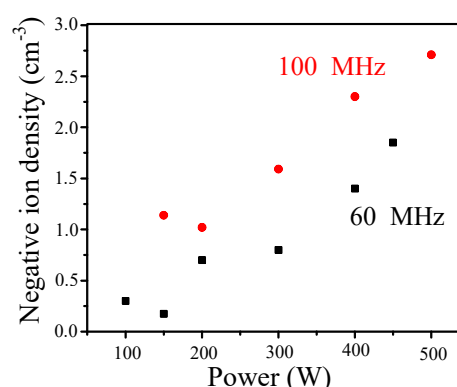


Fig. 1. Negative ion density in CW O<sub>2</sub> plasma at 2.0 Pa as function of VHF power.

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