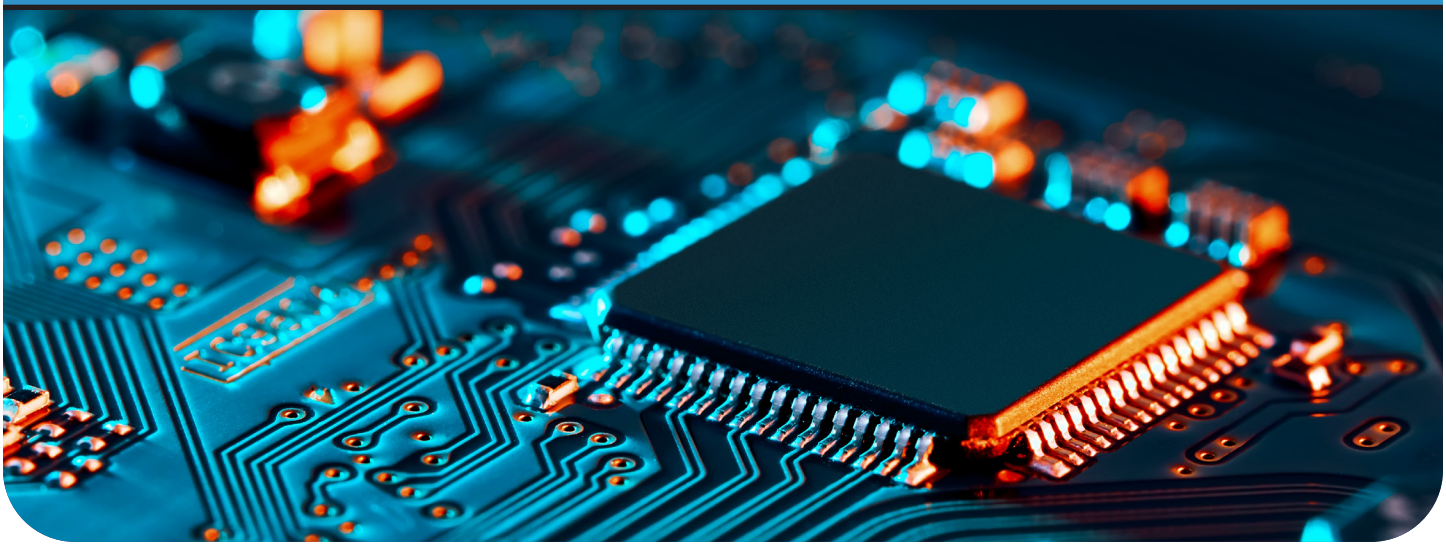
Monitoring Semiconductor Processes using Spectroscopy

How Spectral Tools Boost Yields and Ensure Device Quality



A global supplier of process control equipment for the semiconductor industry sought a compact, robust spectrometer to integrate into its overlay metrology systems. Ocean Optics delivered a high resolution, thermally stable spectrometer that provides users with accurate, reliable feedback on process deviations, helping to reduce errors and boost productivity.

Spectroscopy and Semiconductor Processing

Continuing research and development of semiconductor materials has led to remarkable strides in chip performance while trying to keep pace with the increasing demand for semiconductor devices, which today play a part in everything from agricultural operations to traffic control. But as advances in chip size and performance become more challenging to achieve, semiconductor manufacturers have renewed their focus on making improvements in fabrication and output. Streamlining processes, enhancing product quality and increasing wafer yields are evolving objectives.

Producing semiconductors is a complex undertaking, with precise monitoring of fabrication processes integral to successful yields. As a proven analytical technology, spectroscopy is embraced by the semiconductor industry because of its versatility, simplicity and accessibility. Compact spectral systems are routinely used throughout semiconductor inspection, testing and manufacturing processes, where real-time, in situ analysis helps to ensure reliable results. For example, even slight deviations in processes during fabrication can affect the electrical properties of finished wafers.

Optical emission spectroscopy (OES), reflectance and transmission are among the spectral techniques utilized by semiconductor process equipment providers to manage critical manufacturing steps including plasma monitoring (Figure 1) and endpoint detection in lithography, plasma etching and deposition processes. OES can identify materials in the plasmas that manage deposition and etching; reflectance and transmission often are used for thin film thickness measurements.

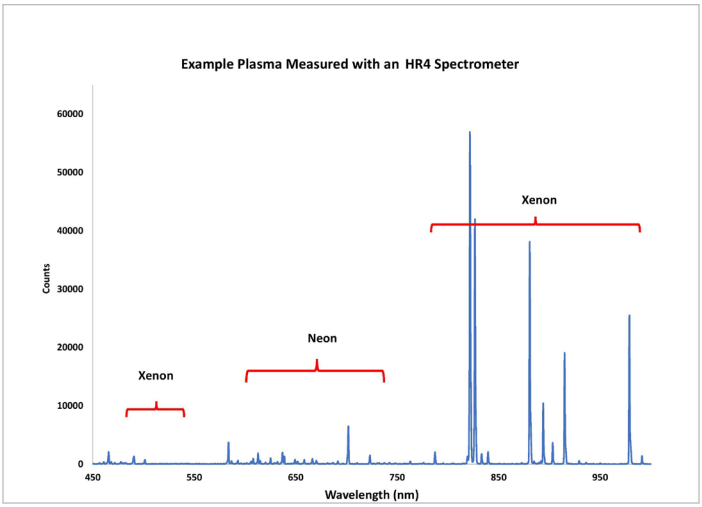


Figure 1. A high resolution, thermally stable spectrometer is ideal for monitoring the emission peaks of gases used in semiconductor and other manufacturing processes.

Semiconductor Processing Challenges

Ocean Optics has a long history of support for semiconductor process equipment suppliers investigating new materials and taking on various challenges related to plasma etching and deposition, overlay control, and plasma ashing and cleaning.

In the case of our overlay-control system customer, the goal was to deliver a robust yet compact spectrometer, easily integrated into the customer's system and capable of providing reliable, high resolution results over time and temperature changes. This is significant, in part, because spectral wavelength drift can produce measurement errors that carry through to the algorithmic modeling the customer uses to control key processes.

In short, our customer required a precise, process-ready spectrometer. Having an existing Ocean Optics spectrometer distinguished by large-bench optical resolution in a compact footprint was a great starting point. Add in a multi-disciplinary team with expertise in opto-mechanical design and testing to reengineer the spectrometer for an added layer of thermal wavelength stability, and the result was a solution that met the customer's needs for peak wavelength accuracy and measurement repeatability.

An additional benefit of our successful spectrometer redesign was elimination of more intrusive and less easily managed approaches to maintaining thermal stability in the setup. This sped up development and made the integration simpler to manage.

In fact, because we have a close partnership with the customer and had collaborated with them on other projects, the spectrometer design changes were accomplished within a short timeframe, and at reasonable cost.

Additional Process Monitoring Applications

With better control of various semiconductor processes, manufacturers can reduce interruptions caused by errors, produce less waste, and deliver higher quality output. For example, when spectroscopy-based endpoint detection is used in metrology systems for overlay control, the endpoint can identify when an etched film has cleared the underlying film, which indicates the next step in the etch process to take.

Spectroscopy also makes endpoint detection more precise, enabling the design of more intricate wafer shapes and patterns. Because manufacturers can more accurately stop and start production processes, smaller features can be made with fewer errors and less unusable space on the wafer. Also, with more accurate endpoint, thinner layers of materials can be used, even as those materials generate faint, difficult to discern spectral signatures and reveal closely aligned spectral peaks.

Ocean Optics has provided spectrometers for plasma monitoring applications, with OES a technique commonly utilized for endpoint detection. For example, detection of a drop-off in certain plasma species can be an indicator in etching processes that action is needed to prevent damage to the wafer.

Leveraging the Power of Light

By customizing our compact, high-performance spectrometers, Ocean Optics delivers the spectral acquisition speed, optical resolution and thermal stability so critical to monitoring semiconductor processes. With flexibility in our hardware and depth to our application knowledge, Ocean Optics provides solutions that process equipment suppliers can use to improve and refine the technologies they offer to the semiconductor industry.

The result? Accelerated ramps, higher process yields, and improved product quality.