Application Note

SEMICONDUCTOR MANUFACTURING SOLUTIONS

Leak Point Detection in Semiconductor Chambers under Rough Vacuum Regime

Precision detection can help take troubleshooting downtime on electrochemical deposition tools from days to just hours, helping to ensure operational integrity and compliance in rough vacuum regime environments.

Introduction

Chamber integrity is critical for semiconductor processing tools in both legacy and modern semiconductor fabrication plants. During electrochemical deposition (ECD)—where copper and other metals are electroplated onto wafers for advanced packaging technologies such as wafer-level packaging (WLP) and through-silicon vias (TSVs)—even minor leaks or contamination can compromise process stability and yield.

Electroplating performance, especially at high plating rates, depends on a stable, controlled environment. Leaks can compromise within-wafer uniformity, within-die co-planarity, and the reliability of microbumps and solder joints, ultimately impacting device yield and performance.

Gas analyzers like INFICON Quantus® HP100 are excellent tools that help equipment engineers with online and offline leak monitoring and troubleshooting.

Challenge

Like other equipment used in semiconductor manufacturing, ECD tools require regular preventive maintenance, with intervals determined by the number of wafers processed and overall run time.

When leaks occur, immediate troubleshooting is critical to minimize tool downtime. Finding the specific leak point for the two cells in addition to the associated tubing is very time consuming because engineers have to replace parts one by one in order to isolate the root cause. This trial-and-error method can take several days, or even weeks, to identify the root cause. Traditional leak checking with helium (He) gas is not ideal, as the tubing is plastic and pipe deformation occurs when pumping the system down. Semiconductor fabs need a more effective solution to reduce tool downtime and improve yield.

Test Case

Quantus HP100, a Self-Plasma Optical Emission Spectroscopy (SPOES) gas analyzer, was utilized to troubleshoot and identify leak points on an ECD tool.

As shown in Figure 1, the tool has two side-by-side chambers that share a common water exhaust line and pumping line. The base pressure during normal operation is around 30 Torr, with nitrogen as the background gas. Figure 1 illustrates several vulnerable joints where O-rings or other sealing components can deteriorate over time, leading to leaks. For this ECD tool, the tool user has a maximum leak tolerance at a rate of rise (RoR) of 10 Torr/min. The test introduced an equivalent leak rate at a predefined location.

QUANTUS HP100
An optical gas analyzer that can support up to 450 Torr without a differential pumping system.

SPOES
Self-Plasma Optical Emission Spectroscopy unleashes the power of OES technology to a new level.

LEAK POINT IDENTIFICATION
Quantus HP100 provides a quick and reliable leak point identification with argon (Ar) as trace gas.

Solution

Quantus HP100 is a newly designed gas analyzer in the INFICON optical gas analyzer portfolio that can work over a broad pressure range while maintaining excellent sensitivity. The compact form factor and pump-free design support leak detection up to 120 Torr for nitrogen or 450 Torr for argon (Ar) as background gas.

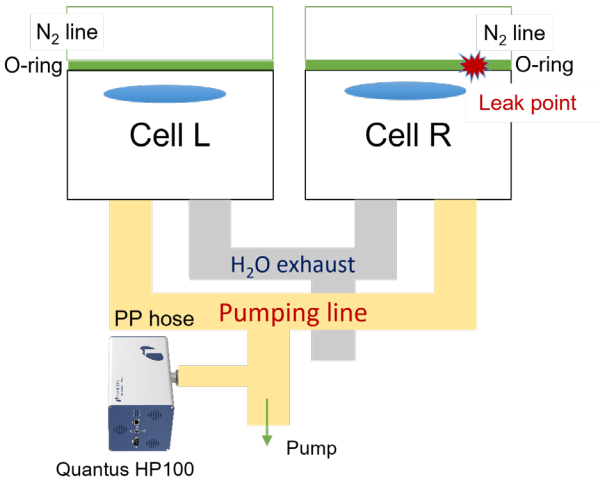

Figure 1. Schematic diagram of the ECD tool.

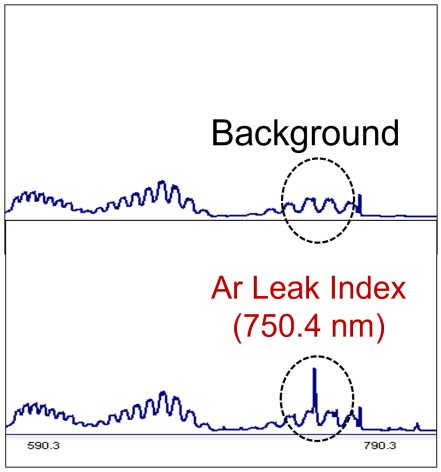

Figure 2. Optical emission spectra at base pressure (top) and when Ar gas is introduced into the system (bottom).

Quantus HP100 has a plasma sensor cell that generates a localized microplasma, which emits light representing the gas species. Unlike conventional He leak detectors, this system uses Ar as the chamber leak tracer gas, offering a more economical and environmentally sustainable solution. As shown in Figure 1, Quantus HP100 is installed on the leak check port of the ECD tool, and the base pressure at this location is 30 Torr with nitrogen as background gas.

At base pressure, Quantus HP100 has a typical optical spectrum as shown in the top panel of Figure 2 (showing the spectrum from approximately 600 to 800 nm). However, when Ar gas is sprayed around the chambers, a new optical emission line of Ar at 750.4 nm (see the bottom panel of Figure 2) appears and clearly indicates a leak when the Ar gas reaches proximately to the leak point.

Using the Quantus HP100, the leak point can be easily identified by monitoring the amplitude of the Ar emission line as Ar is sprayed around the outside of the vacuum chamber and lines.

Real-Time Leak Detection Utilizing Argon

Unlike conventional leak detectors that use He as the tracer gas, Quantus HP100 exhibits a highly sensitive and reliable response when Ar is introduced into the chamber. The time trajectory in Figure 3 illustrates the response of the Ar emission line at 750.4 nm when Ar gas is sprayed at the leak point. It is noticeable that by moving the Ar spray nozzle close to the leak point, the intensity of Ar 750.4 nm increases and then decreases when the trace gas is removed.

Conclusion

INFICON Quantus HP100 natively supports high-pressure applications without requiring a differential pumping system, providing an effective solution to minimize troubleshooting time on an ECD tool. The excellent sensitivity and compact form factor make it a competitive sensor suitable for a wide range of applications in semiconductor manufacturing and display markets. This new method reduces tool downtime from days to hours. The detection response time can be further reduced by customizing the sensor installation instead of relying on the existing leak check port on the tool.

More information → inficon.com

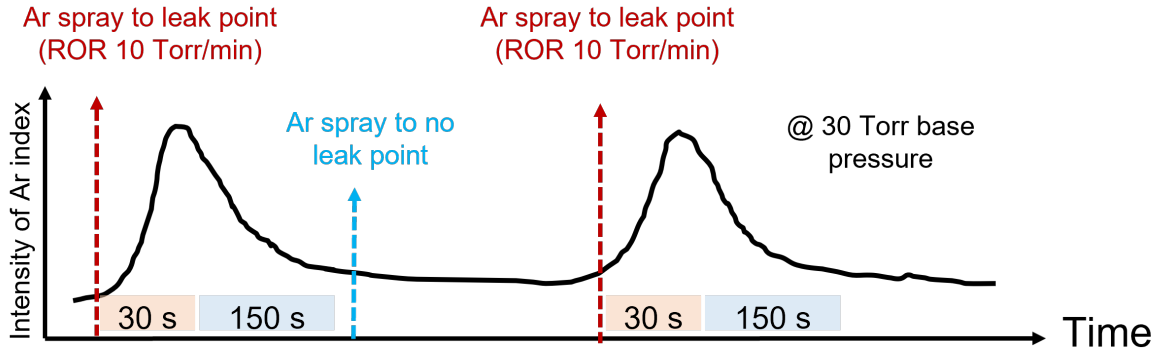

Figure 3. Time trajectory showing the response of the Ar emission line at 750.4 nm when spaying Ar gas toward the leak point.

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