USC UNIVERSITY OF
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STANDARD OPERATING PROCEDURE FOR SiO2 OPTICAL EMISSION SPECTROSCOPY (OES) ENDPOINT PROCEDURE

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1. PURPOSE

This SOP describes how to set up Optical Emission Spectroscopy (OES), how to interpret the signal traces, and how to calibrate the endpoint for SiO_2 etching in CHF_3/Ar. For the current process, OES is best treated as a calibrated process monitor only after correlation to measured oxide thickness.

Application: 613 nm SiO_2 on Si • Oxford ICP etch • Monitoring mode (Signal)

Document purpose	**Operator guide for setup, interpretation, and calibration of OES endpoint**	**Recommended start point**	**704 / 750 nm, Falling 95%**
Important note	OES for this process behaves as a weak trend endpoint and must be thickness-calibrated	**Verified observation**	Full clear observed near 19 min for a 613 nm SiO_2 etch

2. PRINCIPLE OF OPERATION

During plasma etching, excited species emit light at characteristic wavelengths. The OES system tracks the intensity of selected lines over time. As the exposed surface and plasma chemistry evolve during oxide removal, the normalized signal can rise, fall, or change slope. The endpoint is valid only when the signal feature consistently correlates with actual oxide clear.

- Wavelength 1 (primary): 704 nm — fluorine-related emission used to follow oxide etch chemistry.
- Wavelength 2 (reference): 750 nm — argon reference used to separate chemistry drift from plasma drift.
- The **704 nm** wavelength is selected as the primary process-monitoring line because it is associated with **fluorine-related plasma emission**, which is more sensitive to the SiO_2 etch chemistry in a CHF_3/Ar plasma. The **750 nm** wavelength is selected as a **reference argon line** because it mainly reflects overall plasma stability rather than oxide consumption. Monitoring these two wavelengths together helps distinguish **true chemistry-driven changes** from normal plasma intensity drift, making endpoint interpretation more reliable.
- For this CHF_3/Ar SiO_2 process, the useful behavior is a gradual falling normalized signal rather than a strong sharp transition.

3. RECOMMENDED INITIAL SETUP

Parameter	**Recommended starting value**
Endpoint using	Signal
Threshold type	Falling
Threshold value	95%
Smoothing time	4 s

Parameter	Recommended starting value
Closed time	3 s
Normalisation time	15 s
Normalisation level	100%
Overrun time	5 s
Capture time	1 s
Wavelength 1	704 nm
Wavelength 2	750 nm
Integration time	100–150 ms
Samples to average	5–10
Boxcar width	3–5 pixels
Spectra logging	Yes

4. STEP-BY-STEP PROCEDURE

4.1 Before the run

- Verify starting oxide thickness and substrate stack.
- Use the same etch recipe, gas flows, pressure, RF/ICP power, and platen conditions for all calibration runs.
- Confirm the chamber window is clean enough for stable optical collection.
- Enter Wavelength 1 = 704 nm and Wavelength 2 = 750 nm.
- Enter the initial OES settings from Section 3 and enable spectra logging.

4.2 During the run

- Start the plasma and ignore the first few seconds of signal motion; this is ignition and stabilization, not endpoint.
- Watch the normalized signal on the percent axis. For this process the signal typically rises rapidly at ignition, then slowly trends downward.
- Do not rely on a single visual impression. Save the full trace every time.
- For calibration wafers, either let the tool stop on threshold or stop at a planned time, then measure the oxide immediately.

4.3 After the run

- Measure remaining oxide thickness.
- Record the stop time, minimum normalized signal reached, and whether oxide remained.
- Use only uninterrupted single-pass runs for endpoint calibration whenever possible.

- If the wafer is removed and reloaded, treat the second run as a new experiment rather than a continuation.

5. HOW TO INTERPRET THE OES PLOT

The figure below shows a typical SiO_2 etch OES trace for this process. The interpretation should focus on signal shape, not just whether the trace is above or below 100%.

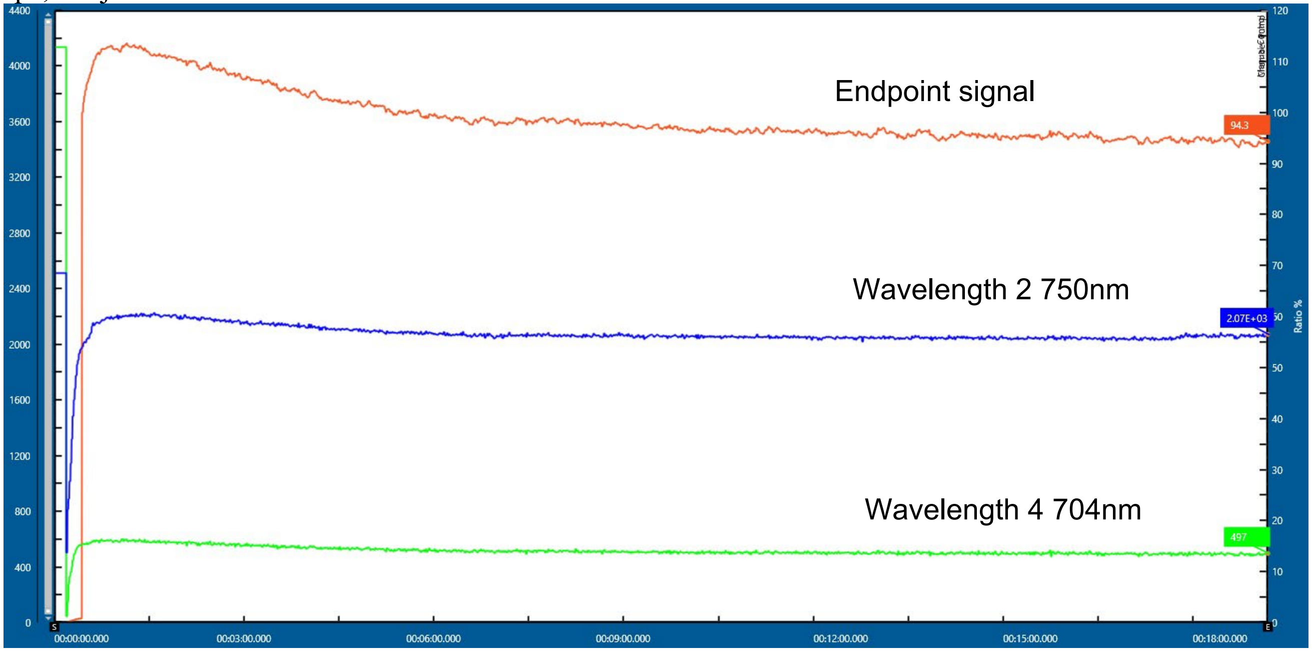

Figure 1. Example OES trace for SiO_2 etch in CHF_3/Ar. The orange trace is the normalized signal (% on the right axis); the blue and green traces are monitored intensity channels on the left axis.

5.1 What each region means

Plot feature	Interpretation
Initial sharp rise	Plasma ignition, gas stabilization, and early surface conditioning. This is not endpoint.
Orange trace near or above 100%	Normalized endpoint signal. Being above 100% does not prove oxide is still present; it only means the signal is above the normalization baseline.
Slow downward drift	For this process, oxide removal produces a gradual falling trend rather than a strong step change.
Minimum near 94–95%	Based on current calibration, full clear can occur while the normalized signal is still around this range.
Horizontal threshold line	Auto-stop occurs only when the normalized signal crosses this user-defined threshold.

5.2 Current process interpretation

In the current calibration set, the signal did not show a dramatic endpoint collapse. Full oxide clear was observed in one calibration run at about 19 min for a 613 nm SiO_2 etch, even though the normalized signal stayed above 94%.

This means the OES feature is weak but still potentially usable with a narrow falling threshold window and thickness correlation.

6. CALIBRATION WORKFLOW

- Run several wafers at fixed times that bracket the clear point, for example 17 min, 18 min, 19 min, 19.5 min, and 20 min, using the 613 nm starting thickness as the calibration basis.
- Measure the remaining oxide after each run.
- Record the minimum normalized OES value for each wafer.
- Select the threshold that gives the earliest reliable trigger without leaving oxide behind.
- Adjust overrun only after the threshold region is known.

Run	**Etch time**	**Minimum OES %**	**Remaining oxide**
Example 1	19 min	94.3%	613 nm etched; no oxide detected
Example 2	threshold at 93%	93%	304 nm SiO_2 remained
New run	________	________	________

Interpretation: a 93% falling threshold is too low for this setup, while a threshold near 95% remains a reasonable starting point for the next uninterrupted calibration run.

7. TROUBLESHOOTING AND DECISION GUIDE

Observed behavior	**Likely meaning**	**Action**
Threshold reached but oxide remains	Threshold is too early	Lower the falling threshold slightly or increase overrun after confirming repeatability.
Oxide clears before threshold is reached	Threshold is too low or OES feature is weak	Raise the threshold toward 95–96% or use time-based control while continuing calibration.
Signal stays above 100% even after clear	Baseline comparison only; not a direct thickness indicator	Do not interpret 100% as “oxide present.” Use thickness correlation instead.
Large run-to-run drift after unloading and reloading	Baseline and chamber condition changed	Treat the reloaded wafer as a new run.
No obvious knee or collapse in the signal	Weak endpoint feature	Use OES as a calibrated monitor and keep spectra logging on.

8. INTERPRETING THE SiO2 SINE WAVE

Use this as the next calibration start point: 704 nm / 750 nm, Falling threshold 95%, 15 s normalisation, 4 s smoothing, 3 s closed time, and 5 s overrun. Verify the stop point with an uninterrupted single-pass run and post-etch thickness measurement.

9. RECORDS TO KEEP FOR EACH RUN

- Wafer ID and starting oxide thickness
- Date, chamber condition, and recipe revision
- Wavelengths used
- Threshold type and value
- Normalization, smoothing, closed time, and overrun
- Stop time and minimum normalized signal
- Post-etch measured oxide thickness

Contributors	**Revised Date**
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