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Improvement of foreline plasma optical emission spectroscopy for monitoring plasma processes

Recently, advanced process control (APC) for the semiconductor and display industry becomes important due to tighter process windows. Therefore, process monitoring techniques providing reliable diagnostics data for the APC have attracting considerable attention. The industry-compatible process monitoring techniques are required to satisfy the following conditions: (i) non-invasive to the process, (ii) insensitive against perturbation by the process, (iii) readily comprehensible to process engineer, (iv) applicable regardless of process conditions (power, pressure, gases, etc) and (v) economical as considering of maintenance. In the industry compatible point of view, foreline plasma optical emission spectroscopy (FPOES) technique also referred to as a self-plasma OES or a remote-plasma OES is promising by virtue of its capability to perform in situ non-invasive detection of gas species during processes. Recent applications of the FPOES in monitoring processes are such as the end point detection in low-open ratio etch process, the leak and fault detection, the optimization of seasoning, and etc.
In this presentation, we show the recent results on improvement of the FPOES. The FPOES is composed of two parts. The first part is electrodes for discharging a plasma in the foreline, that is independent of the plasma discharged in processing chamber. The second parts is an optical path structure including a window for monitoring the gas species of the plasma using optical emission spectroscopy. For reliable application of the FPOES as a process diagnostics technique, the stability of the plasma in FPOES is important under foreline discharge conditions of pressures and gases. We optimized the electrode structure and the power to obtain the stable plasma in the foreline through comparison experiments using various cylindrical and planar type electrodes. The usefulness of the improved FPOES was tested and validated by applying it to in situ monitoring of real plasma processes. In addition, an active microwave spectroscopy (AMS) measuring the plasma electron density of the FPOES is utilized to improve the FPOES reliability.

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