In-situ gas monitoring as an industrial tool for rapid troubleshooting

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Presentation outline

• Why in-situ gas monitoring – current state of the industry

• Description of Remote Plasma Emission Monitoring technique

• Qualitative identification of process problems
  • Air leaks
  • Water leaks
  • Contaminated process gas

• Using RPEM as a quantitative monitoring tool
The current state of process monitoring

Some form of pressure monitoring > Almost everyone

Pressure monitoring in each zone > Most users

Access to a He leak detector > Most users

Immediate access to a He leak detector > Some users

Access to a QMS (RGA) > Some users

RGA permanently on the tool > Very few users
In-situ gas monitoring
Why and why not?

• Take pre-emptive action – **proactive not reactive**!

• Identify problems early before they affect the substrate

• Predict if a problem is likely to occur

• Schedule maintenance just in time

Expensive    Easy to break    Complex operation
Remote Plasma Emission Spectroscopy (RPEM)

- Original concept used by Mann in 1981 leak detection

Spectrum analysis gives species composition
Fast feedback control of the current allows for a stable plasma to be generated from \(1 \times 10^{-6} \text{ mbar}\) to \(0.5 \text{ mbar}\).
Good agreement between QMS results and RPEM for many gases
Detection of water leaks

- OH and H emissions indicate water vapor
- Clear increase seen when dynamic seal is moving
Detecting process gas contamination

- Ar process gas line contaminated with air
- MFC feedback would have shown no problem
- No system leak to detect – in situ gas monitoring only way to see this
He leak detection with RPEM

- Differential spectrum produced when spraying He around an air leak
He leak detection with RPEM

- Possible to localise air leaks by monitoring He emission
- Not a complete replacement for a dedicated He leak detector
- Leak rates are not directly quantifiable

**504nm He emission**

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c. 1E-6 mbar/l/s
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The RPEM quantification problem

- Gas readings are interactive (relative to each other)
- Results are more like ratios of gases

QMS RGA

RPEM
The RPEM quantification problem (and solution)

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- Cold cathode pressure
- Pirani pressure
- Spectrometer emission intensity

Total pressure

- Gas factor correction

Spectrometer irradiance calibration

- Emission probability correction

Ratio of gases

Gas partial pressures
The RPEM quantification problem (and solution)
The RPEM quantification problem (and solution)

- Quantifiable gas partial pressure readings are possible using RPEM
- Data can be produced that is a close match with a QMS RGA
Case study – R2R process mapping

- AlOx evaporation onto 12µm PET
- Webwidth: 2450mm
- Bobst K5000 R&D metalizer
Case study – R2R process mapping

- Two process zones
- Plasma pre-treatment
- Al evaporation
- Evaporation zone plasma

Low vacuum zone (c. 1E-2 mbar)

Pre-treat plasma

Drum

Evaporation zone plasma

High vacuum zone (c. 1E-5 mbar)

Al evaporator

Optix
Case study – R2R process mapping

- Boats heating
- Wire feeding
- Drum rotation
- Plasma pre-treat ignited
- Evaporation plasma ignited
Case study – R2R process mapping

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Case study – R2R process mapping

- CO$_2$ outgassing from the evaporation boats
- Small increase in water vapor due to heating

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Case study – R2R process mapping

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- Gettering of OH and O from evaporated Al
- Outgassing of CO – organic contamination on wire?

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Case study – R2R process mapping

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- N₂ is being “dragged” in from the low vacuum zone of the system

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Case study – R2R process mapping

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Case study – R2R process mapping

- Effect of the pre-treat plasma in the low vac. zone
- Reaction of web ligands with O – forming CO / CO₂

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Case study – R2R process mapping

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Case study – R2R process mapping

- Formation of CO and CO$_2$
- Effect of the evap. plasma on the web can be monitored

- Boats heating
- Wire feeding
- Drum rotation
- Plasma pre-treat ignited
- Evaporation plasma ignited
• Common industrial vacuum processing problems can be identified early, before the consequences escalate.

• Examples include water leaks, air leaks, outgassing, gas contaminants

• Gas concentrations can be quantified when using RPEM

• Processes can be “fingerprinted” – for proactive problem solving
Thank you for your attention!

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