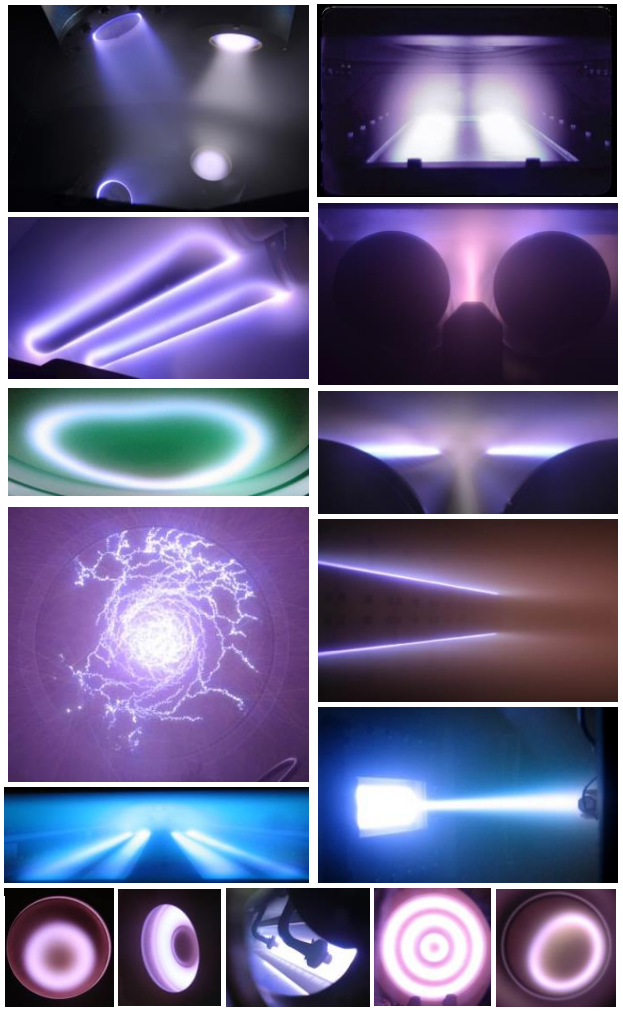
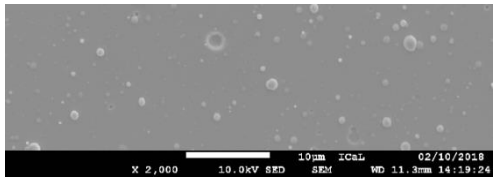
OPTIX Robust & Easy to Use Residual Gas Analysis for the Vacuum Industry

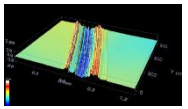
- **ALD**
- **Atmospheric vacuum sampling via roughing**
- **Contamination check**
- **CVD**
- **Etch Endpoint**
- **Heat Treatment**
- **Leak Detection (any species)**
- **Plasma Treatment**
- **Process Gas Analysis**
- **OLED**
- **MOCVD**
- **PVD**
- **Plasma Spraying**

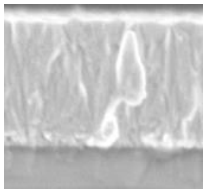
23 Years of of Products and Technology from Gencoa

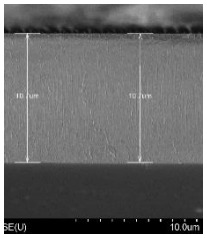
Rotatable & Planar Magnetron Sputter Cathodes • Retrofit magnetic packs • Plasma Treaters • Speedflo Reactive Gas Controllers • IM Ion Sources & power supplies • Arc MAX sources & power supplies • Active Anodes and Gas Delivery Bars • OPTIX Gas and Chemical Sensing • S and Se Sensor • PEC Pulsed Effusion Cell • V⁺DLC - Transparent DLC • IC Nano antimicrobial layer technology • Process implementation & tuning •

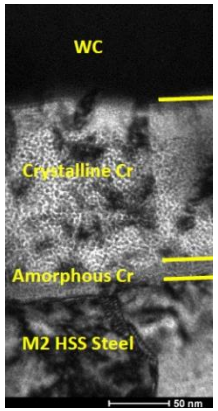


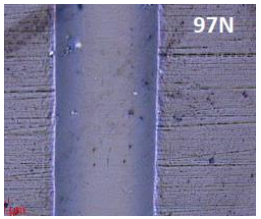


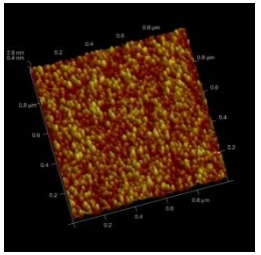


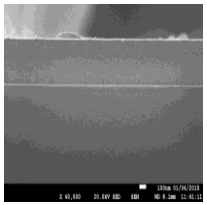


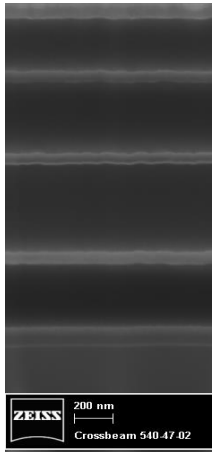


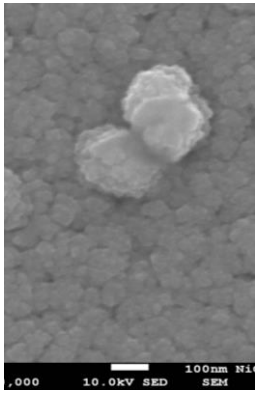












Why Monitor Your Vacuum Process ?

Save Money by Avoiding Problems

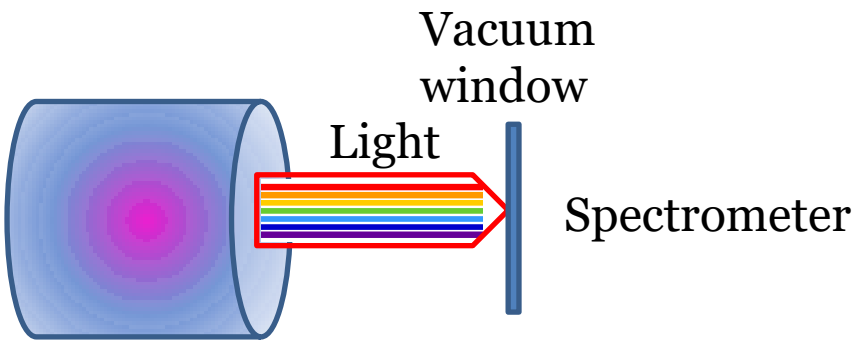
- Identify vacuum or process problems before they have a financial impact
- OPTIX maps the process environment to ensure reliable production
- Improves quality of products and repeatability
- Outputs for better process control

OPTIX vs RGA

OPTIX – remote plasma gas analysis (RPGA)

Optical method - high speed

Detector outside of the vacuum – cannot be damaged by the vacuum environment

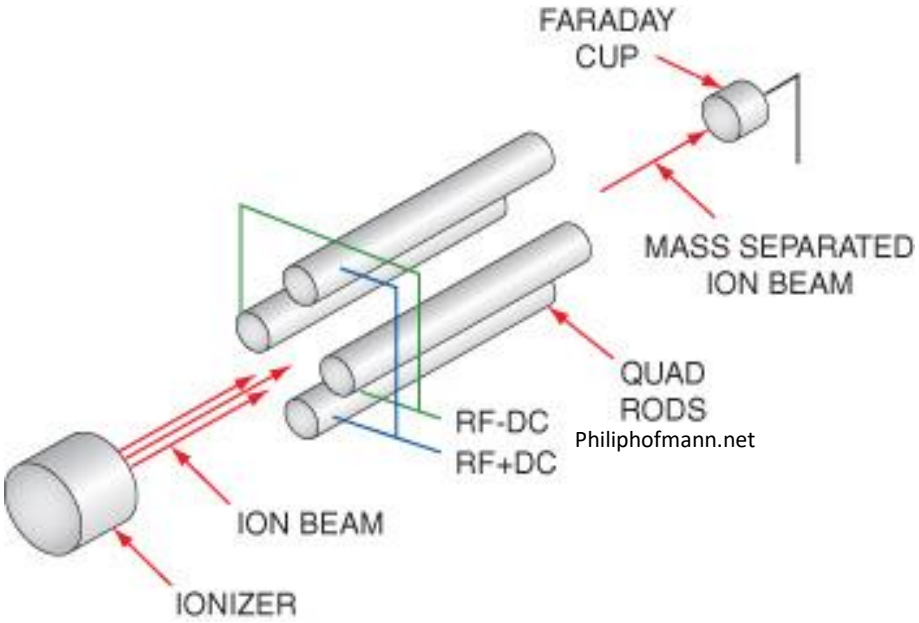


Remote plasma

Low ppm detection

Quadrupole Residual Gas Analyzers (RGAs)

Detector inside of the vacuum – will be damaged by the vacuum environment by high pressure, operator error, or contamination



Low ppm detection

OPTIX vs RGA

OPTIX – remote plasma gas analysis (RPGA) Optical method	Quadrupole Residual Gas Analyzers (RGAs)
Robust– detector separated from chemicals by optical window	Detector in contact with chemicals – easy to contaminate, hard to clean
No filaments –simple electrode geometry	Filaments and ionizers are consumables
Operates 0.5 to 10^{-6} mbar	Only operates reliably down to 10^{-4} mbar
Direct chamber monitoring – no need for differential pumping unless atmospheric sampling	Higher than 10^{-4} mbar pressure needs differential pumping – loss of sensitivity
FAST – 'speed of light', 10-50 msec response	Typically 0.5 to several seconds range
Tolerates volatiles in the vacuum – hydrocarbons, solvents, long chain polymers	Only small amounts of contamination before sensor failure
Wide range of useful software applications available – gas tracking, leak detection, pump-down monitoring, water tracker, end-point detection, multi-mode process tracking	Typically gas tracking & leak detection
Sensor degassing mode – avoid false reading	Yes, but degas can affect filament lifetime

OPTIX Remote Plasma Gas Analysis RPGA

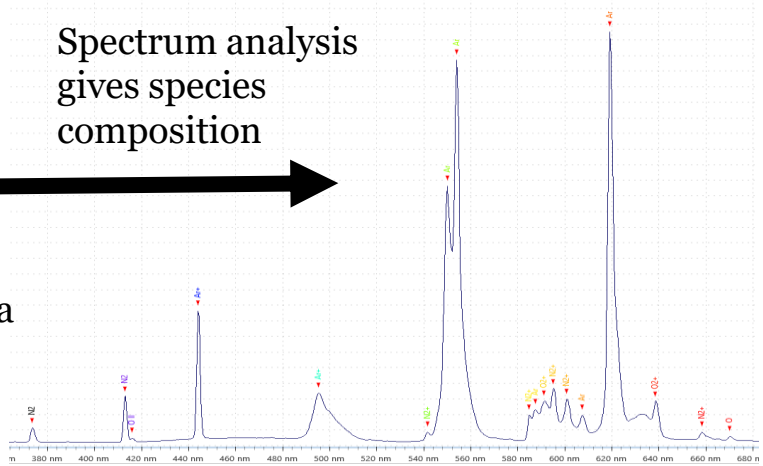
Vacuum process chamber 0.5 to 10^{-6} mbar or with a rotary pump to support atmospheric sensing

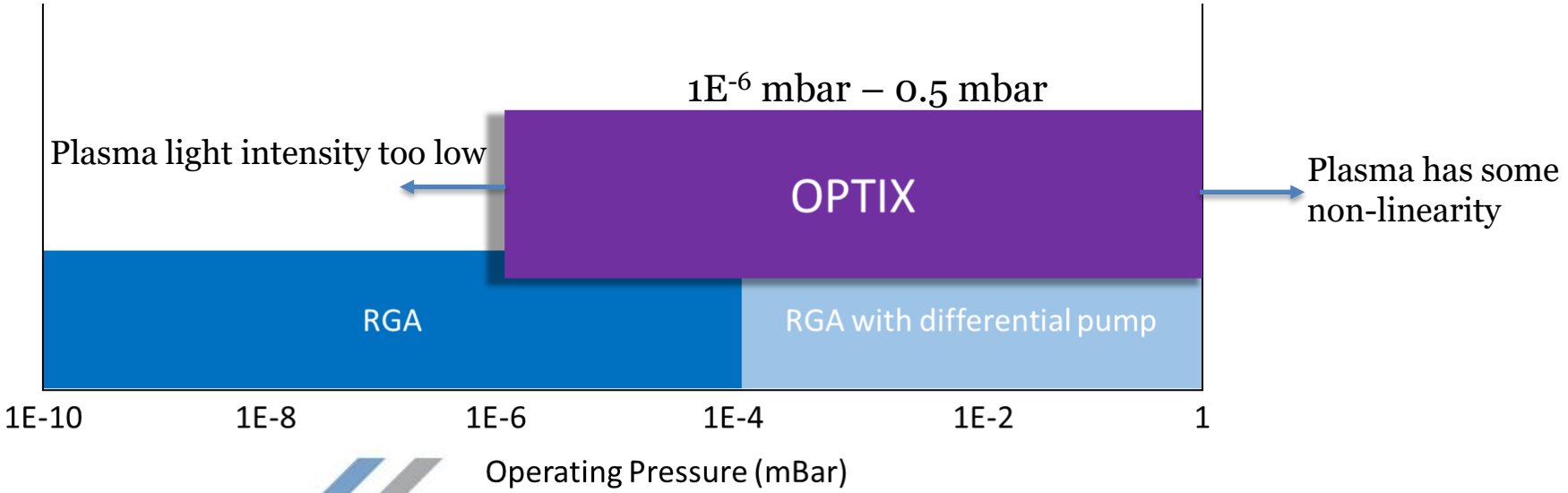
Wide pressure range remote plasma generator

High intensity plasma

Wide range spectrometer 200-850nm

Spectrum analysis gives species composition



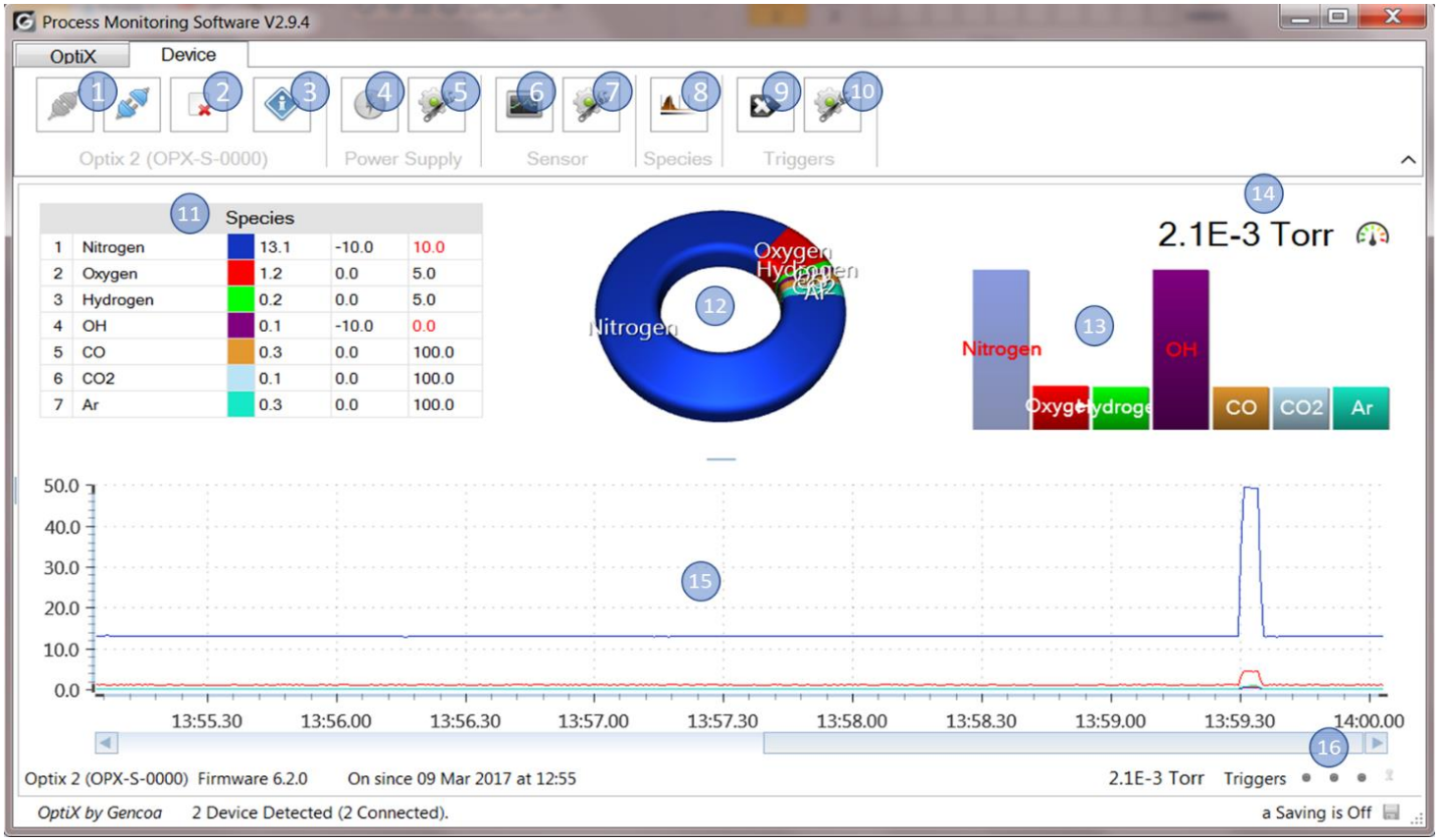


OPTIX leak detection and new applications outside conventional RGA technology

Unlike RGA's the OPTIX detector is separated from the plasma and chemical environment by a physical window. Hence the detector is not affected by the nature of the media to be analyzed. As long as the plasma can be sustained & light is visible, chemical information can be obtained. This results in a much more rugged device.

Leak checking	Volatile deposition processes	End-point	Chemical analysis from atmosphere
Other gases such as N2	OLED, CVD	Etching	Gas chromotography
Refrigerant and air conditioning systems	ALD, MOCVD	Process gas consumption	Liquid and fuels composition analysis
Fuels and oil leaks from components	Flash evaporation	Freeze drying	APCI Atmospheric pressure chemical ionization analysis

OPTIX Software - Easy to use software with advanced process applications for plasma gas monitoring of vacuum – can be purchased with spectrometer head alone

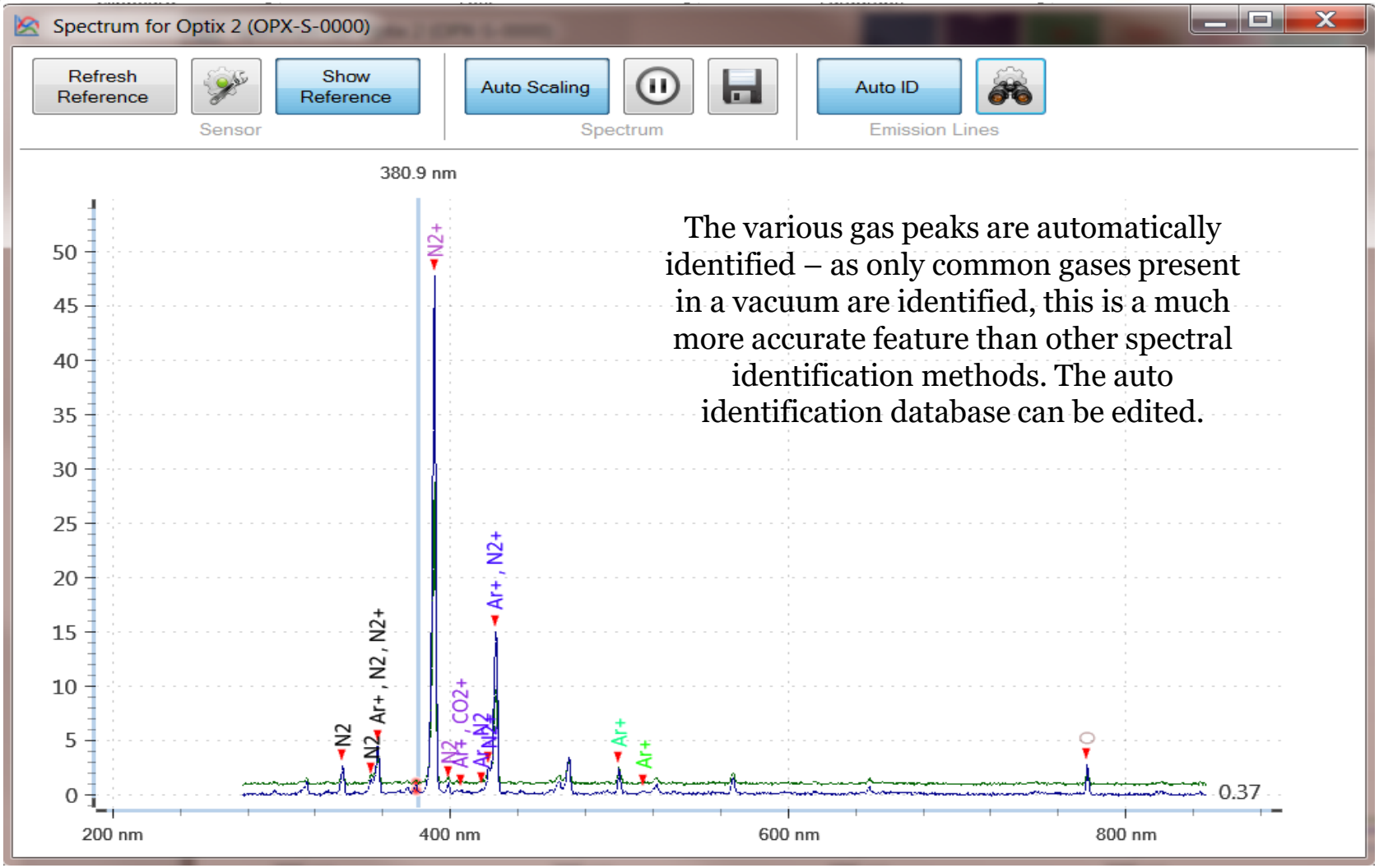


1. **Connect / Disconnect Remove Optix sensor**
2. **Optix Device settings**
3. **Turn the power supply on. Power supply settings.**
4. **View Spectrum plot.**
5. **Sensor settings. Species setup screen.**
6. **Clear triggers.**
7. **Trigger settings**
8. **Species table.**
9. **Species doughnut.**
10. **Trigger settings.**
11. **Species Table.**
12. **Species doughnut.**
13. **Species bar chart.**
14. **The current total pressure reading.**
15. **Species trend view.**
16. **Trigger status.**

OPTIX Software – Highly refined with the following features included

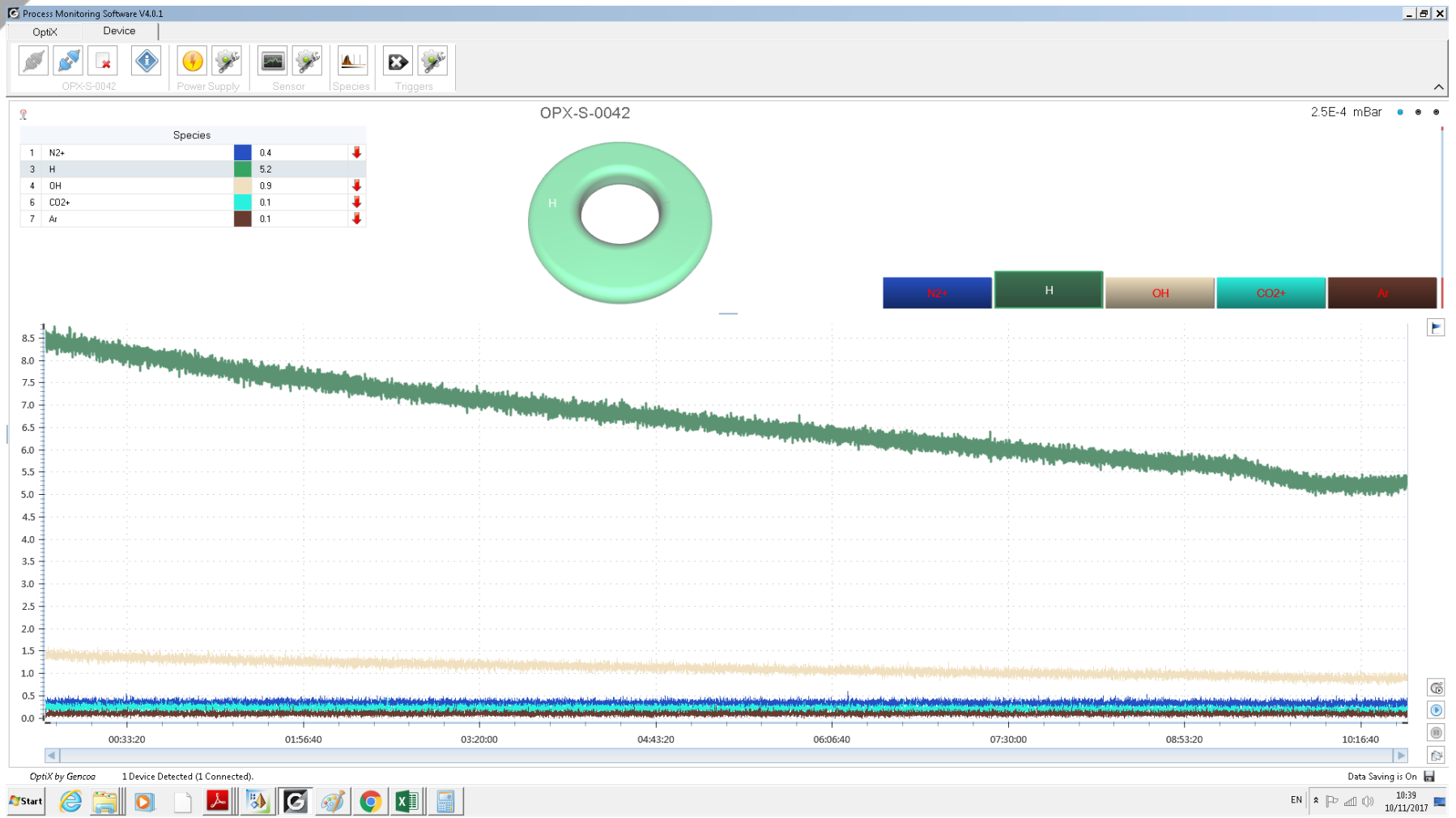
- Quantitative gas analysis down to 2 ppm (Pressure gauge added for QGA)
- Gas mixture balance – up to 8 gases – can be selected
- Process gas tracking with trigger / alarm outputs
- Full spectrum view 200-850nm, control of integration time for sensitivity adjustments
- Tuneable spectrum view – more focussed range
- Automatic gas peak detection – gas auto indentification database can be adjusted to incorporate additional un-common peaks of specific interest
- Leak detection mode for any gas
- Process water tracker with triggers / alarm outputs
- Chamber pump-down tracker with triggers / alarm outputs
- Vacuum switch to prevent accidental operation at atmosphere
- In-built vacuum pressure reading
- Control of plasma generator to tune power parameters
- Multiple sensor monitoring
- Multiple language display options – English, Japanese, Chinese, French, Spanish

Software Spectrum View - spectrum displays the constituent species of the plasma

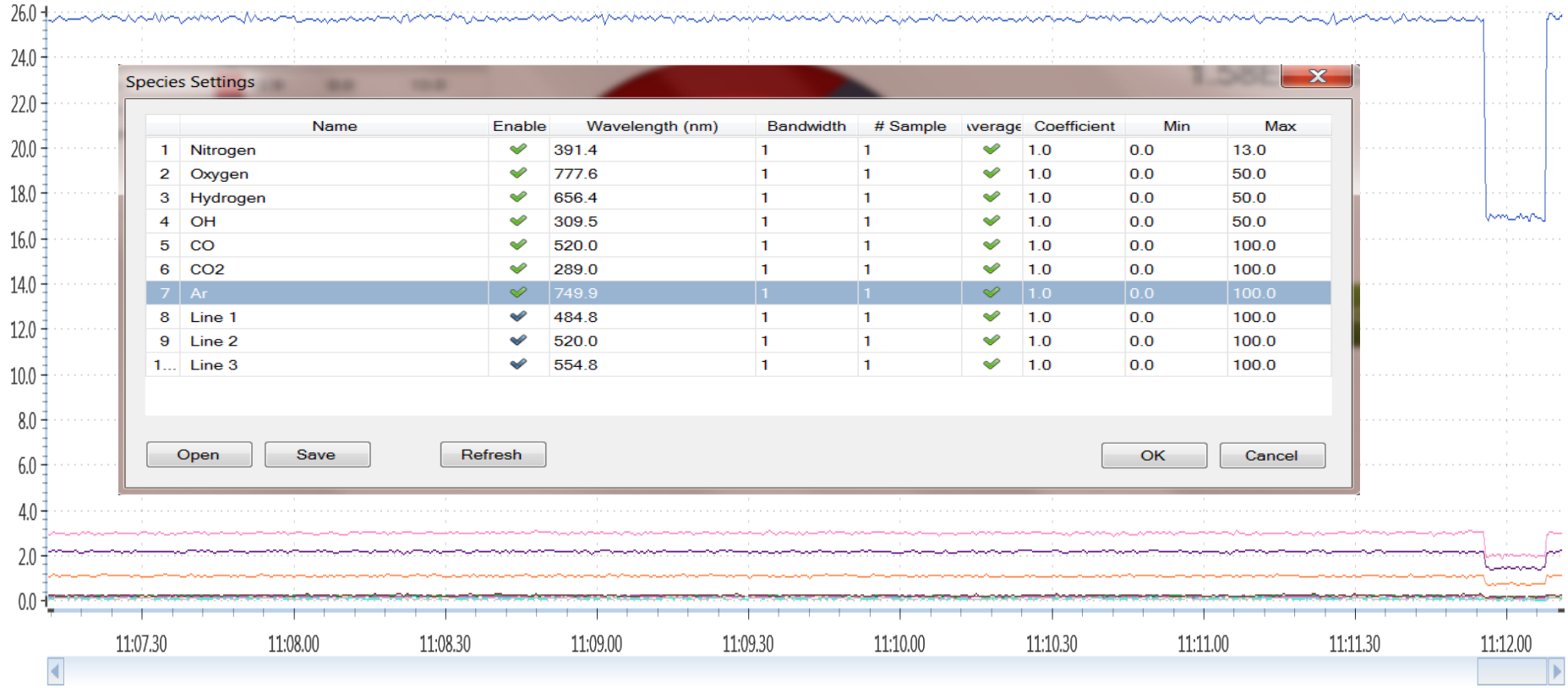


The various gas peaks are automatically identified – as only common gases present in a vacuum are identified, this is a much more accurate feature than other spectral identification methods. The auto identification database can be edited.

Software Gas Tracking View



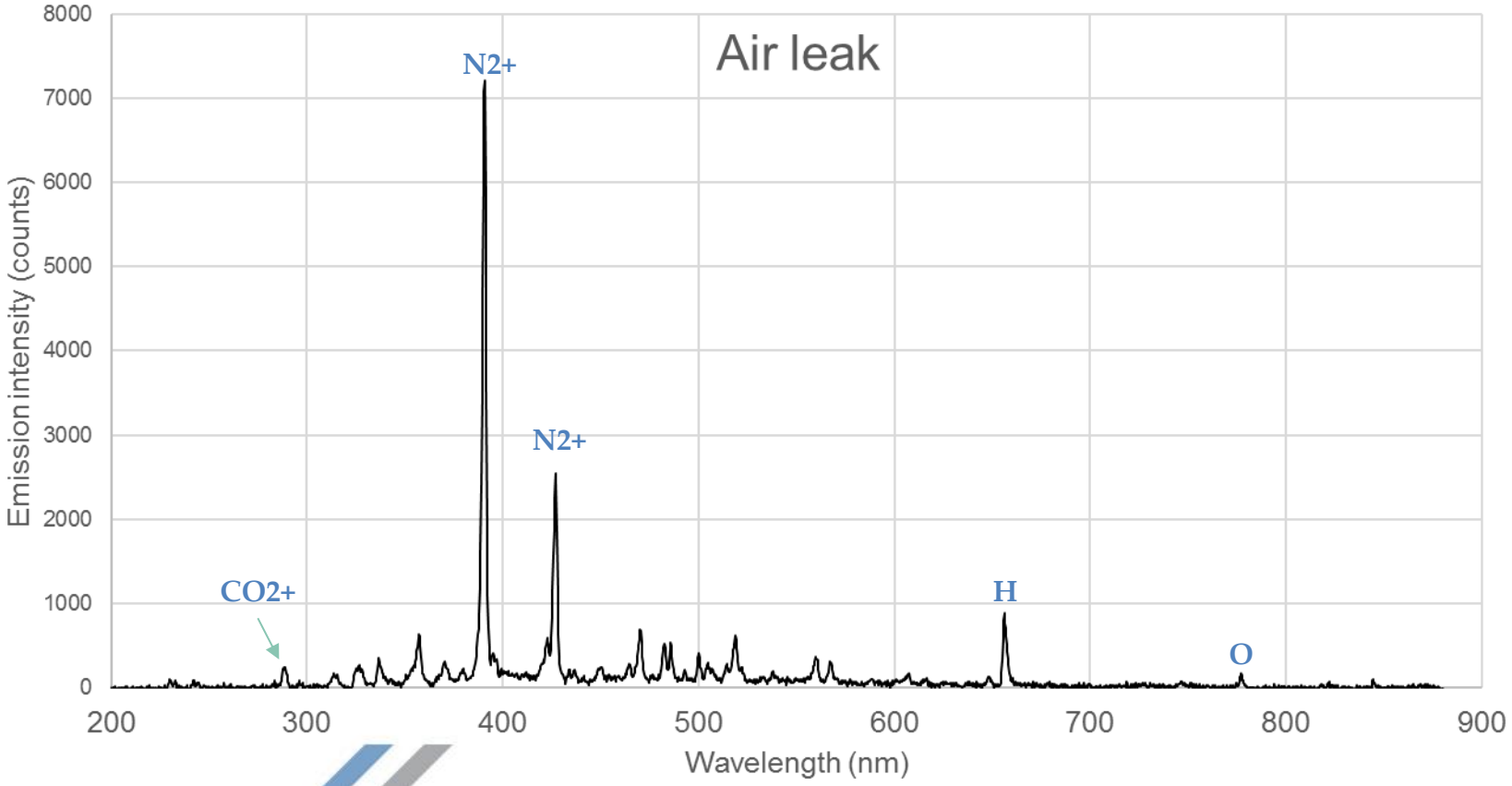
OPTIX Software – an unlimited number of gas species can be monitored via the trend-line feature



OPTIX RPGA Spectrum Interpretation

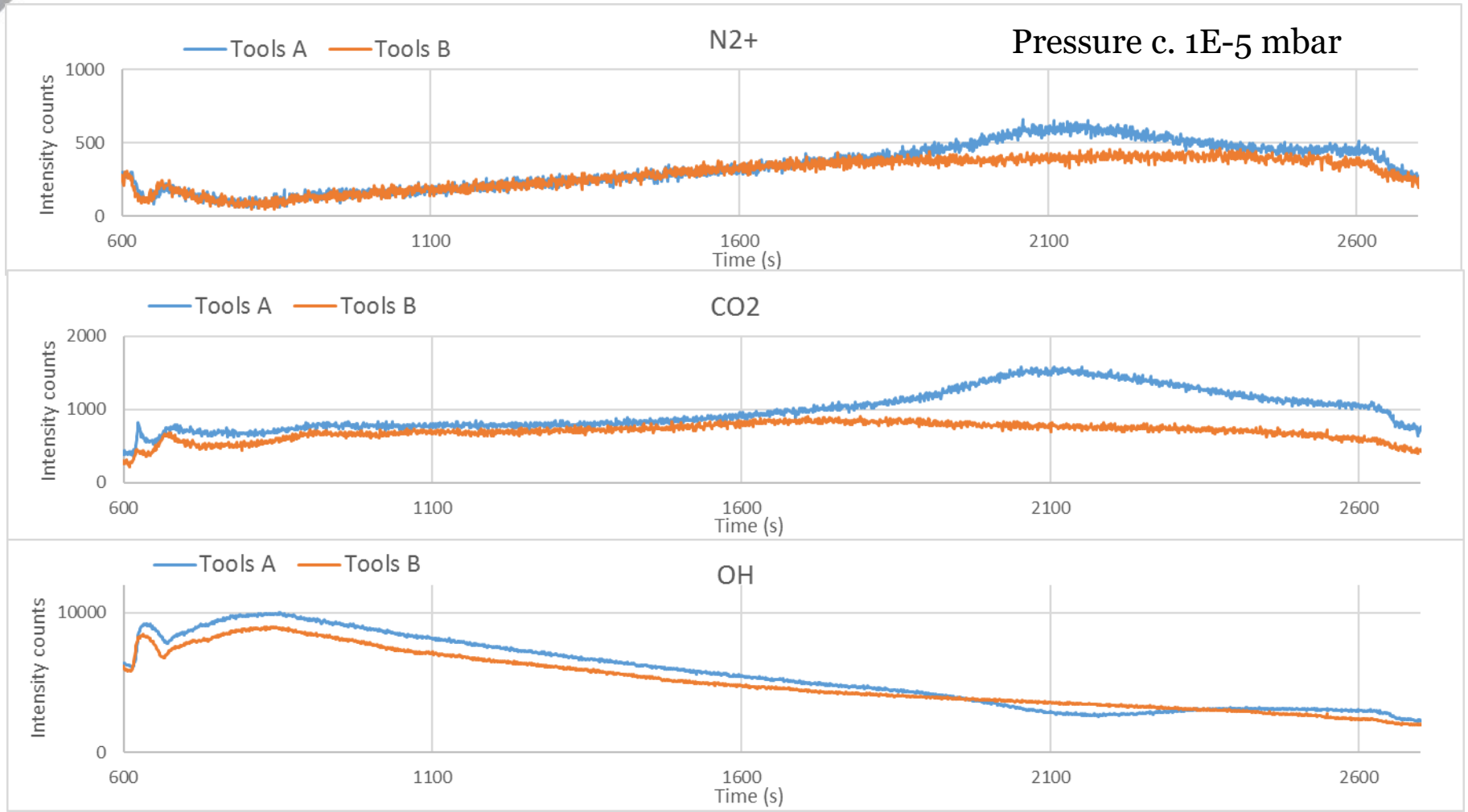
- A single leak can emit multiple emission lines showing the exact composition
- OPTIX automatically identifies the species which makes interpretation easier

Example of an air leak:

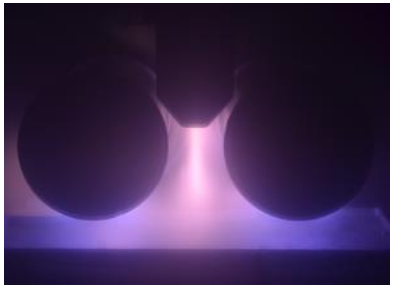


OPTIX gas measurement during heating phase of an Arc based hard coating cycle

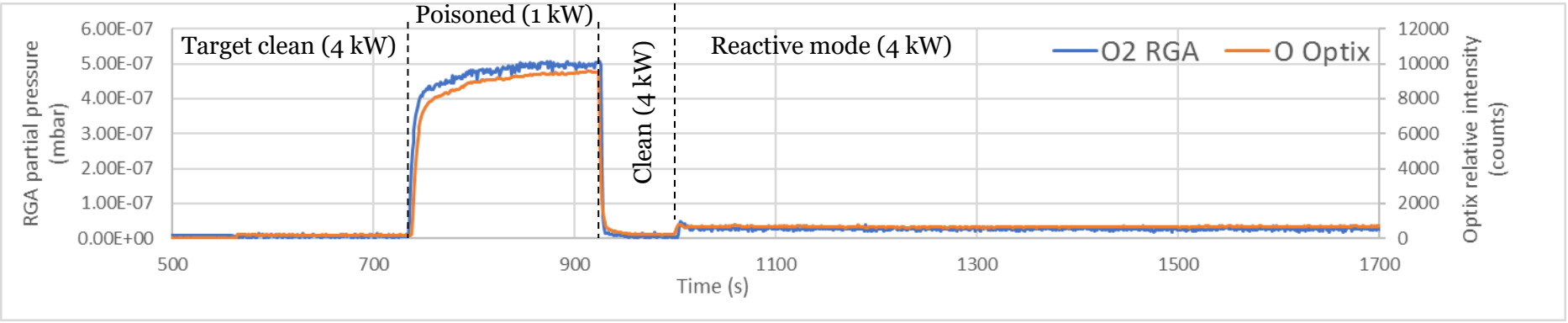
- Outgassing of species during heating phase prior to coating
- Comparison of outgassing between different tools

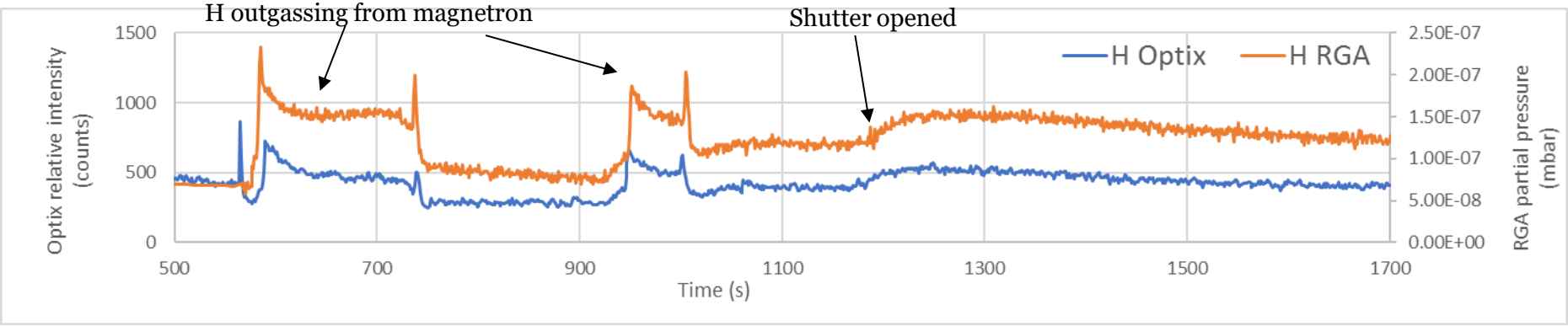


OPTIX gas measurement during reactive sputtering, comparison with high pressure RGA



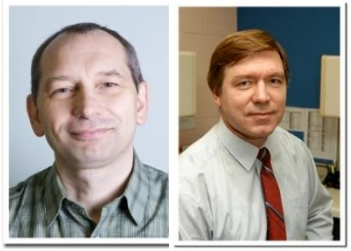
Reactive sputtering – process pressure 4E-3 mbar



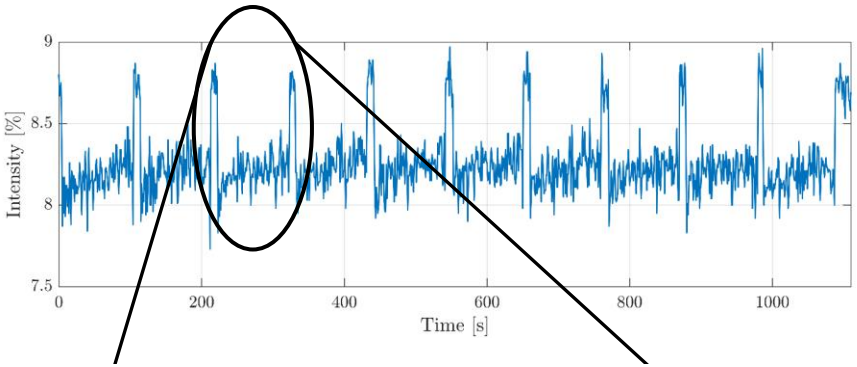


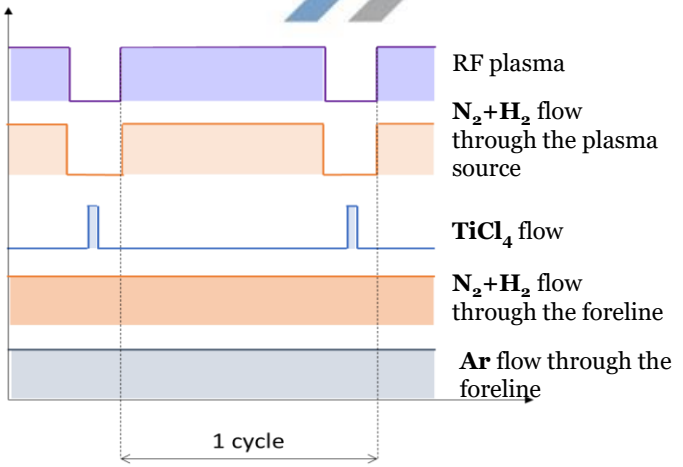
OPTIX for ALD Deposition cycle monitoring

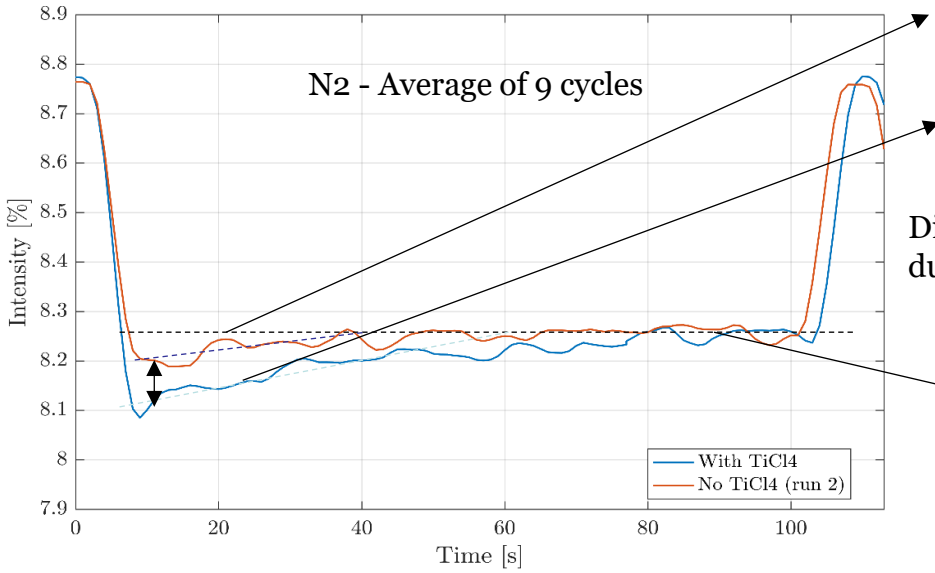
O. Zabeida, S. Woodward-Gagne, L. Martinu,
Polytechnique Montreal



TiN deposition cycle – monitoring film growth







Cycle **with no** TiCl4

Cycle **with** TiCl4

Difference is due to N2 consumption during film growth

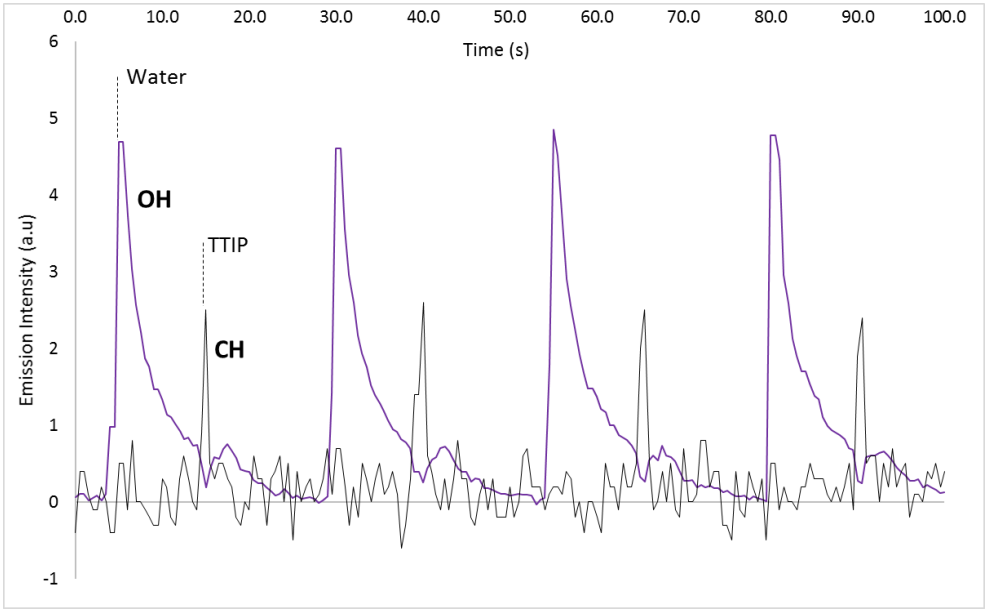
Film growth ends

OPTIX for ALD Deposition cycle monitoring

UNIVERSITY OF LIVERPOOL

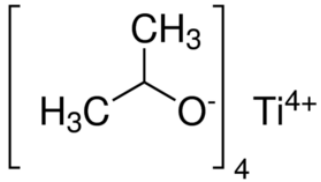
Dr. Richard Potter and Ben Peek

TiO2 deposition cycle monitoring



Heated 90°C

Titanium isopropoxide (TTIP)



Precursor injection

ALD reactor

c. 100 mTorr

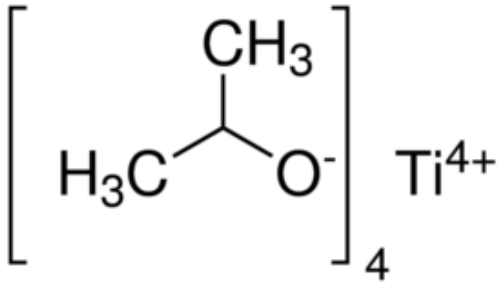
Mechanical pump

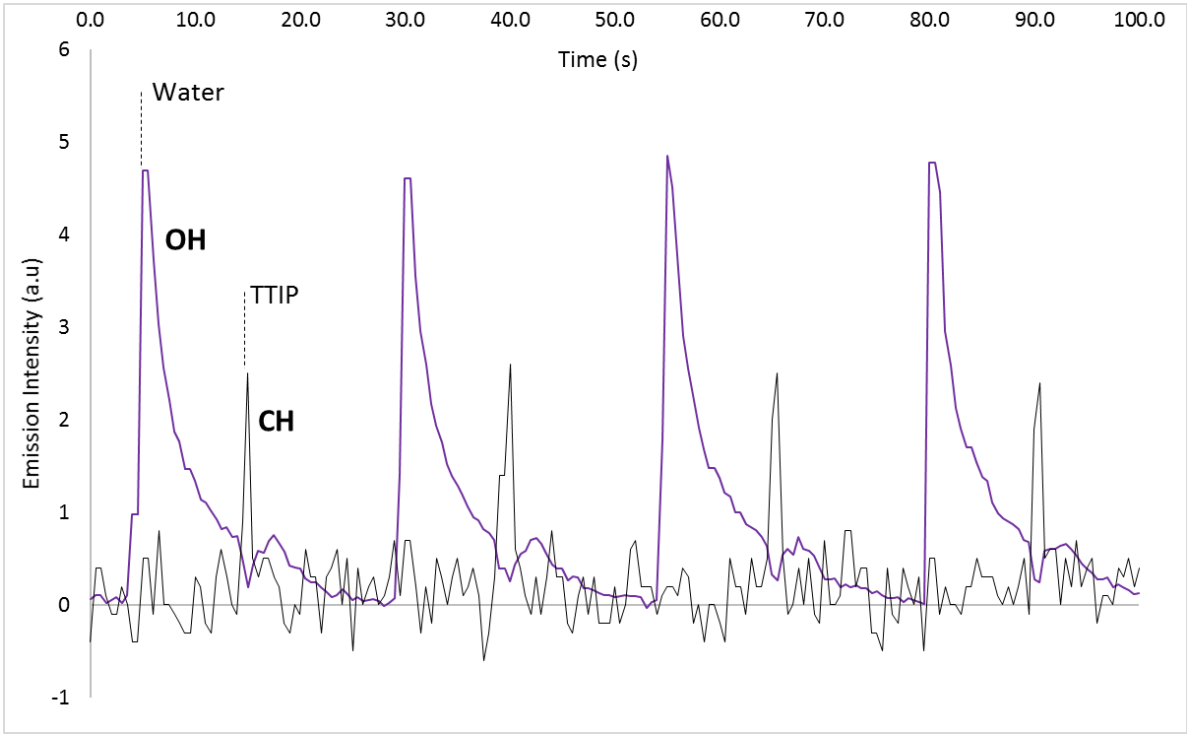
ALD Deposition cycle monitoring

TiO_2 deposition cycle monitoring

- Precursor A – Water vapour
- Precursor B - Titanium isopropoxide (TTIP)
- Water observed via OH (309.6 nm) and TTIP via CH (387 nm)
- 25s cycle time, 2000 cycles, 13 hours for complete process

Titanium isopropoxide (TTIP)





OPTIX for ALD Deposition cycle monitoring

GENCOA

UNIVERSITY OF LIVERPOOL

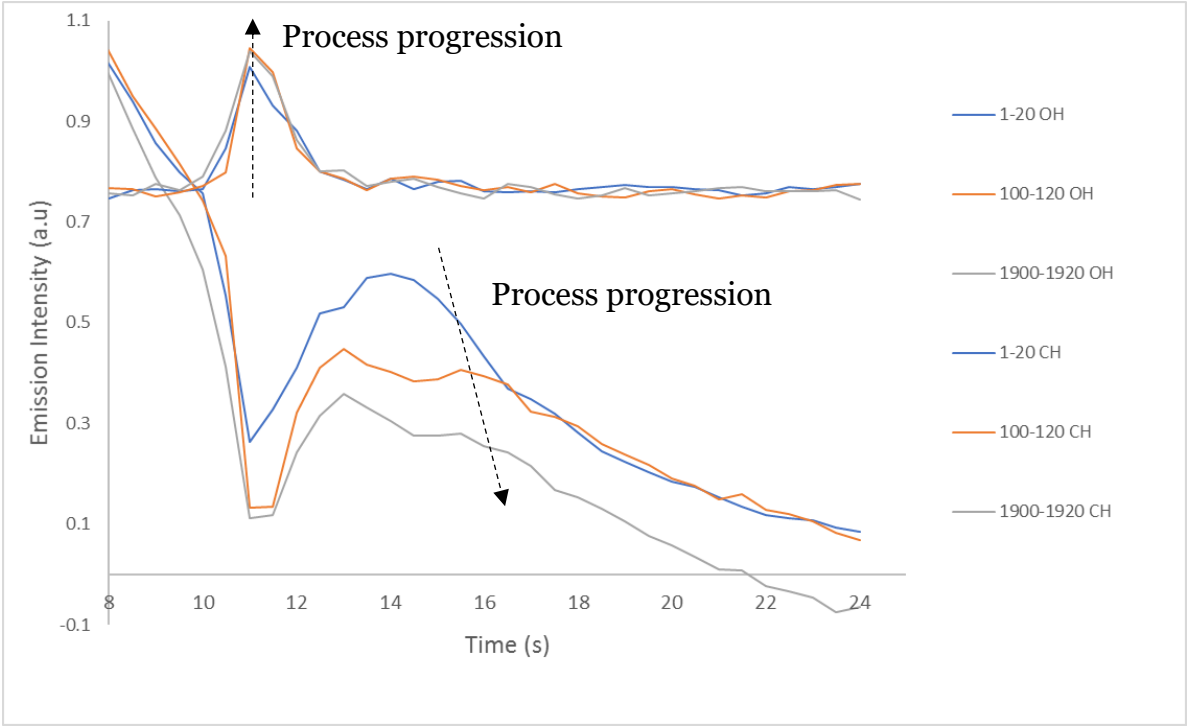
- An increase in CH observed as process progresses
- The amount of OH observed after TTIP injection decreases with time
- OH observed after TTIP likely indicator of TTIP/Surface reaction by-products

- Precursor A – Water vapour
- Precursor B - Titanium isopropoxide (TTIP)
- Water observed via OH (309.6 nm) and TTIP via CH (387 nm)
- 25s cycle time, 2000 cycles, 13 hours for complete process

Start (cycles 1-20)

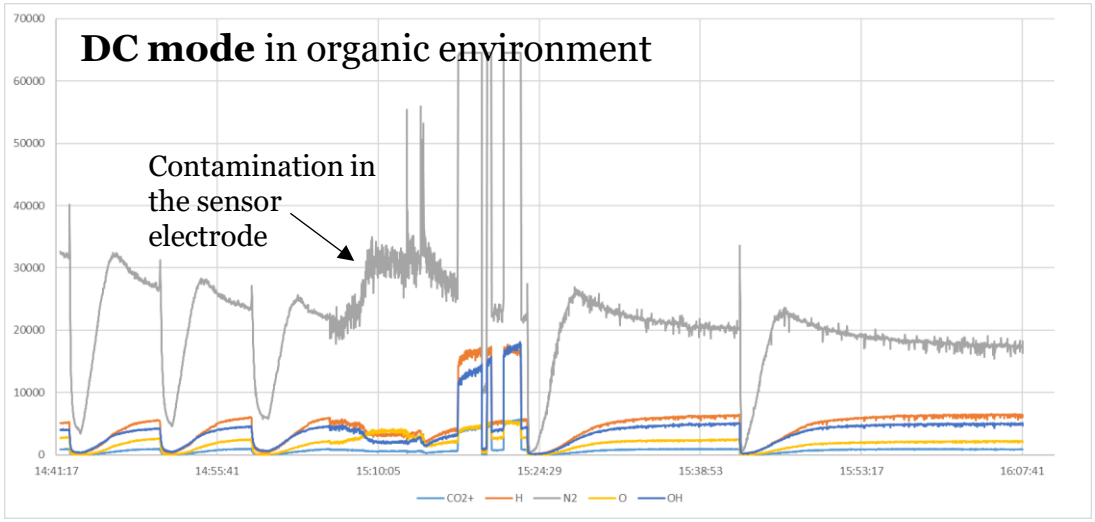
Mid (cycles 100-120)

End (cycles 1900-1920)

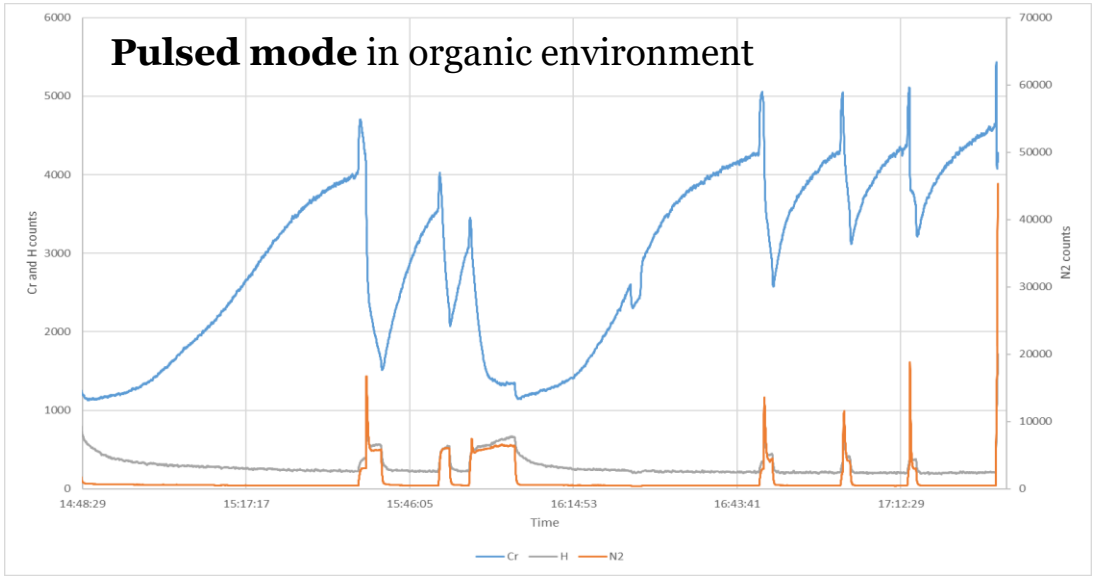


OPTIX has two possible power modes DC & Pulsed Mode

Hydrocarbon contamination prevention via patented pulsed power mode



DC mode operation results in eventual contamination of the sensor's electrodes – resulting in unstable operation



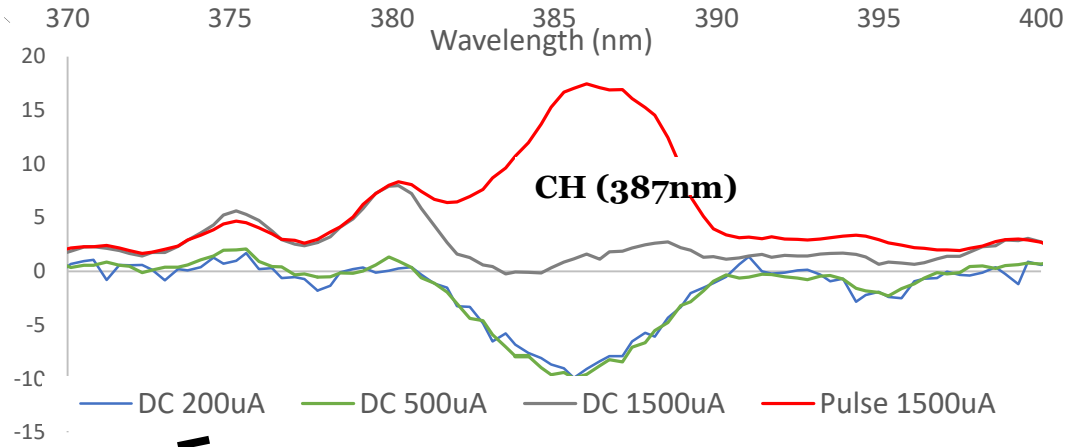
Pulsed mode operation is able to continuously "sputter clean" the electrodes resulting in stable operation over time

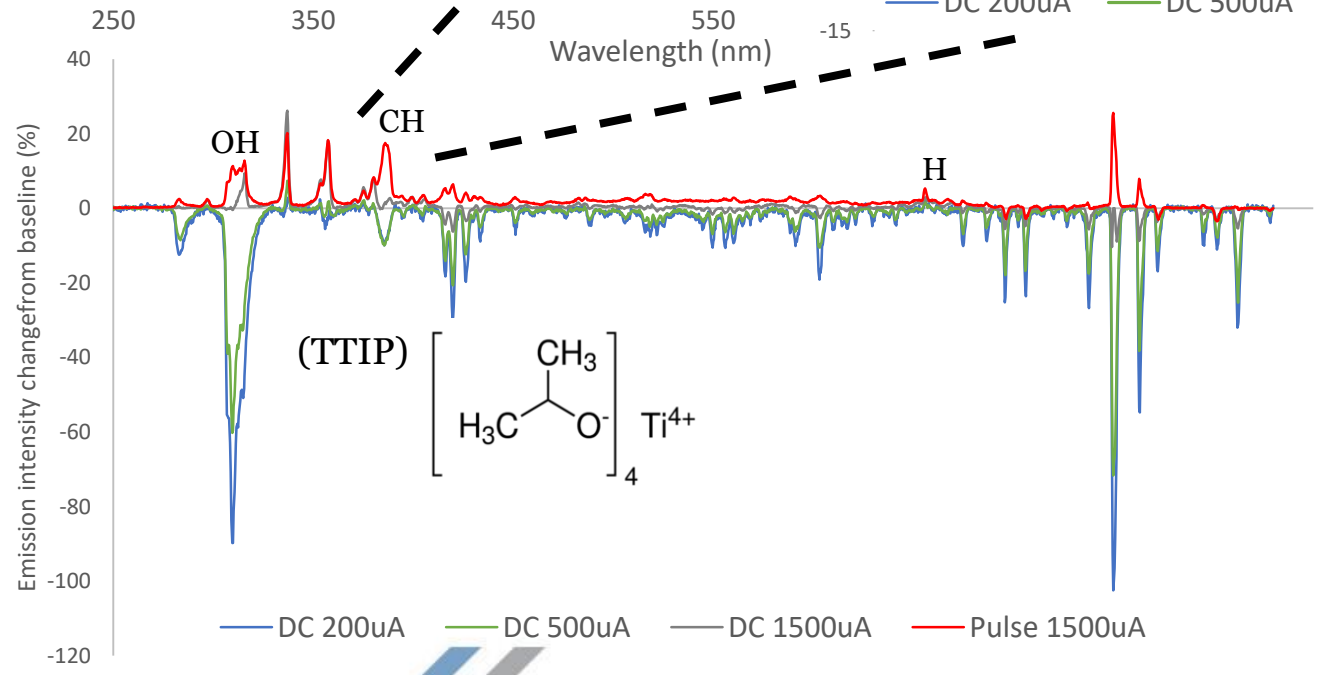
PULSED MODE is recommended for all process with high levels of volatile species – ALD, CVD, MOCVD, OLED

OPTIX Pulsed Mode
Organics sensitivity enhancement

OPTIX plasma generation by DC power mode of 200, 500 & 1500µA compared with pulsed DC at 1500µA

Spectral Zoom

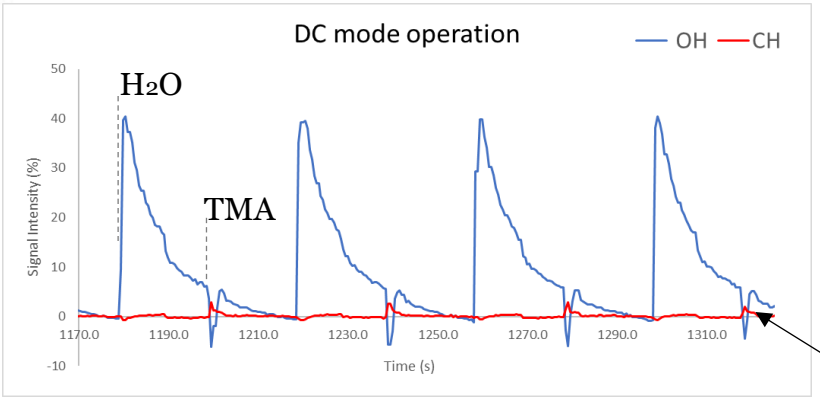


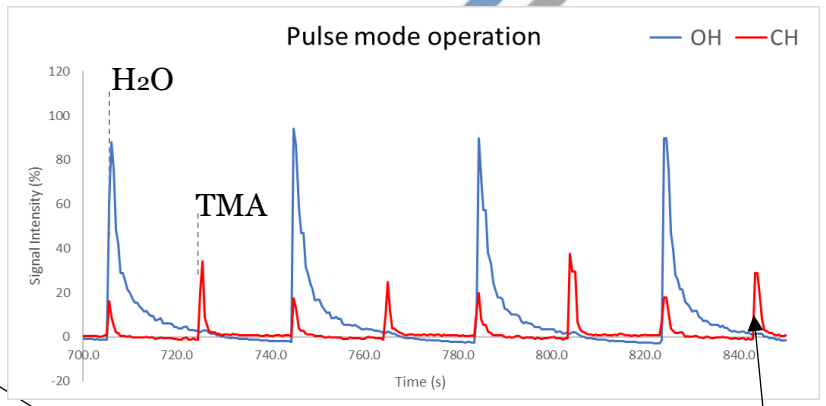


- DC mode operation can result in weak sensitivity or even supressed readings for detection of high concentrations of hydrocarbons
- **OPTIX pulsed mode** significantly increases detection sensitivity of large organic molecules

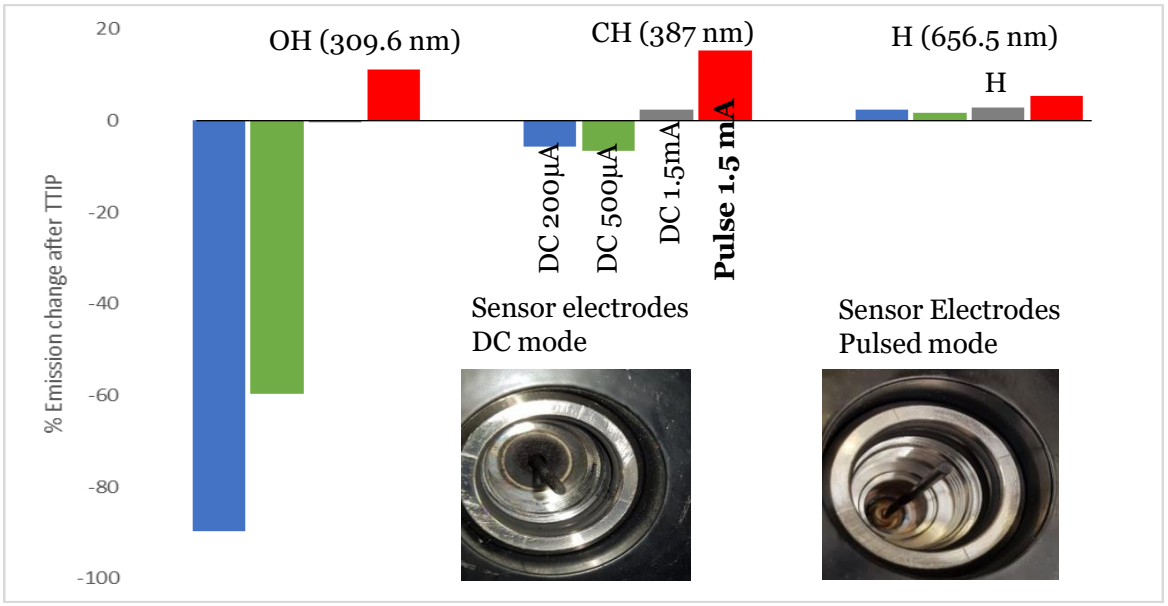
OPTIX Pulsed Mode
Organics sensitivity enhancement

- **Optix pulsed mode** significantly increases detection sensitivity of large organic molecules





Signal change after injection of TTIP



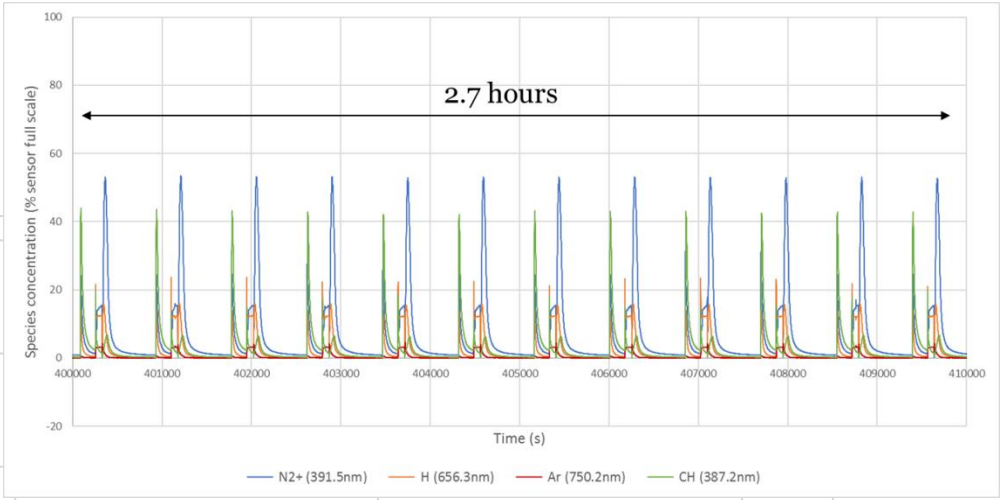
Very weak CH reading from TMA with DC mode – CH reaction by product not detected

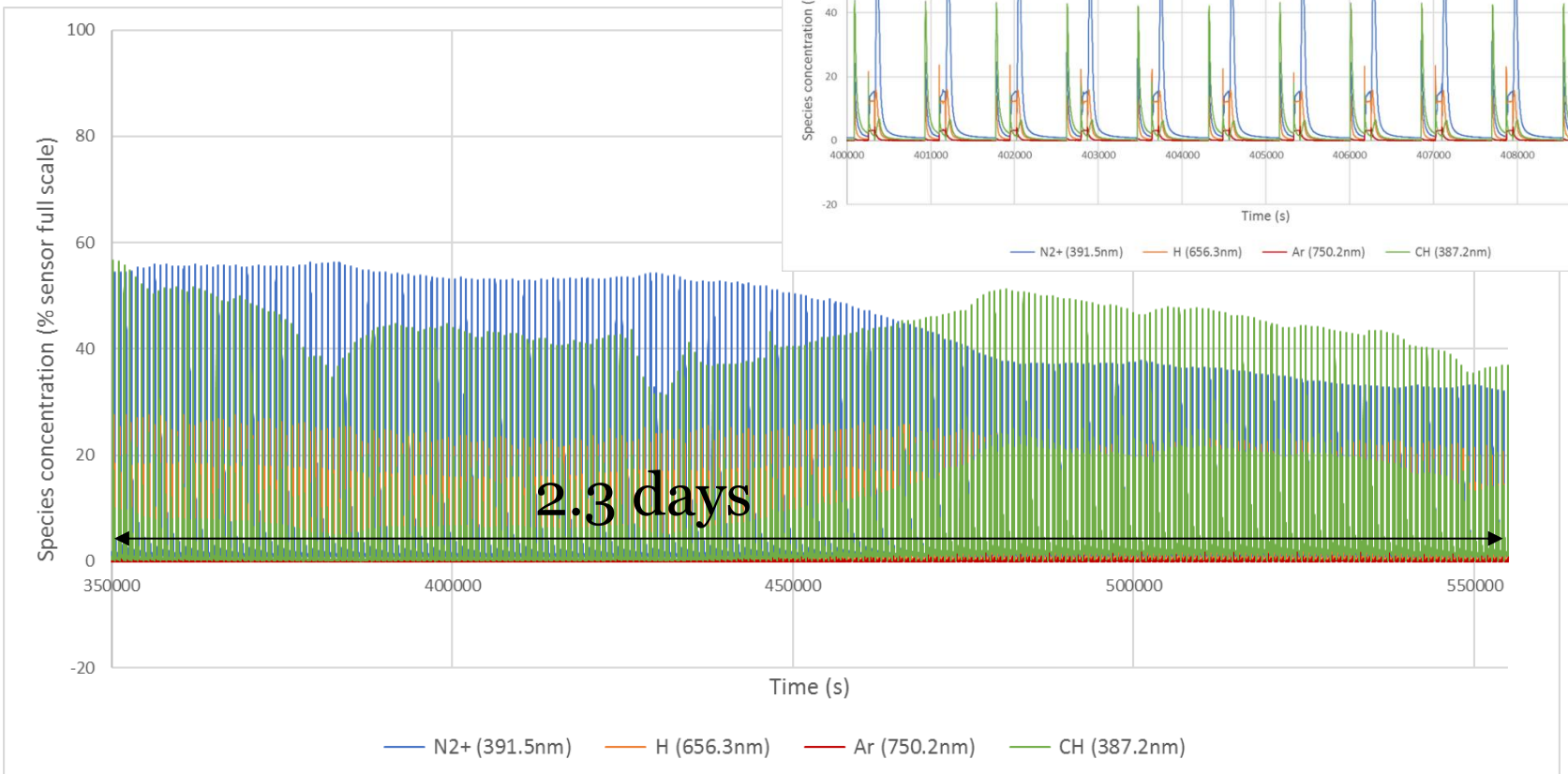
Strong CH reading from TMA detected with pulsed DC mode - CH from methane reaction by product detected

OPTIX for ALD Deposition cycle monitoring

Deposition of Nb Metal via PEALD

- Sensor over the 2+ day deposition cycle displays variations in the process over a longer period which aren't present for small timeframes

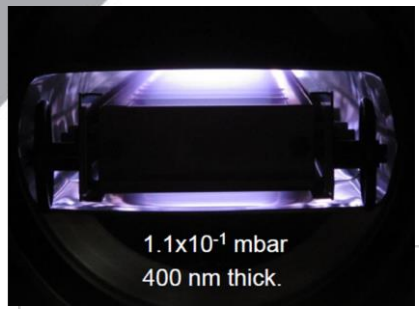


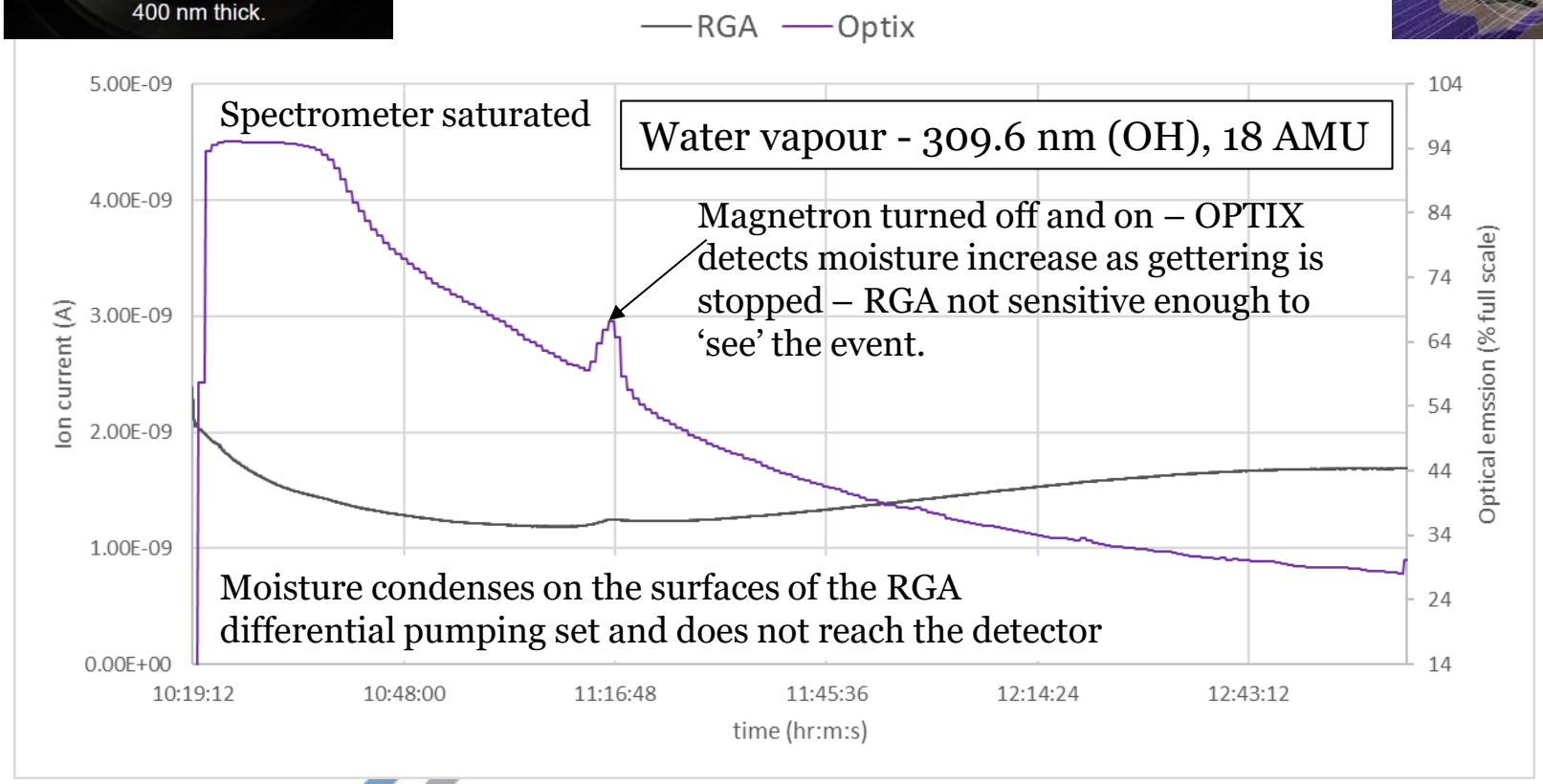


OPTIX for outgassing measurement during carbon sputter coating process

Courtesy of CERN Vacuum Surfaces and Coatings Group

Carbon sputtered coating deposited on particle accelerator inner surface to reduce secondary electron yield
Deposition pressure at **1.1E-1 mbar**
Performance of coating is sensitive to the presence of H outgassing from the magnetron environment
Objective to monitor H outgassing during the deposition



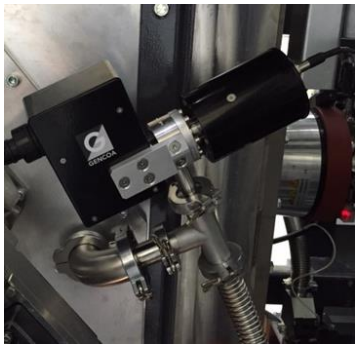


OPTIX for Web Coating

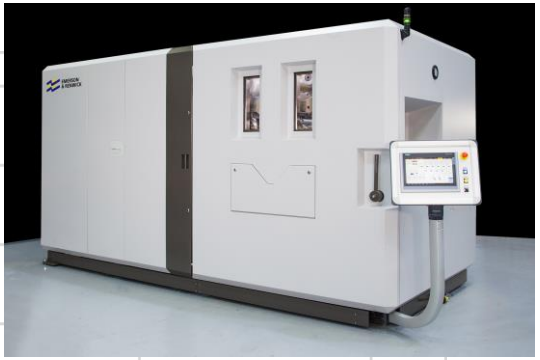
Pump down monitoring, Web material plasma pre-treatment characterising, and AlOx magnetron sputter deposition monitoring

Innovate UK
Technology Strategy Board

EMERSON & RENWICK
THE ART OF ENGINEERING

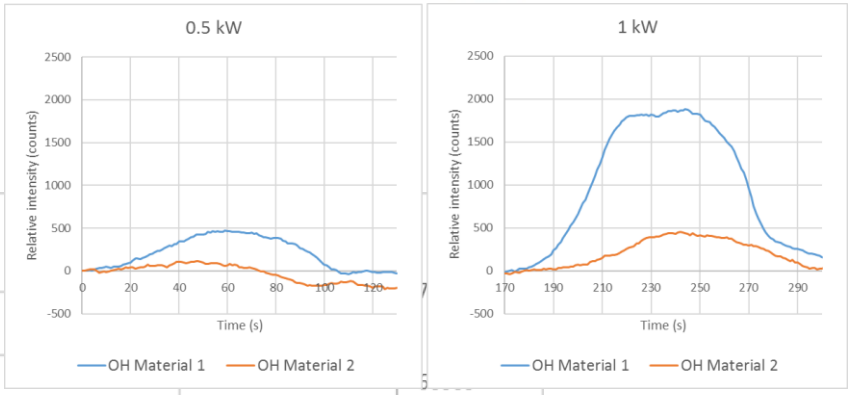


- Roll-to-roll deposition of reactively sputtered AlOx onto 125µm PET
- Optix sensor teed with a differentially pumped RGA



OPTIX monitoring plasma pre-treatment of plastic web based substrate

- Moisture liberation measured at different treater powers
- OPTIX can also compare moisture liberation from different materials



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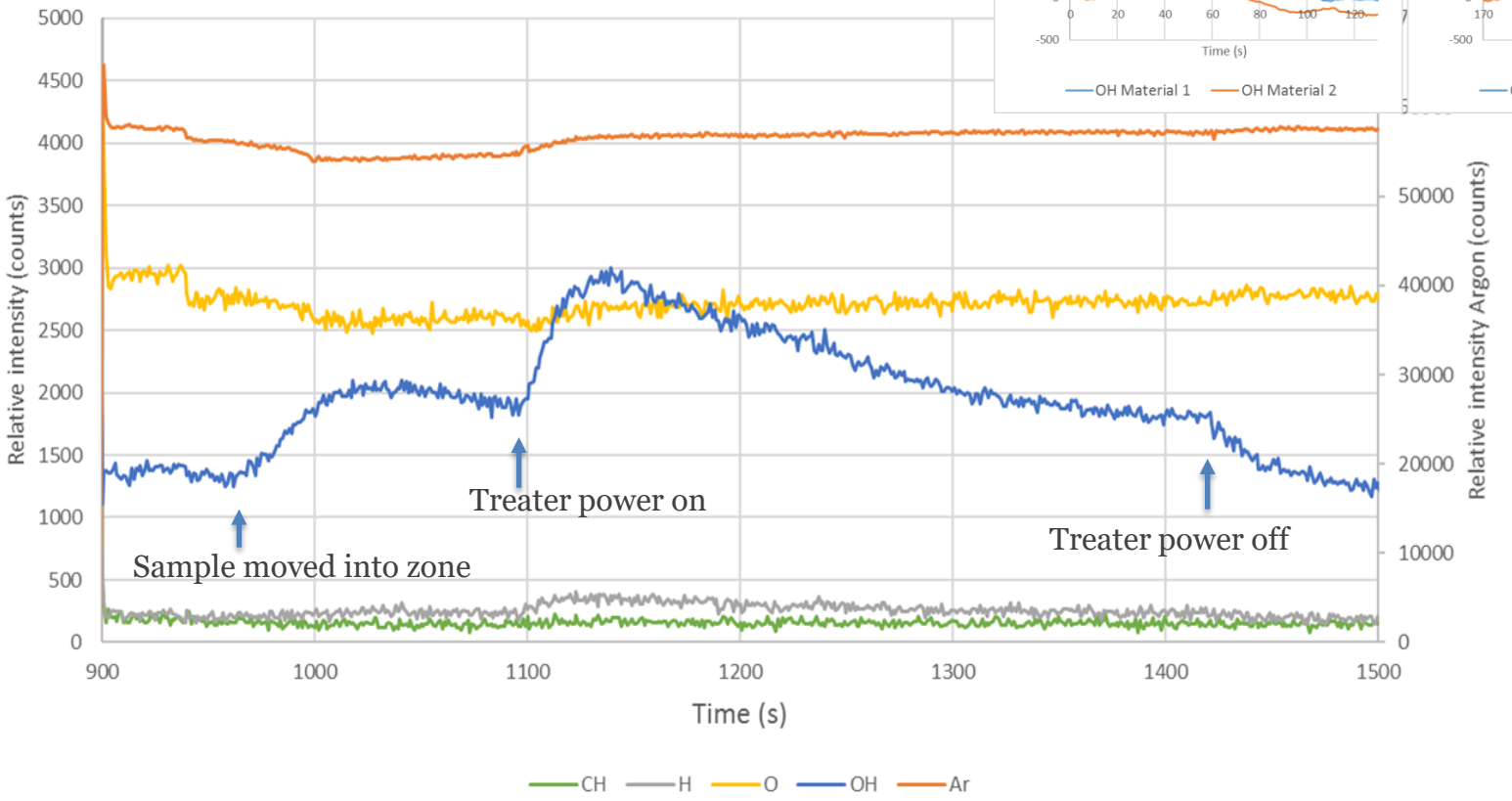
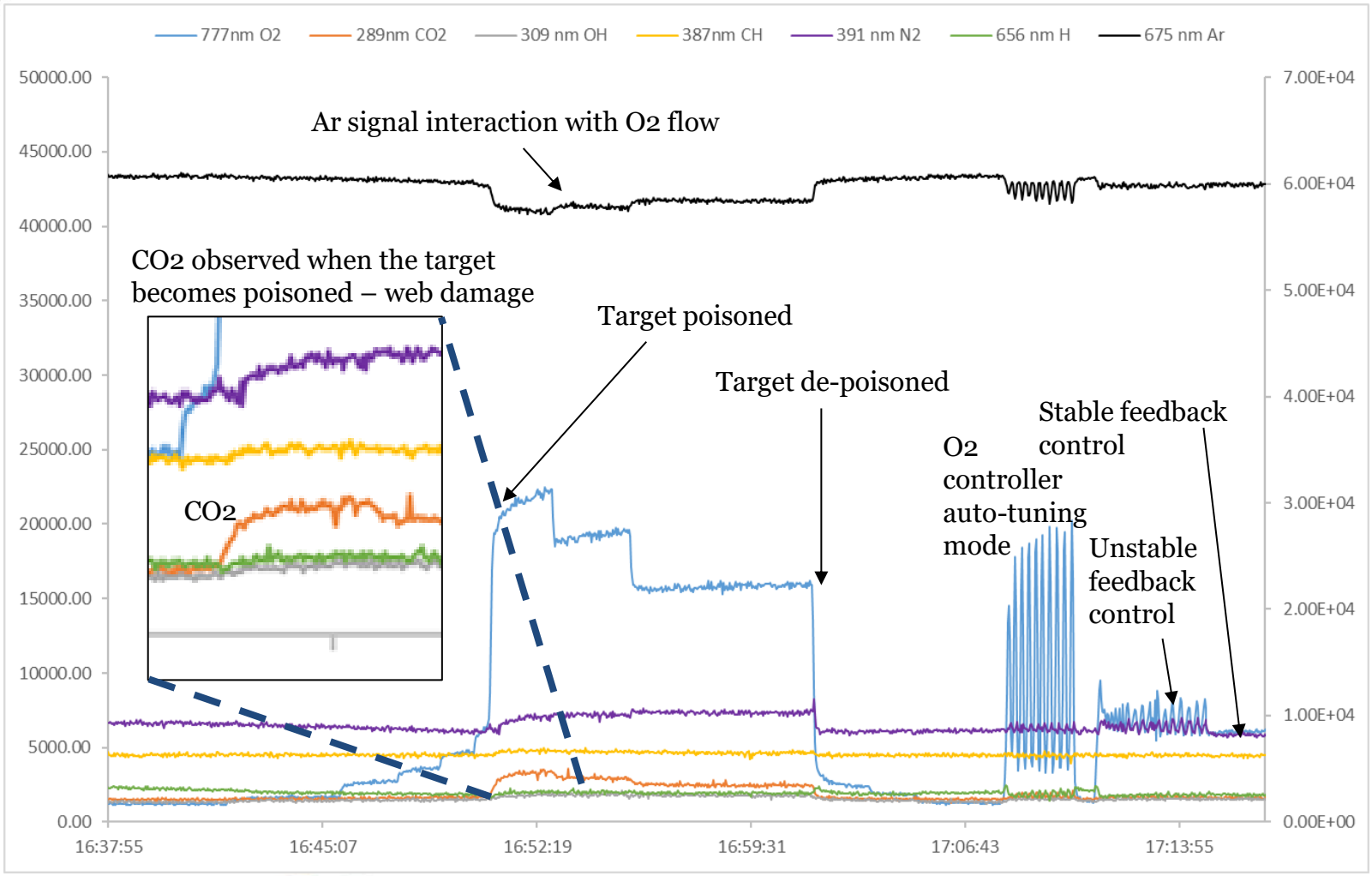
Web static plasma treatment



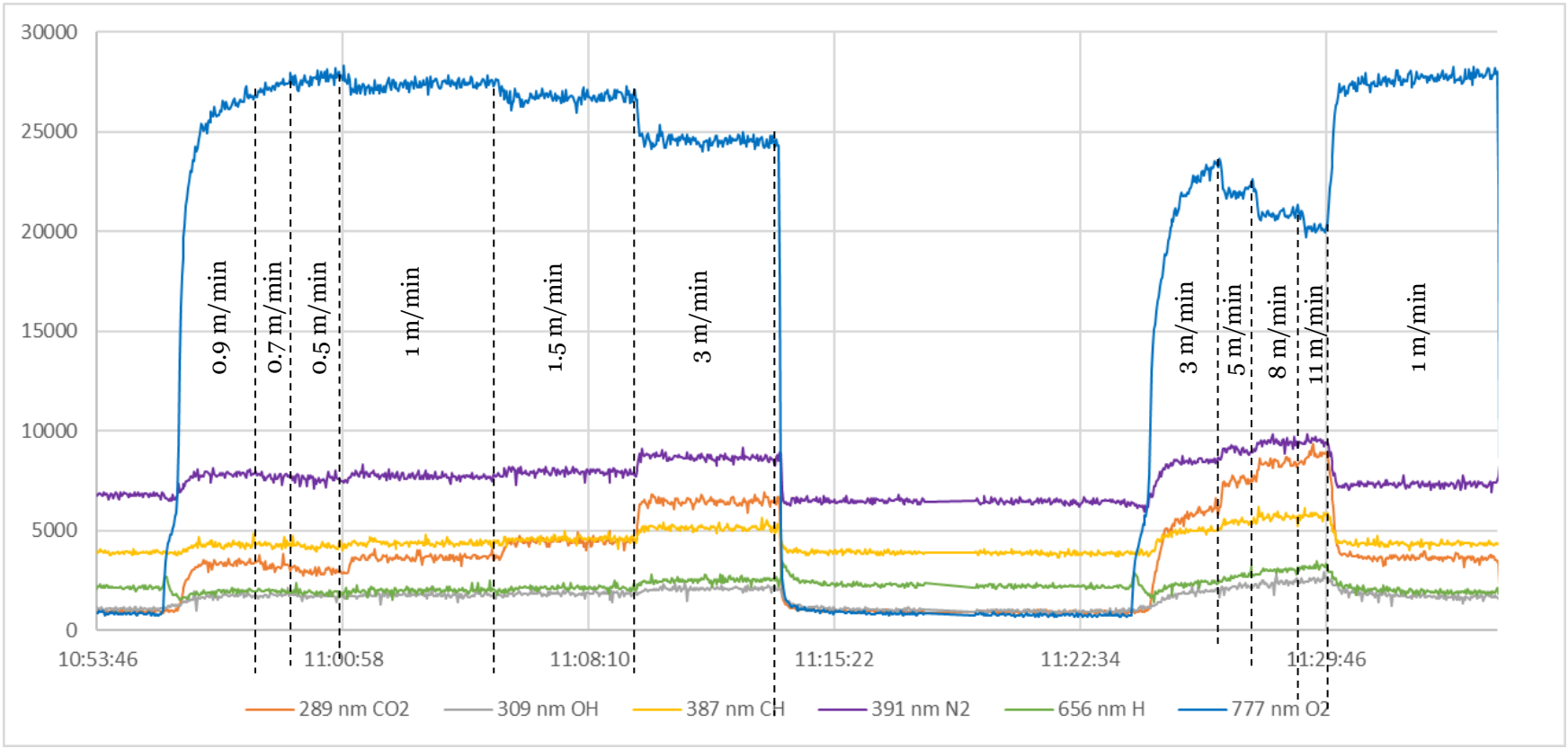
OPTIX for reactive sputtering of AlOx on roll-to-roll web coater

Reactive sputter characterisation



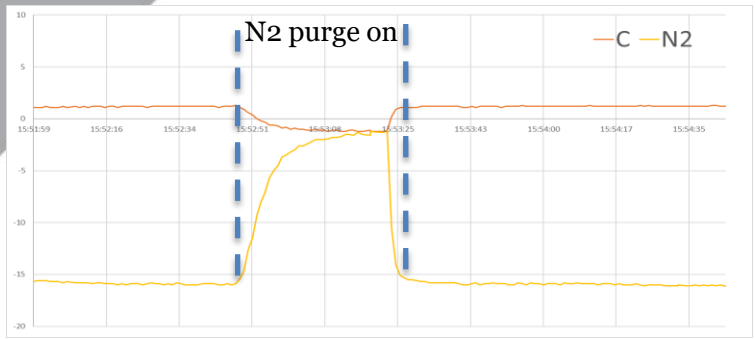
OPTIX CO2 monitoring to determine reasons for CO2 liberation in poisoned mode

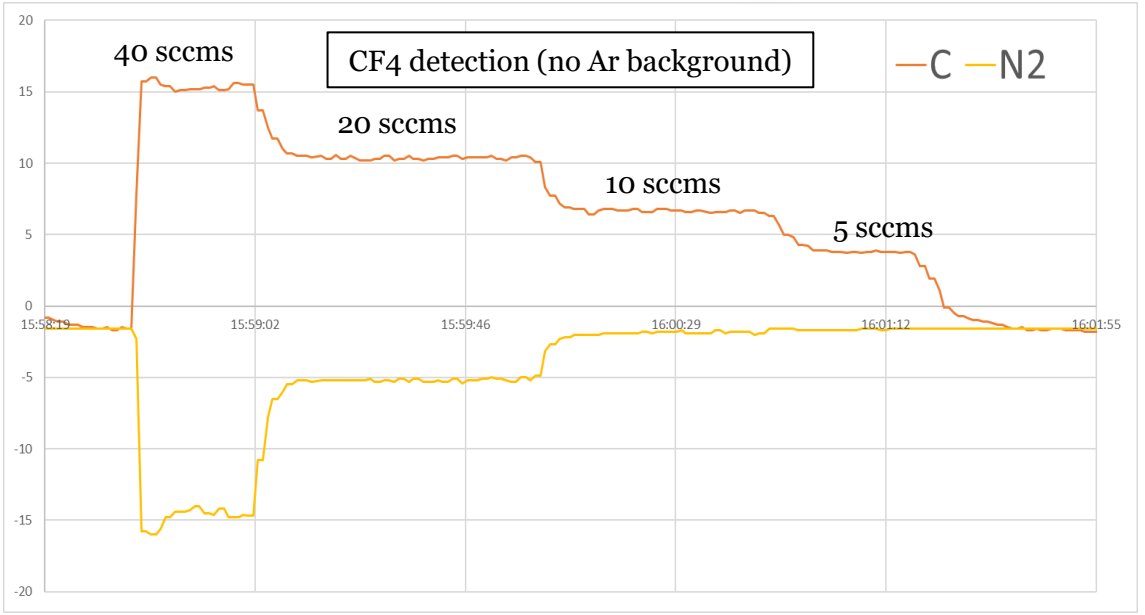
- Web speed varied to determine the source of the CO2
  - No influence = cathode
  - Influence = web
- Strong influence of web speed observed
- Inverse effect on O2 observed

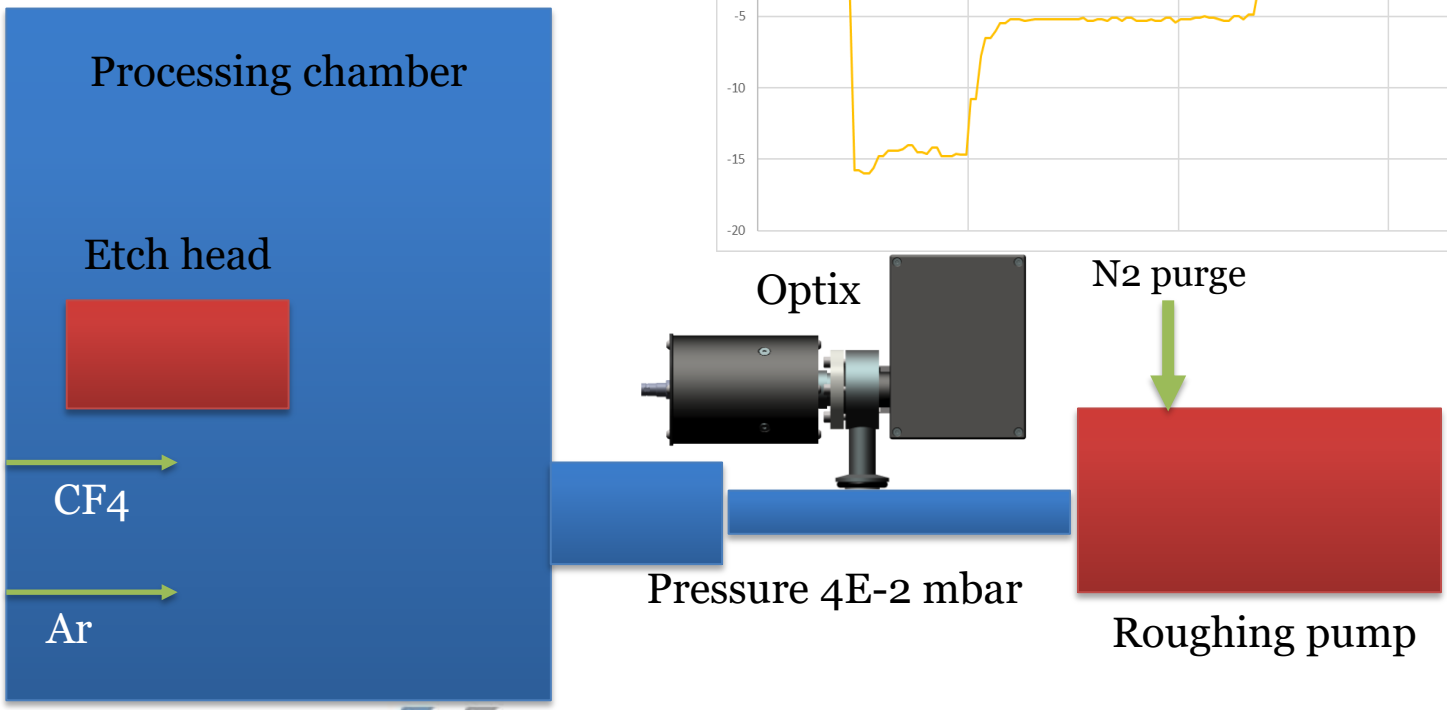


OPTIX for a reactive ion etch process

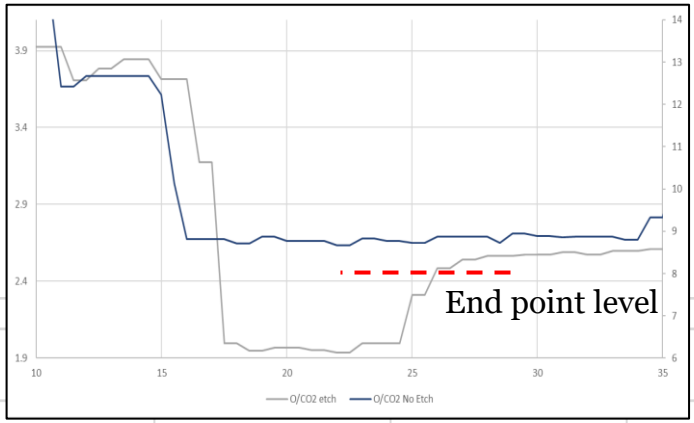
Detection of reactive ion etching effluent in the process backing line

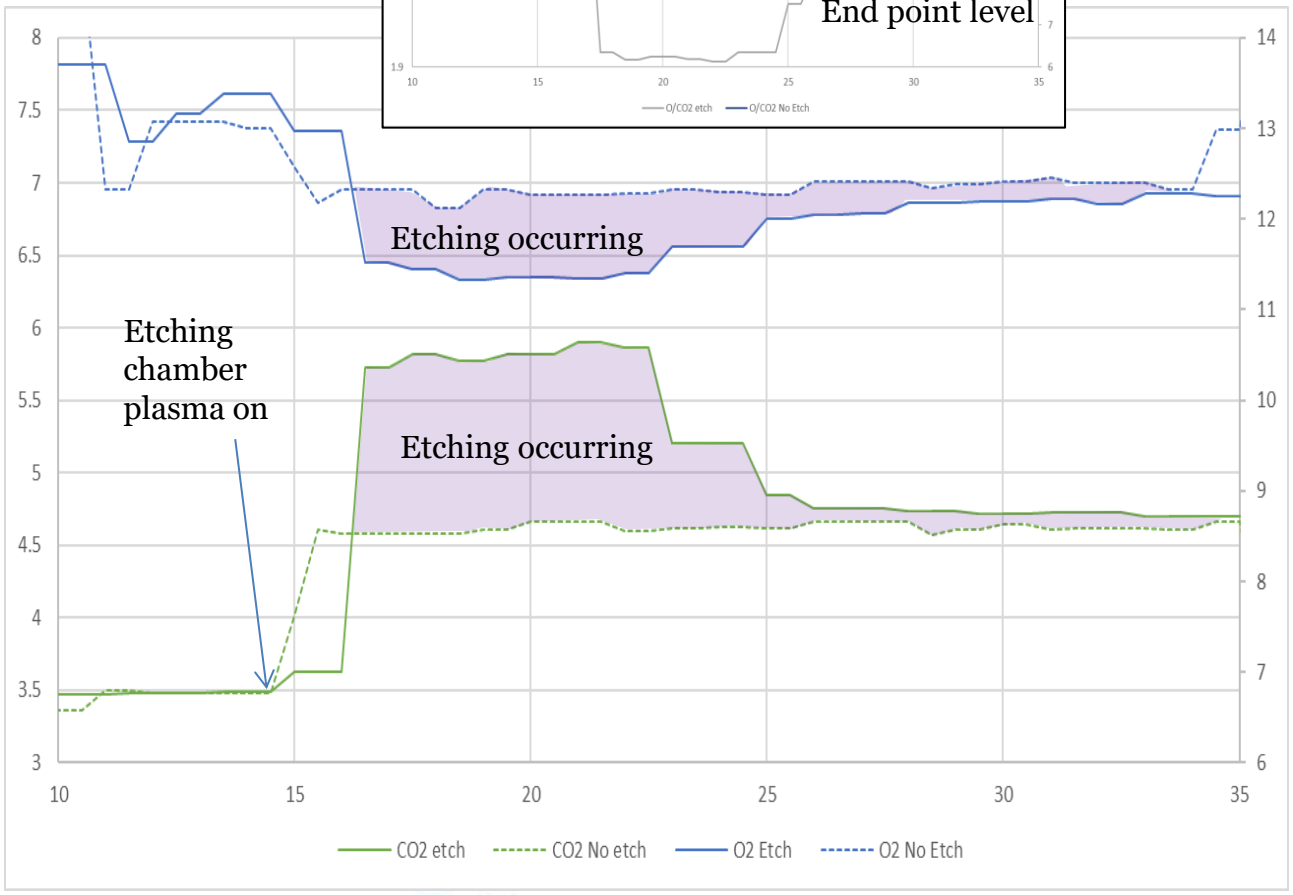


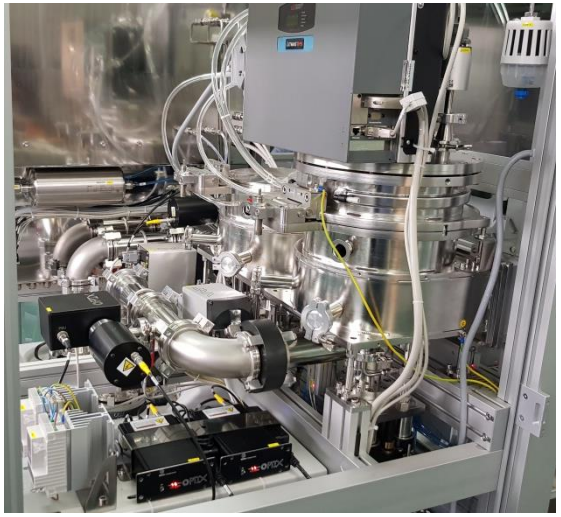


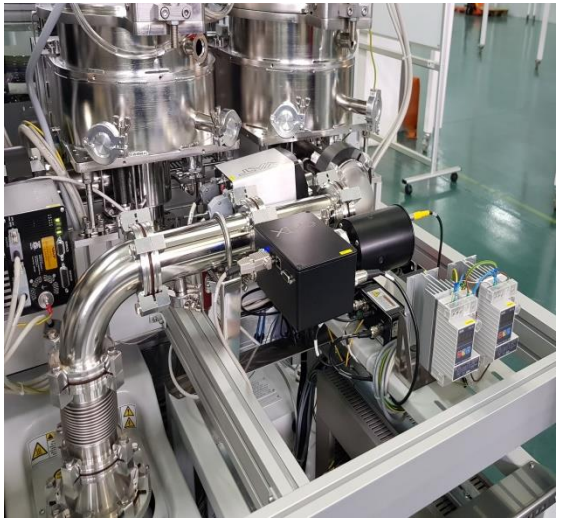


OPTIX for an etch process end point detection

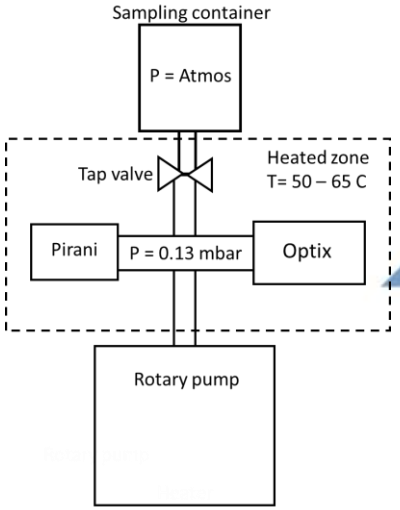




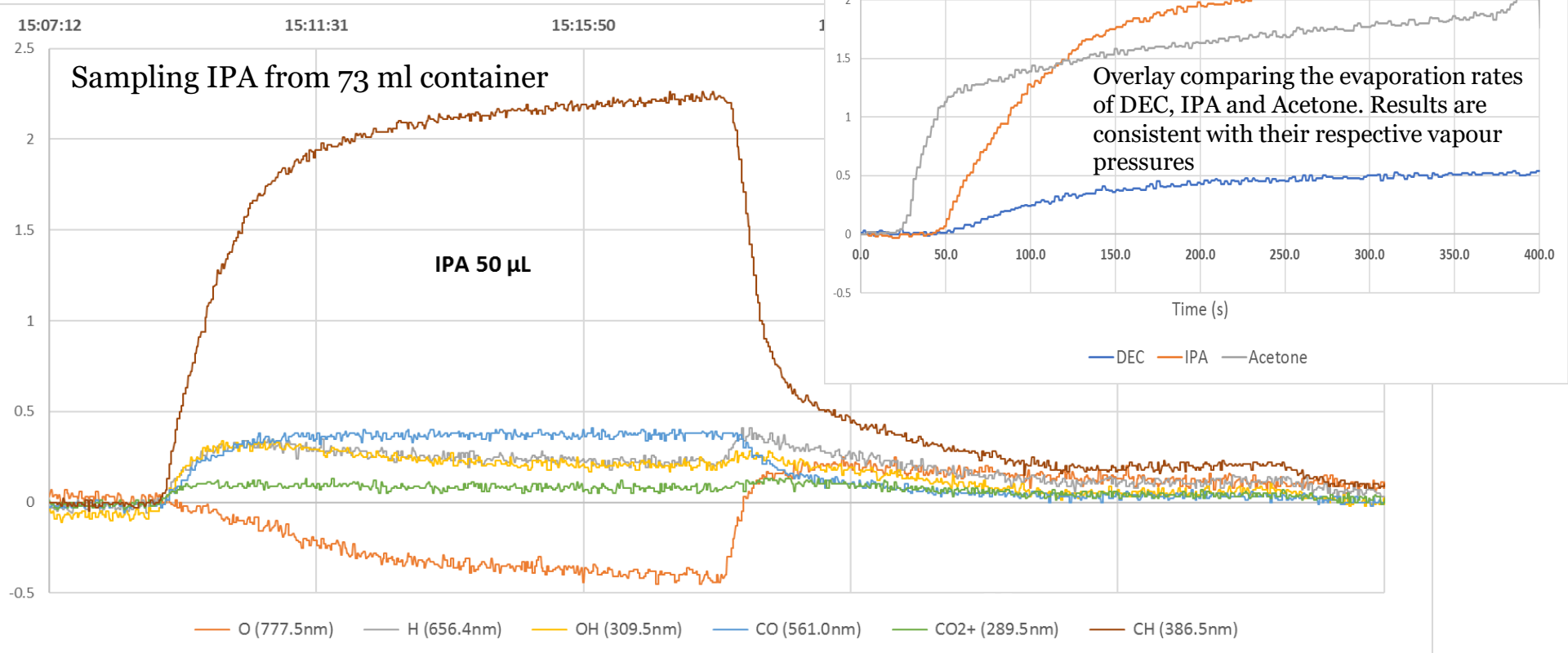




OPTIX for atmospheric chemical sensing

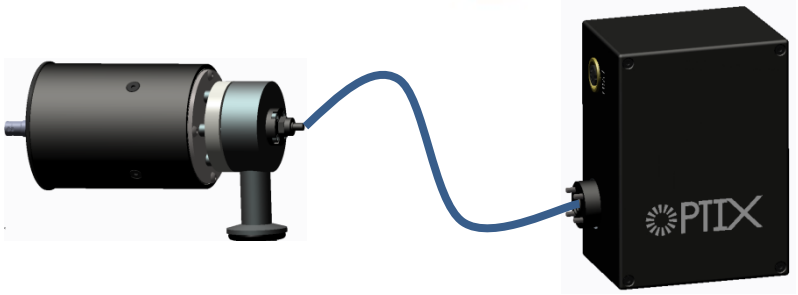


- Base pressure with valve closed 1E-2 mbar
- All tests at 300 µA DC plasma sensor power
- Optix plasma generator and sampling system heated to 50C
- Solvent container **not** heated



Hardware Configurations Options

Standard OPTIX package, plasma generator with power supply (DC as standard, pulsed DC as an option) with Spectrometer head and OPTIX software package / cables

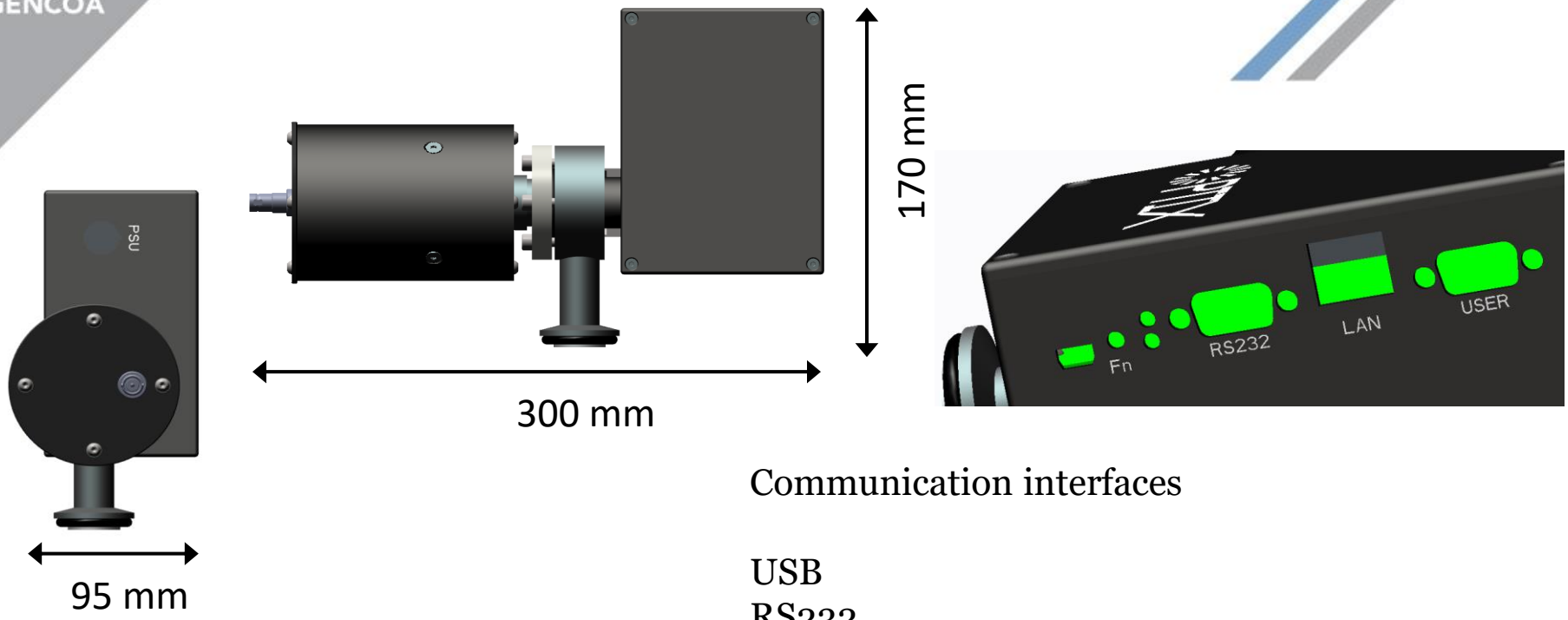


Standard OPTIX package, with optional optical fiber link between sensor and spectrometer – increases flexibility of the package – use items separately

Plasma generator with power supply (DC as standard, pulsed DC as an option) and cables – generates an intense plasma over a wide pressure range – can link to Speedflo or other control platforms

Spectrometer head with OPTIX software package – take advantage of the OPTIX software suite to manage your plasma monitoring and take advantage of the communication and trigger facilities

Size & Communication Options



Optix sensor: 300mm x 170mm x 95mm
PSU: 165 mm x 105mm x 55mm
Sensor weight: 2.2kg
Vacuum connection: KF25 flange
Mounting orientation: Any

Communication interfaces

USB
RS232
Ethernet
Digital relay output x 4

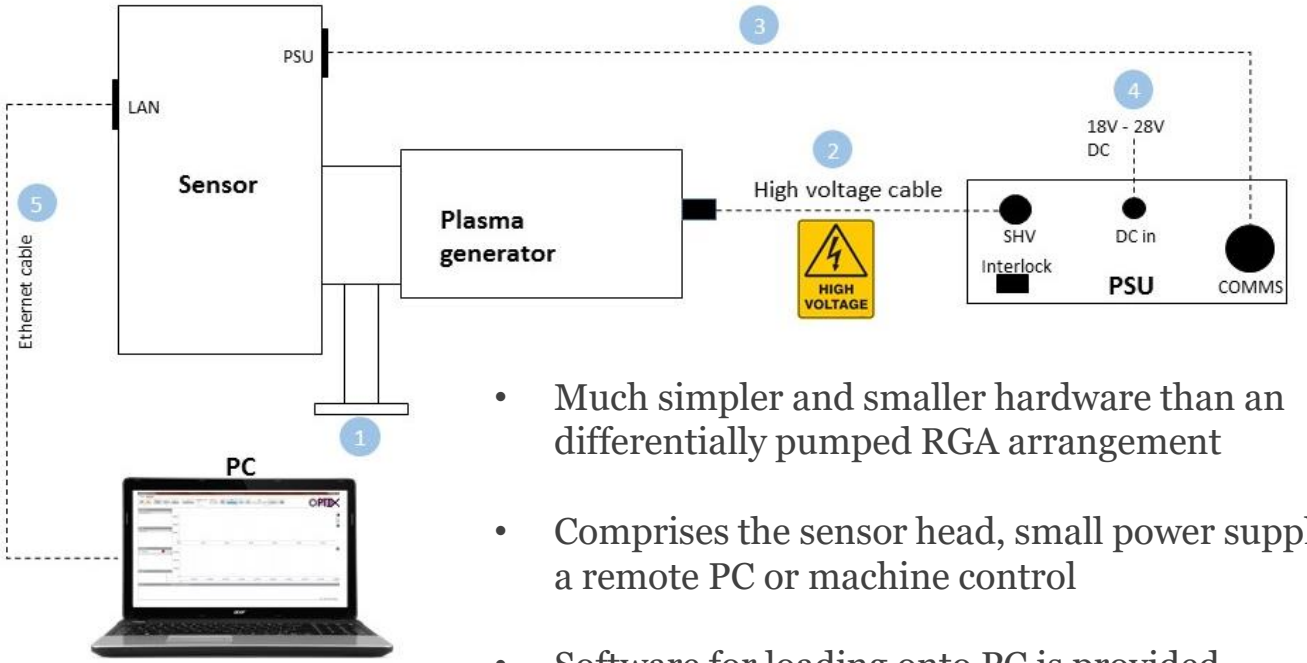
Optional PLC communication interface

Software Windows 7, 8 and 10 compatible

Electrical Input voltage: 15V
Input power: 20W typical
Output voltage: 3kV max
Output current: 1.5 mA max

Operating data

Total pressure operating range: 1x10-6 mbar – 0.5 mbar
Sensitivity: 50 ppm air in argon at 1.6x10-2 total pressure
Spectral range: 200nm – 900nm
Update speed: 5ms – 5 seconds (depending on sensitivity selected)
Total pressure measurement: Integrated (1x10-6 mbar – 1x10-2 mbar measurement range)
Electronics maximum operating temperature: 40°C



- Much simpler and smaller hardware than an differentially pumped RGA arrangement
- Comprises the sensor head, small power supply and a remote PC or machine control
- Software for loading onto PC is provided

OPTIX – making Residual Gas Analysis easy for industrial processes

- Highly robust and easy to use – no filaments to replace & easy to use software
- OPTIX can work at all process pressures – no need to differentially pump unless atmospheric sensing
- Highly mobile – can be carried in a small bag for on-site trouble shooting
- OPTIX is less sensitive to contamination than RGA's, can be used for 'dirty' hydrocarbon environments as well as etch, CVD and ALD type processes
- This sensing technique offers a lower cost and lower complexity solution than alternative methods
- Can link directly to Speedflo reactive gas controller or PLC for feedback control