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PECVD Chamber Cleaning End Time Detection (ETD) Using Optical Emission Spectroscopy (OES) Data

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Semiconductor industry has already fully utilized 300mm wafer fabrication, and advanced process control (APC) with real-time *in-situ* process monitoring technique contributed to reduce equipment wait time waste (WTW) and equipment output waste (EOW), which are represented as normalized differences between instantaneous throughput and averaged throughput over a period of time. Despite the numerous efforts in the reduction of perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) in semiconductor manufacturing for satisfying *Green Fab* challenge, no significant efforts on efficient fabrication equipment operation have been reported from semiconductor fabrication research area. Adoption of a real-time *in-situ* process and equipment monitoring technique to research environment can provide benefits of reduction in greenhouse gases and increase in tool operation efficiency.

In this paper, we studied plasma enhanced chemical vapor deposition (PECVD) chamber cleaning monitoring using optical emission spectroscopy (OES). While dielectric thin film is deposited in PECVD, the process chambers become coated with process chemicals during the deposition process. To eliminate cross-contamination and maintain consistent process performance, chambers are being cleaned periodically to remove build-up polymeric materials inside the chamber; however, running a cleaning process for a prolong time can increase greenhouse chemical usage and WTW. Generally speaking, chamber cleaning time and amount of gas usage varies depending on the type of material and the thickness of deposited layer in previous processes. Real-time *in-situ* monitoring of chamber cleaning with added sensors has been investigated to improve productivity, waste reduction and cost reduction.

One can expect to prevent failure by cross contamination from imperfect chamber cleaning. Fourier transform infrared (FTIR) was used to optimize the type and usage of cleaning gases in CVD for manufacturing cost reduction, and multi-sensor study on reducing PFC gas emission in CVD chamber cleaning has been performed employing quadrupole mass spectrometry (QMS). FTIR and QMS can provide benefits of monitoring chamber residual gases from exhaust, but they require additional set up for real-time data acquisition. In this research, we employed OES for easy to setup and non-invasiveness to the plasma. OES is known as end point detector (EPD) in plasma etching. We practiced end time detection (ETD) of PECVD chamber cleaning process using OES.

Real-time acquired OES was separated into two groups of process and by-produce related gas species, and principal component analysis (PCA) was applied for each group of OES signals in order to generate chamber cleaning end time trace data. PCA in this study has been employed to reduce data dimensionality as well as to generate a combined end time tracing signals for the respective groups. Overlapping the two end time traces from feeding gas and by-product group provided a straight forward intuition on the end point of PECVD chamber cleaning and then saturated. Finally, end time was detected by real-time *in-situ* monitoring of chamber cleaning system as shown in Figure 2. We report that the chamber cleaning time was reduced by 50% employing real-time *in-situ* monitoring of chamber cleaning, and the result is presented in Figure 3.

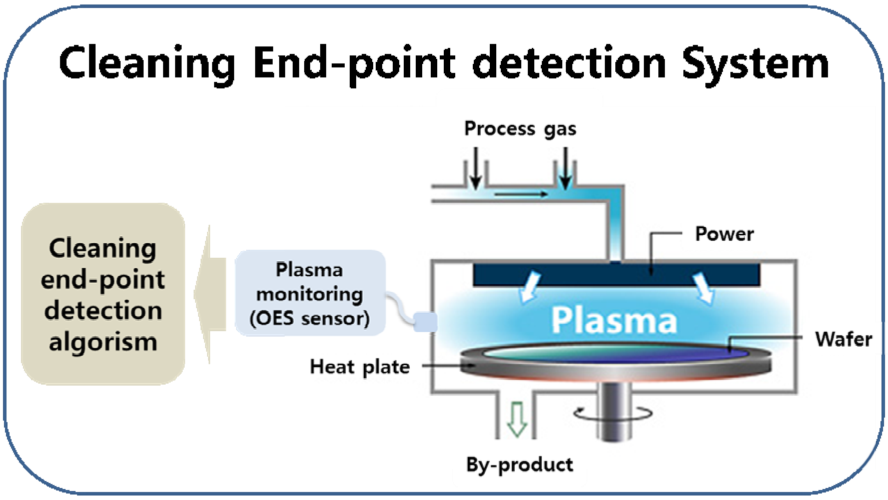

Figure 1. Experimental apparatus and add-on in-situ OES sensor setup

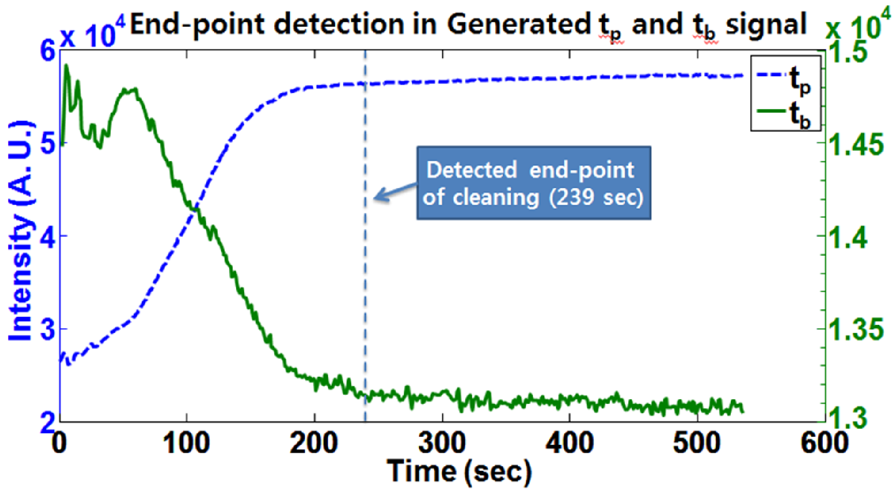

Figure 2. Principal component analysis generated cleaning end time signals

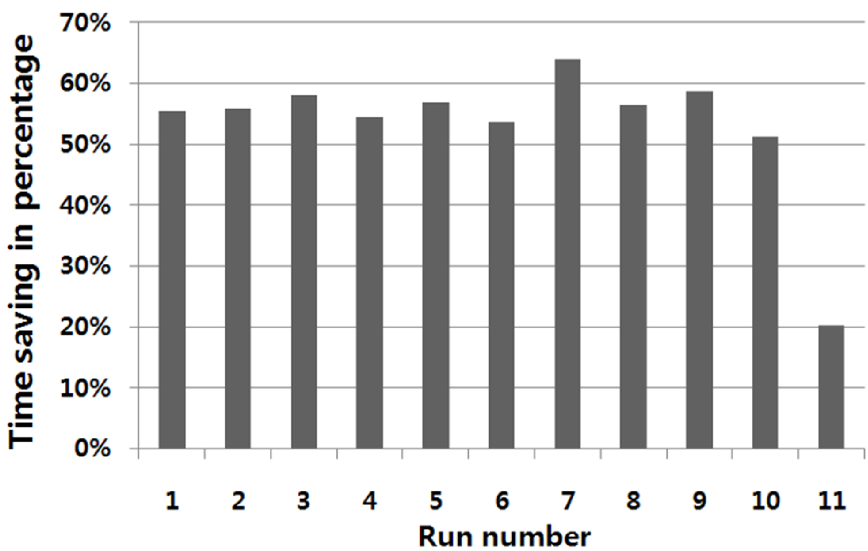

Figure 3. Chamber cleaning time saving with *in-situ* cleaning monitoring