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A Preliminary Research on Optical In-Situ Monitoring of RF Plasma Induced Ion Current Using Optical Plasma Monitoring System (OPMS)

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As the wafer geometric requirements continuously complicated and minutes in tens of nanometers, the expectation of real-time add-on sensors for in-situ plasma process monitoring is rapidly increasing. Various industry applications, utilizing plasma impedance monitor (PIM) and optical emission spectroscopy (OES), on etch end point detection, etch chemistry investigation, health monitoring, fault detection and classification, and advanced process control are good examples. However, process monitoring in semiconductor manufacturing industry requires non-invasiveness. The hypothesis behind the optical monitoring of plasma induced ion current is for the monitoring of plasma induced charging damage in non-invasive optical way. In plasma dielectric via etching, the bombardment of reactive ions on exposed conductor patterns may induce electrical current. Induced electrical charge can further flow down to device level, and accumulated charges in the consecutive plasma processes during back-end metallization can create plasma induced charging damage to shift the threshold voltage of device. As a preliminary research for the hypothesis, we performed two phases experiment to measure the plasma induced current in etch environmental condition. We fabricated electrical test circuits to convert induced current to flickering frequency of LED output, and the flickering frequency was measured by high speed optical plasma monitoring system (OPMS) in 10 kHz. Current-frequency calibration was done in offline by applying stepwise current increase while LED flickering was measured. Once the performance of the test circuits was evaluated, a metal pad for collecting ion bombardment during plasma etch condition was placed inside etch chamber, and the LED output frequency was measured in real-time. It was successful to acquire high speed optical emission data acquisition in 10 kHz. Offline measurement with the test circuitry was satisfactory, and we are continuously investigating the potential of real-time in-situ plasma induce current measurement via OPMS.

Keywords: OES, Plasma ion current, In-situ monitoring