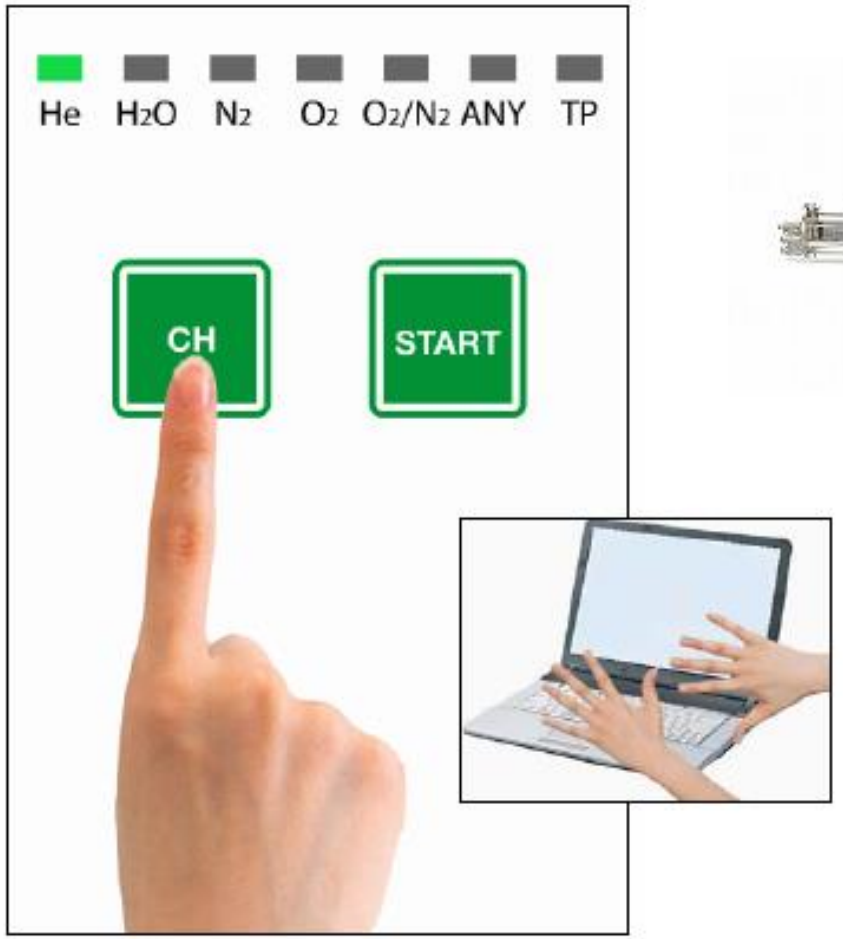
PN-QM01-016-00E

Basic Process Gas Monitor
Qulee BGM2-101/102/201/202

ULVAC
ULVAC,Inc. Components Division

ULVAC, Inc.
Components Division
Measurement Instrument Department
Hideki Yoshizawa

Features of Qulee



Qulee BGM2

- With display function (PC is not required)
- Transducer type

Qulee series

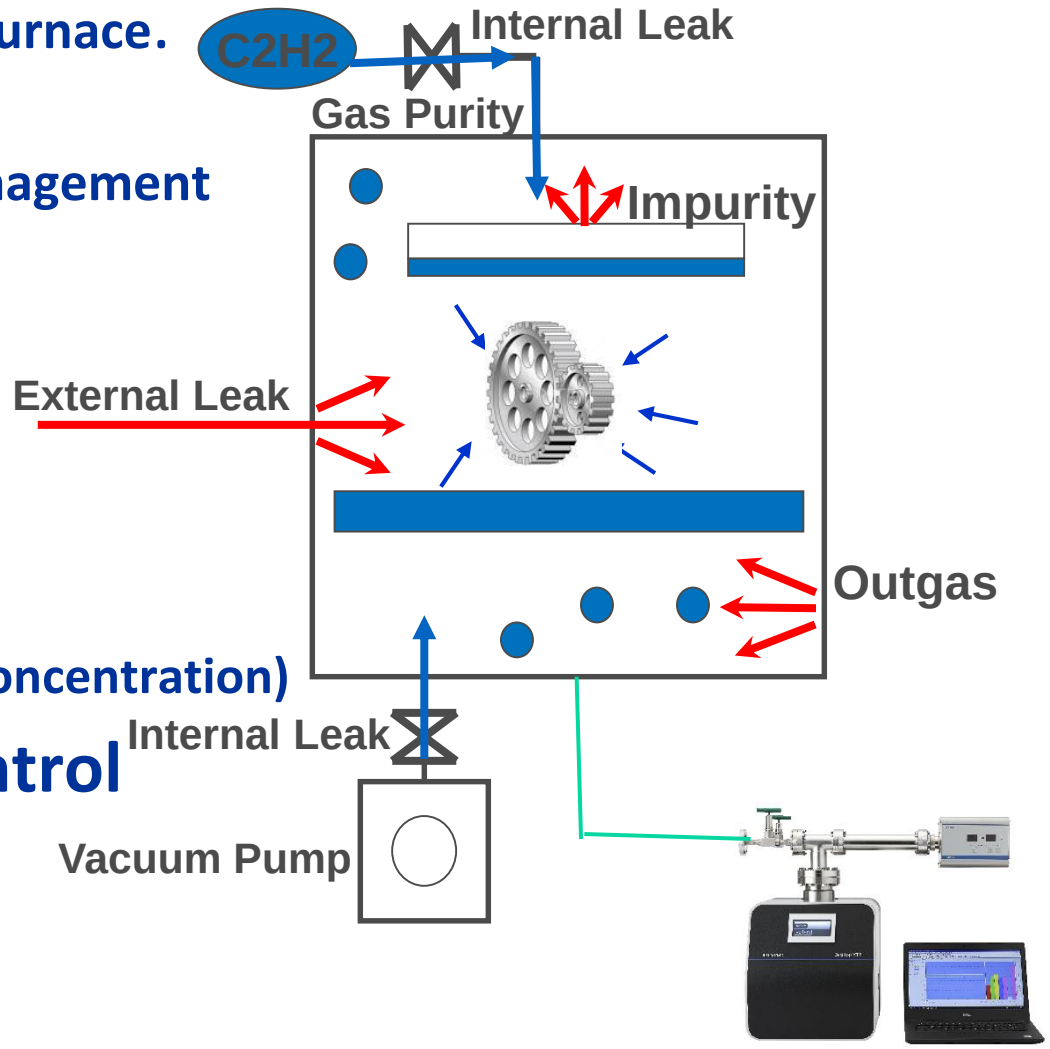
- General-purpose Compact Process Gas Monitor for Sputtering equipment 「Qulee CGM2-051」
- High-sensitivity Compact Process Gas Monitor for Sputtering equipment 「Qulee CGM2-052」
- General-purpose basic Process Gas Monitor for Evaporation system and various Vacuum Furnaces 「Qulee BGM2-101/BGM-201」
- High sensitivity basic Process Gas Monitor for Evaporation system and various Vacuum Furnaces 「Qulee BGM2-102／BGM-202」
- High-performance Process Gas Monitor for various R&D applications 「Qulee HGM2-202／HGM2-302」
- Reactive Process Gas Monitor for CVD devices and Etching system 「Qulee RGM2-202/302」

For example,

Image when Qulee is used in a vacuum carburizing furnace.

■ **When used in a vacuum carburizing furnace.**

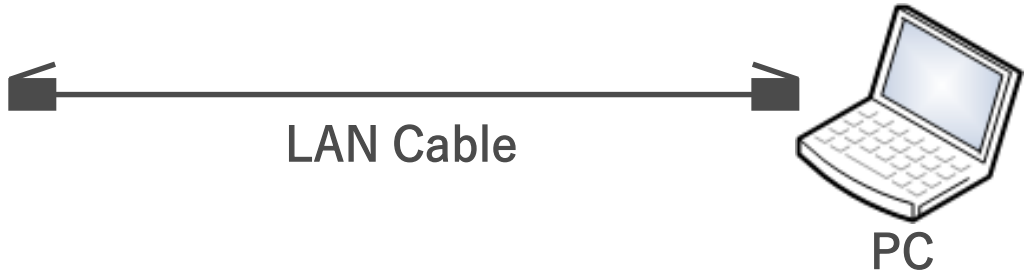
- Process gas concentration management
- **External Leak check**
- **Internal Leak check**
- **Impurities check**
- **Outgas**
- Residual Gas Analysis (oxygen concentration)
- **Carburizing process control**



Connection to PC (Equipment required for connection)

【 Serial communication 】

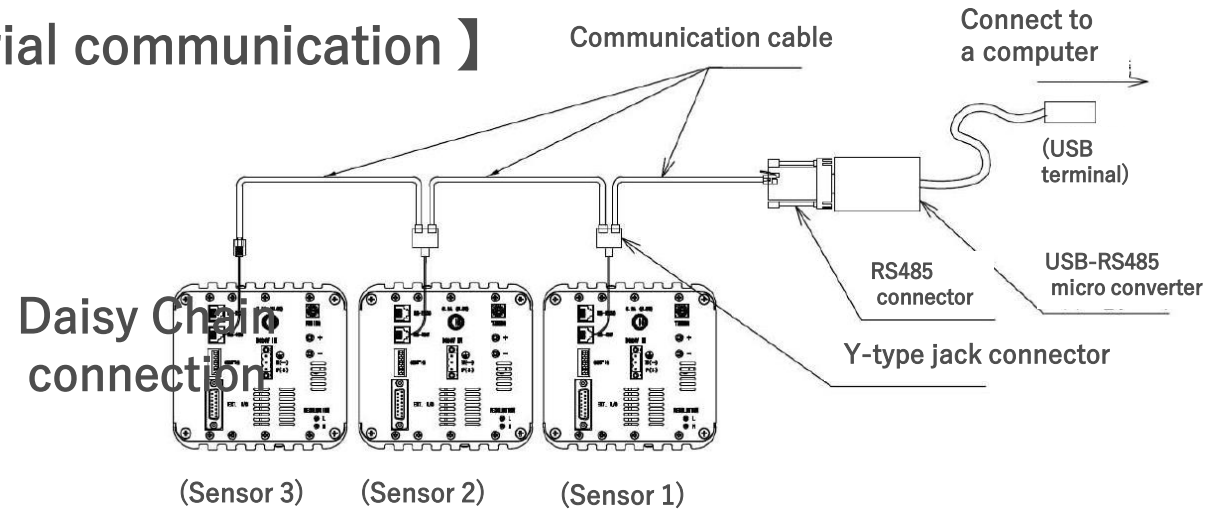
【 Ethernet communication 】



- A LAN cable is used to connect Qulee to a PC.
  ※Please use a double shield type cable.

Connection to PC (The method to connect multiple units)

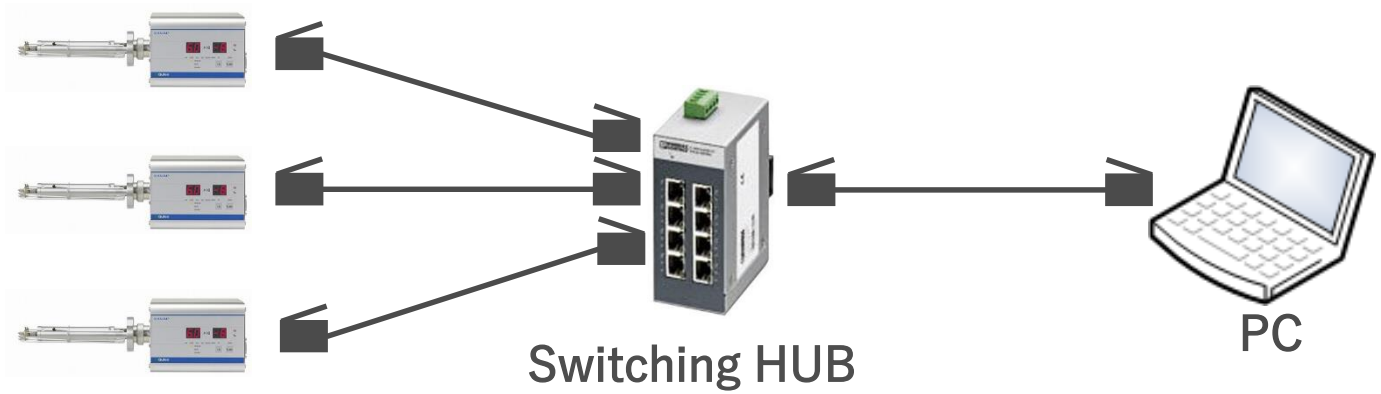
【 Serial communication 】



【 Ethernet communication 】

- Please note that the required length of communication cable to connect multiple units is different from that of cable for serial communication.
- HUB requires power supply(DC24V).

Star connection



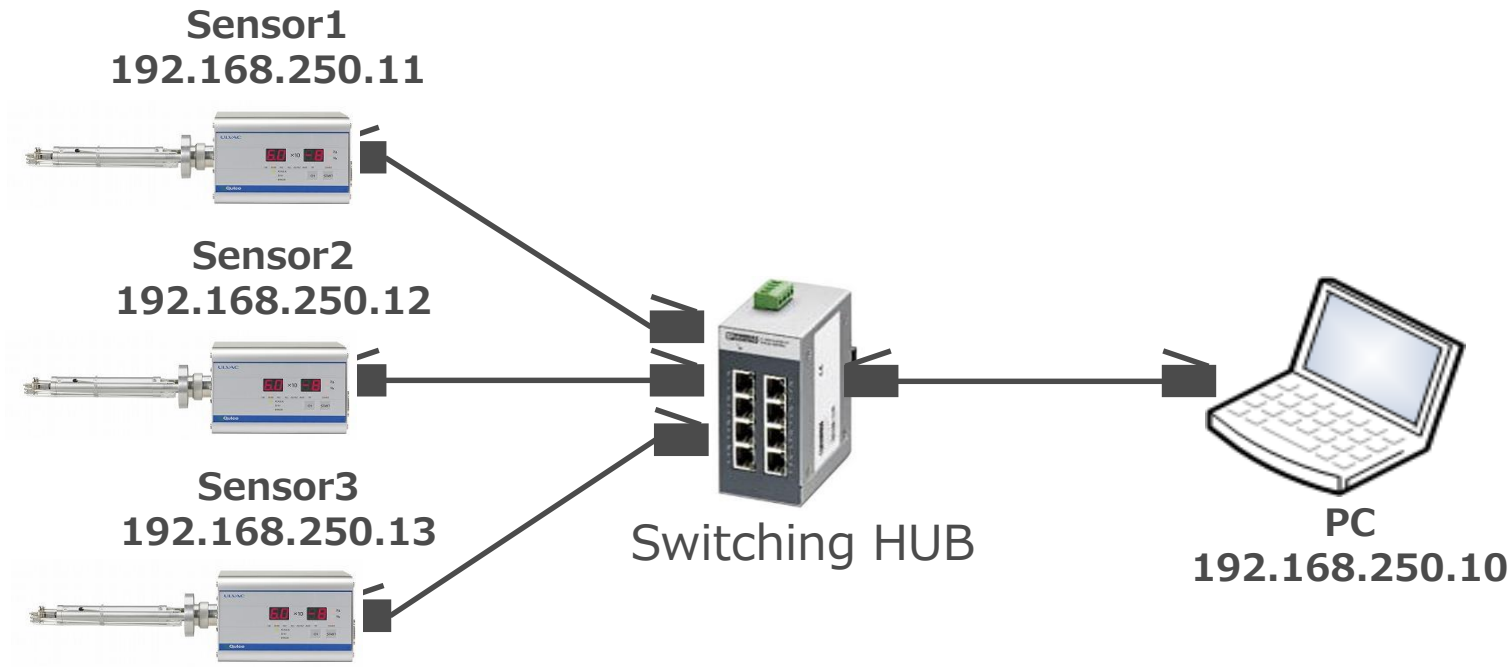
Connection to PC　(The method to connect multiple units)

＊IP Address + main unit Dipswitch setting
＊IP Address is fixed (192.168.250.xxx) and can be set arbitrarily

Qulee's IP Address example
192.168.250.11

Connection to PC （The method to connect multiple units）

【 IP Address setting example 】



-Set the IP address of the PC up to the third digit
(192.168.250.xxx in the example) to the same address as Qulee.
-Do not duplicate IP Address

Connection to PC （Sensor Identification）

The sensor number (S1 to S16) of Qulee is identified by the IP Address and the main unit Dipswitch setting.

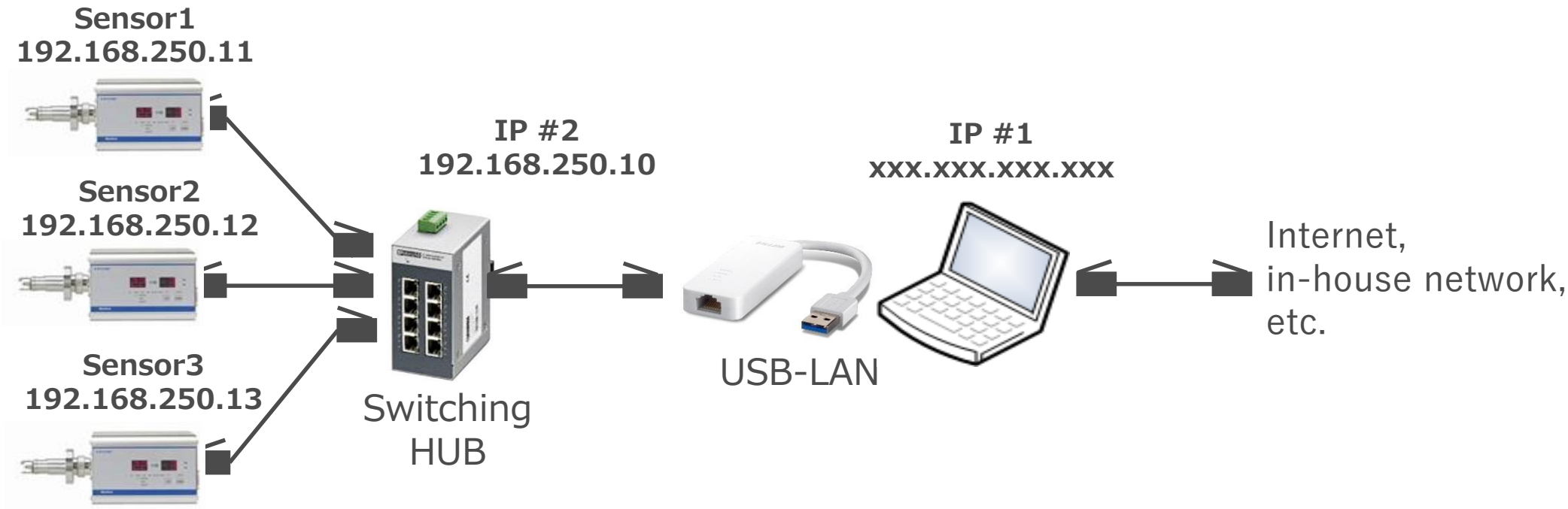
IP Address can be a fixed setting (192.168.250.xxx) or an arbitrary setting.

Example of Qulee IP Address.

192.168.250.11

Connection to PC (The method to connect multiple units)

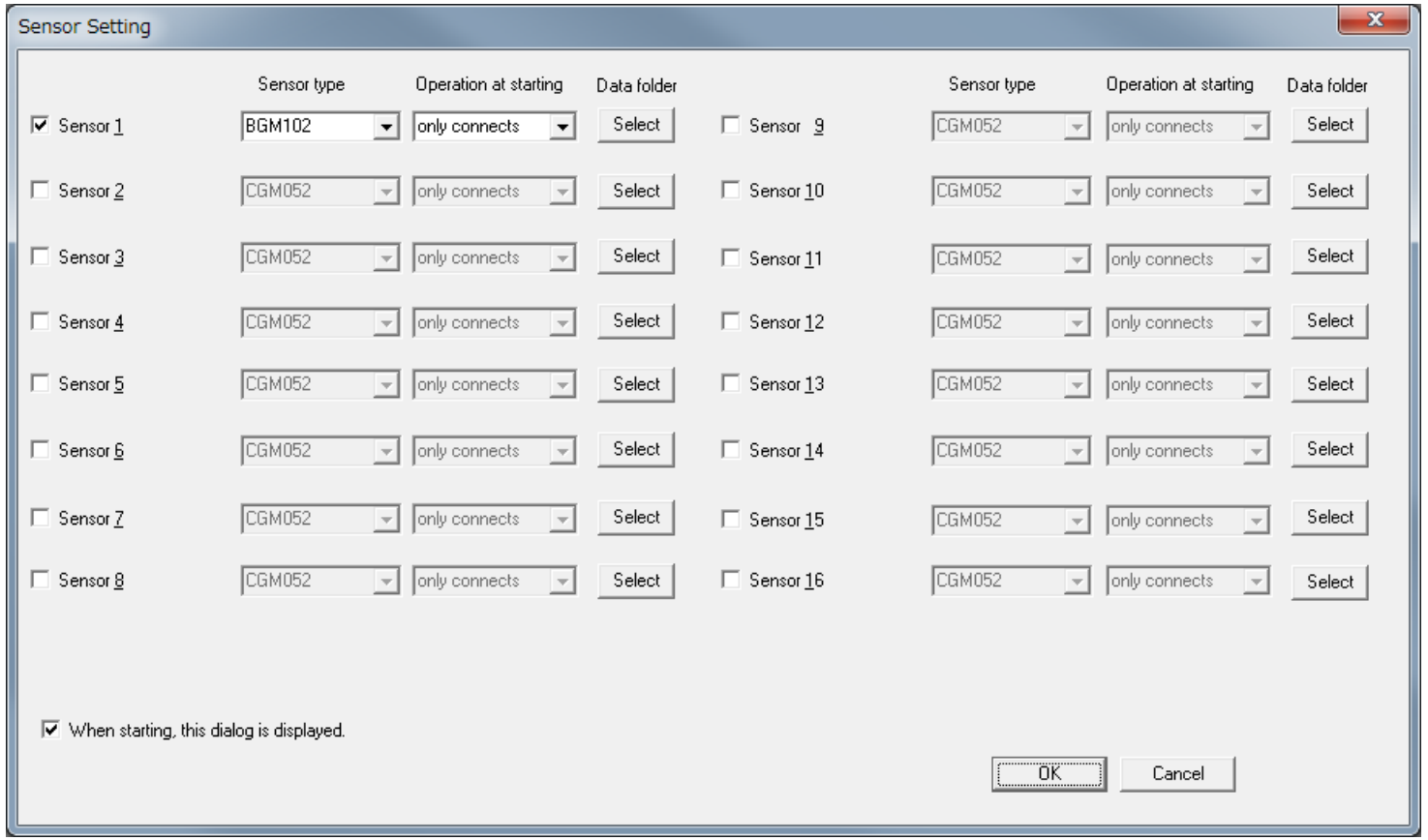
【 IP Address setting example 】



-By using a USB-LAN converter (Option), you can communicate with Qulee separately from other networks.

Connection to PC (New function of Software)

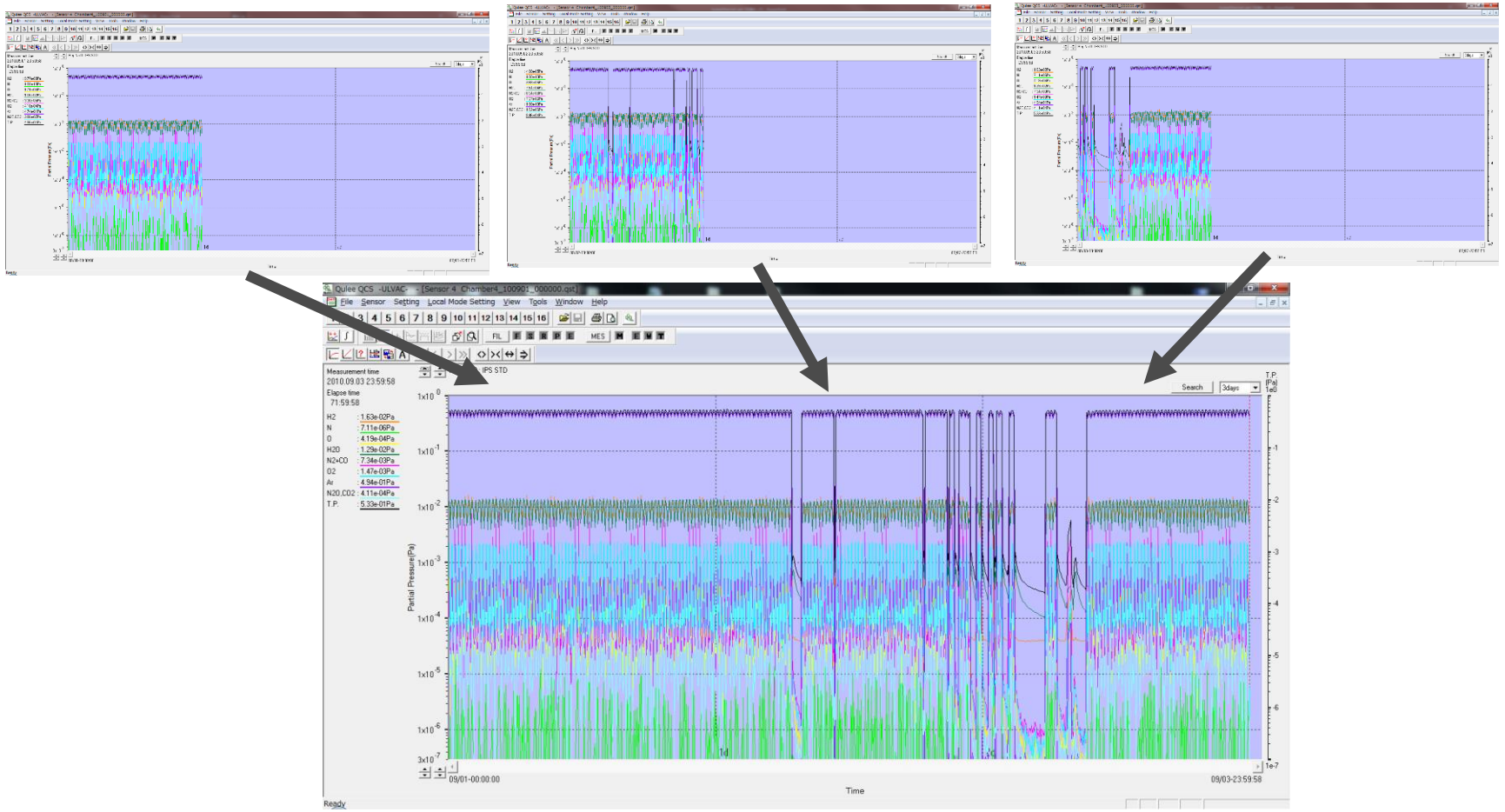
【 Connectable number of sensor units】



Up to 16 sensors can be connected.
※ High-performance computer is recommended when connecting 16 sensors. (Corei7 or higher)

Connection to PC (New function of Software)

【 Data coupling function 】

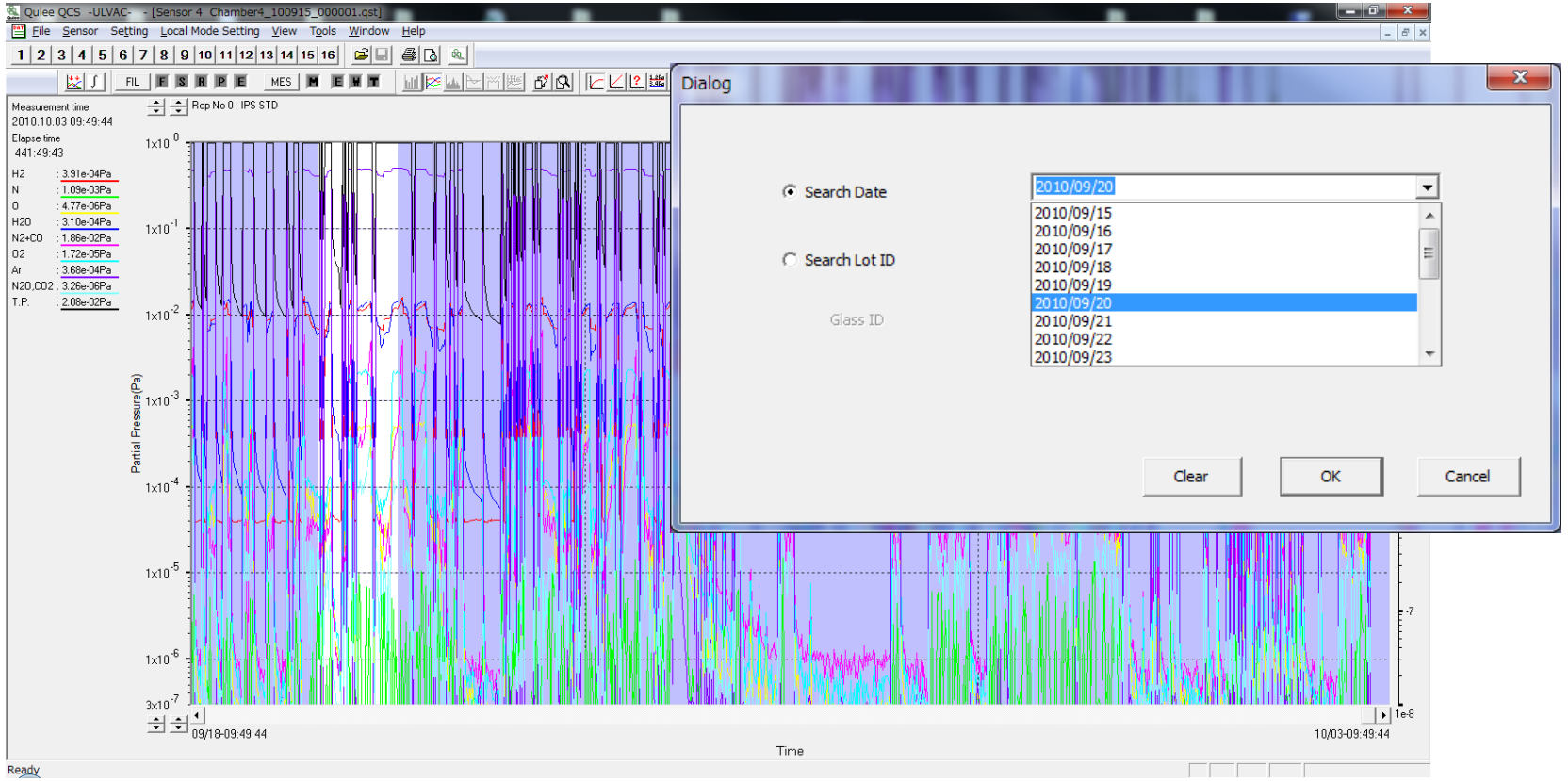


Multiple obtained data are combined in a time series and displayed on one screen.

Connection to PC (New function of Software)

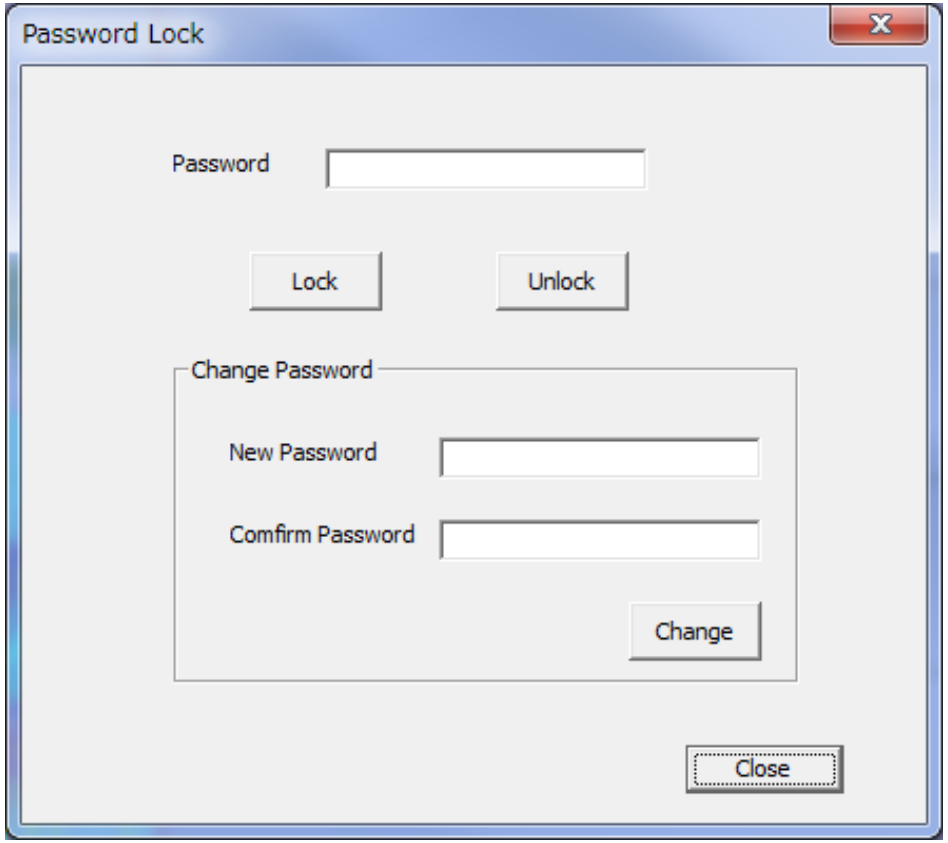
【 Data coupling function 】

Search function (search by date and highlight the relevant part)



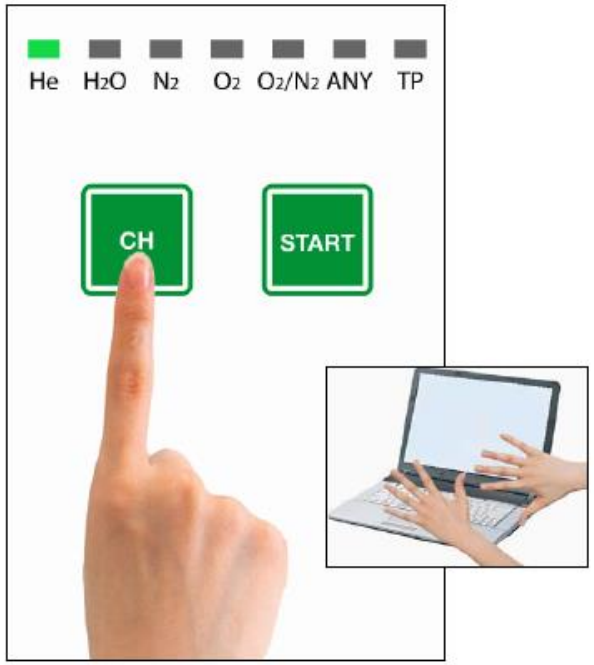
Connection to PC (New function of Software)

【 Password Lock function 】



You can lock the operation function with Password so that it will not be operated arbitrarily during measurement.

Connection to PC (New function of Software)



■Start Analysis with One Click

No complicated operations, significantly improved usability.

Just click START after power turns on to begin analysis.

■Minimized switches and Easy-handling.

Easy-usability for anybody with only two switches.

■Leakage test without PC

It can perform leak tests according to applications.

■ Impurity (H_2O) analysis without PC

This analysis can be done with one click as well.

■Using a PC can eliminate an instruction manual

Eco-friendly, perfect for use in clean rooms.

Specifications

Specifications

Items	Qulee BGM2	
Model	BGM2-101／201	BGM2-102／202
Mass filter type	Quadrupole mass spectrometer	
Mass range	1～100／1～200 amu	
Resolution	M/△M=1M(10% P.H.)	
Sensitivity	10^{-7}A/Pa	4A/Pa
Minimum detectable partial pressure	10^{-8}Pa	10^{-12} Pa
Detector type	Faraday cup	Faraday cup Secondary Electron Multiplier
Maximum operating pressure	1×10^{-2}Pa	
One Click total pressure function	Capable	
One Click function	Capable ・ $He/H_2O/N_2/O_2$/Any Gas	
One Click leak test function	Capable	
Power Input	DC24V	
Maximum bakeout temperature)	120℃（250℃）	
Communication interface	Ethernet Specification	
Operating temperature range	10-40℃	
Standard Software	Qulee QCS（Windows 7/8/10）	

Consideration for the Environment/Safety

■RoHS compliant

Qulee series is compliant with the RoHS Directive.

■Replaceable Ion source and SEM.

An ion source and SEM (secondary electron multiplier) of Qulee series are replaceable. SEM does not use Be, which is a self-regulated substance based on ULVAC environmental standards.

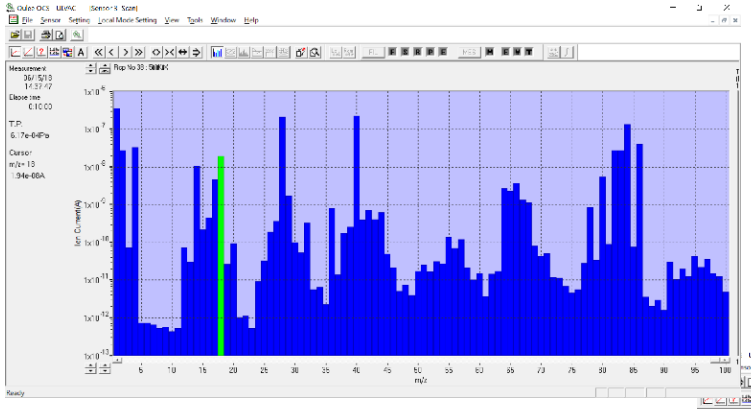
■CE and IP Protection

Qulee series support the following CE and IP protection.

1)EMI
EN55011: Group 2 Class A Electromagnetic radiation disturbance, Conducted disturbance
2)EMS
IEC61000-4-2 Electrostatic discharge immunity
IEC61000-4-3 Radiated immunity
IEC61000-4-4 Fast Transient /Burst immunity
IEC61000-4-5 Surge immunity
IEC61000-4-6 Immunity to conducted disturbances induced by radio-frequency fields
IEC61000-4-8 Power frequency magnetic field immunity
3)IP
IP30 3 The probe for the examination for solid matter with a diameter of 2.5 mm shall not enter at all.
      0 Not protected (from liquids)

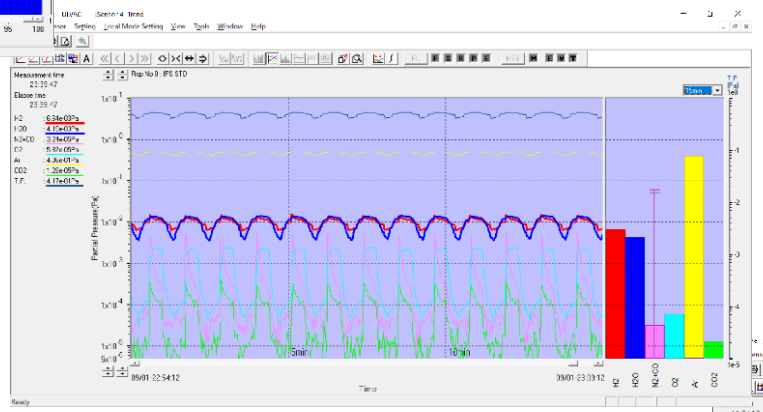
Software for Gas Analyzer Qulee QCS (1)

Qulee QCS: The standard software is renewed and added many functions.



Scan Mode

This mode measures an arbitrary mass number range.
M/e=1 to 200
M/e=50 to 100

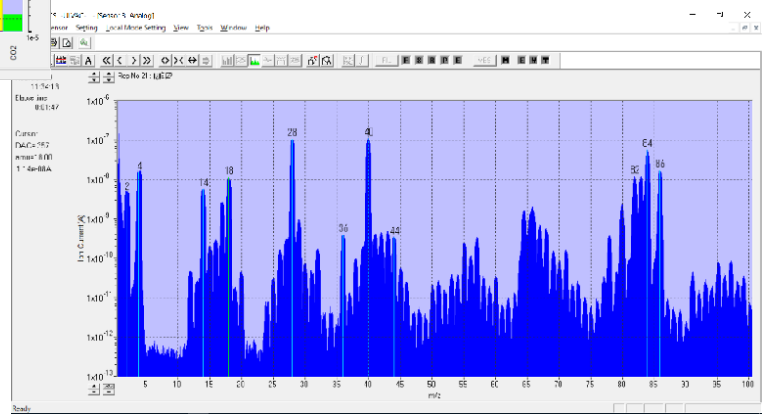


Trend Mode

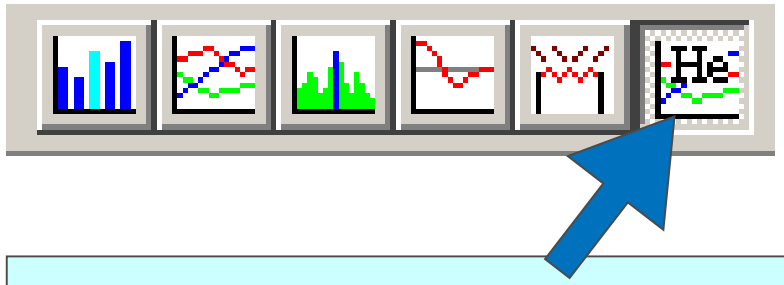
This mode measures the change over time of the arbitrary mass number up to 20 CH.

Analog Mode

This mode displays in analog data.
This mode adjusts the peak top.



Software for Gas Analyzer Qulee QCS (2)

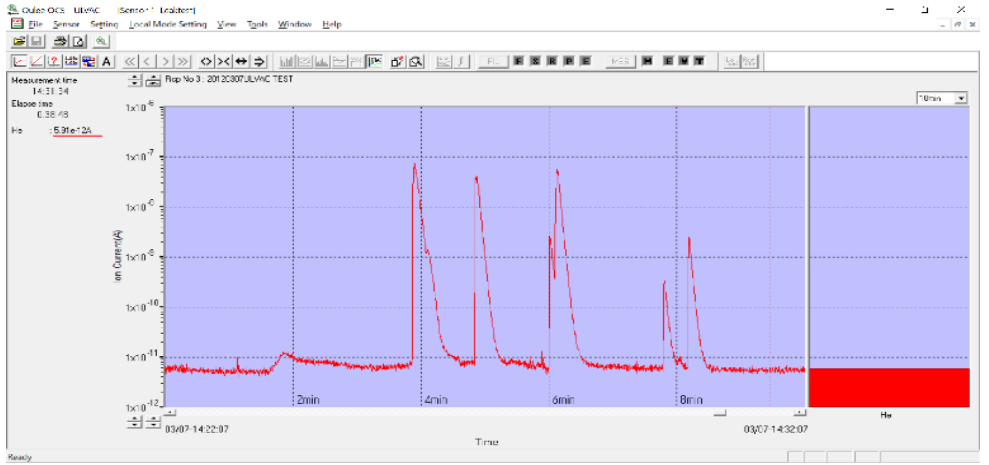


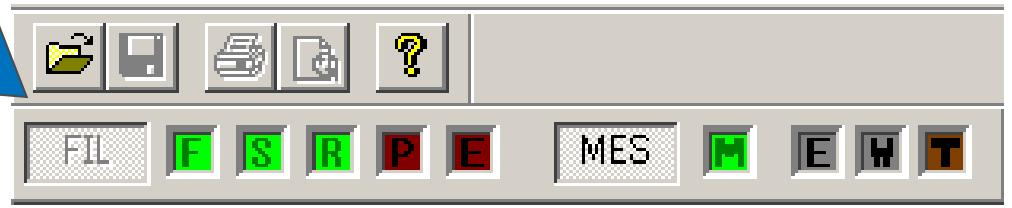
Qulee QCS performs the leak test by just clicking the He leak test mode button in the toolbar.

Easy operation using the toolbar

Filament button

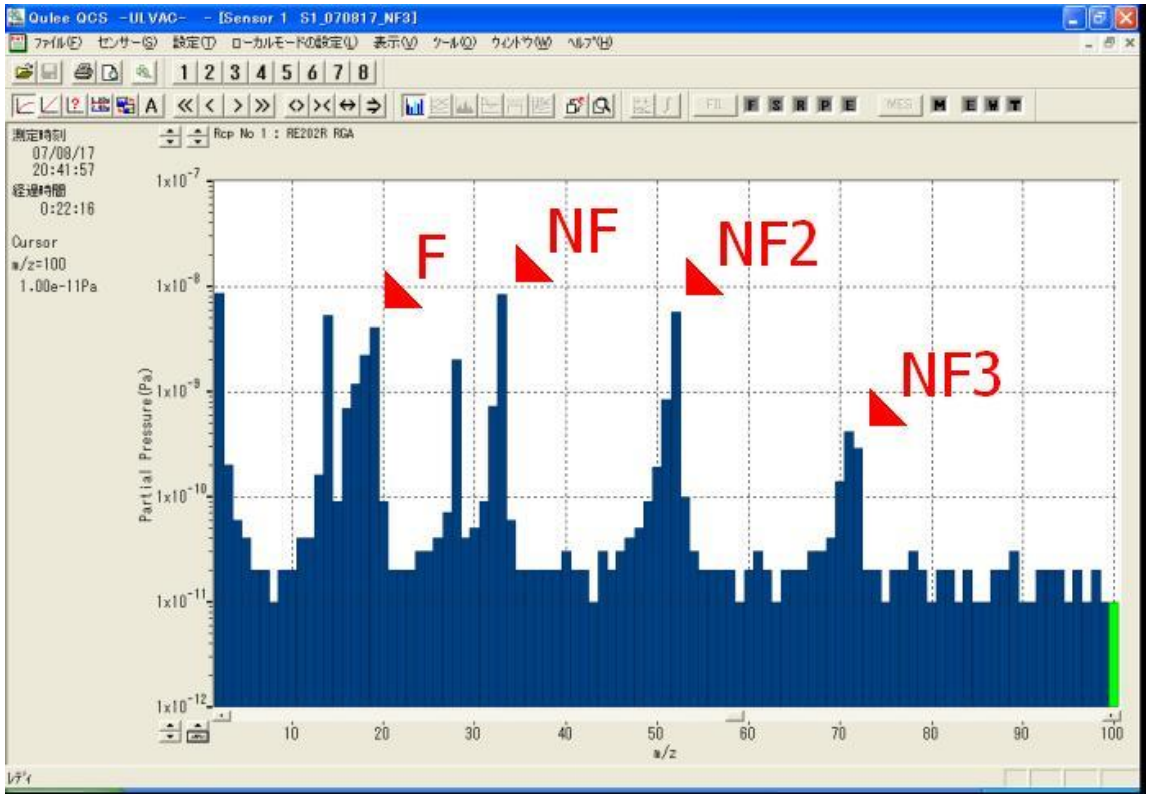
Easy operation by clicking the measurement button





Software for Gas Analyzer Qulee QCS (3)

Analyzer Tube Protection/History Check Function(1)

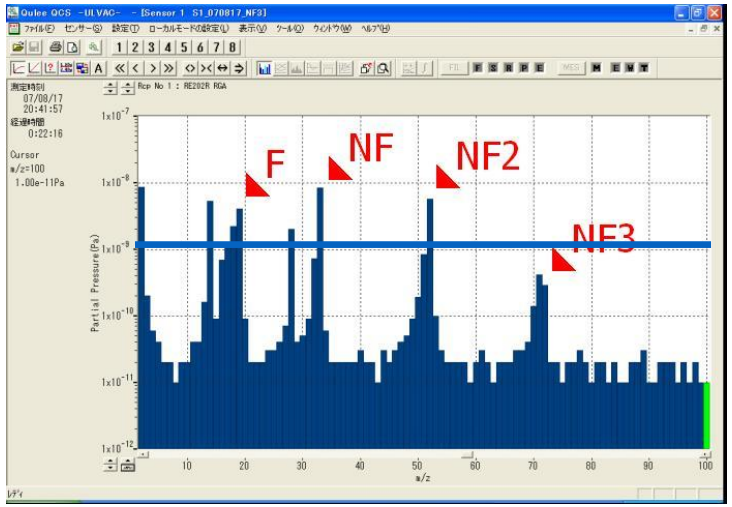


Corrosive and reactive gases such as F and Cl deteriorate the ion source and contaminate the analyzer tube.

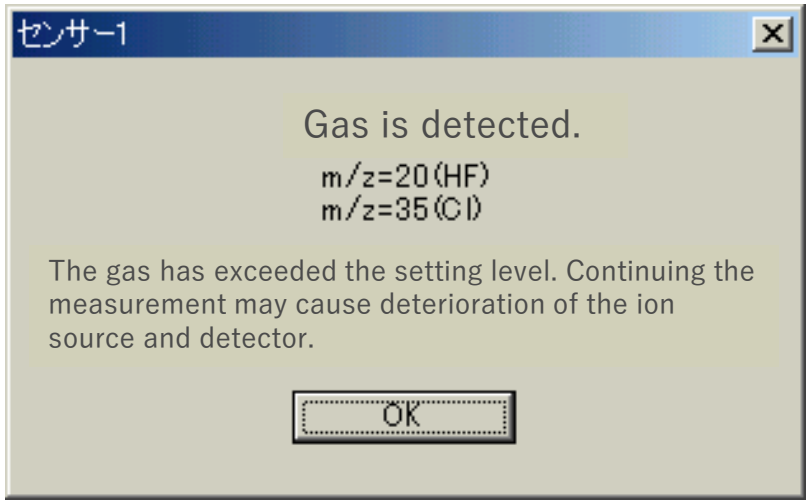
Software for Gas Analyzer Qulee QCS (4)

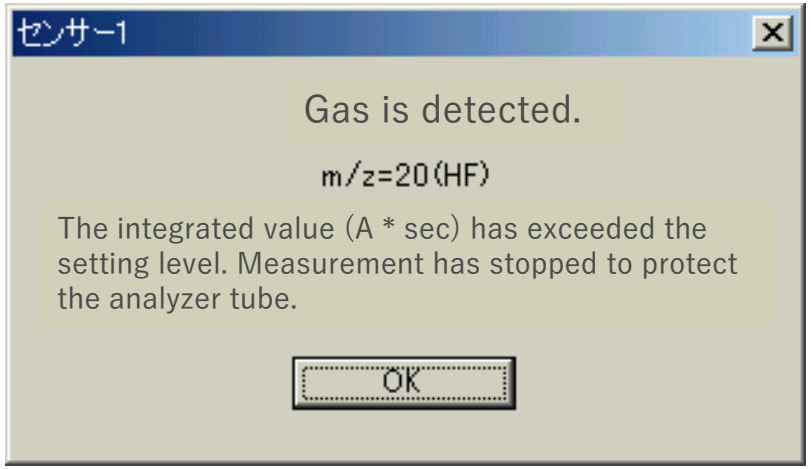
Analyzer Tube Protection/History Check Function(2)

When detecting the peak of reactive or corrosive gases, an error message pops up, and measurement stops.



Analyzer Tube Protection

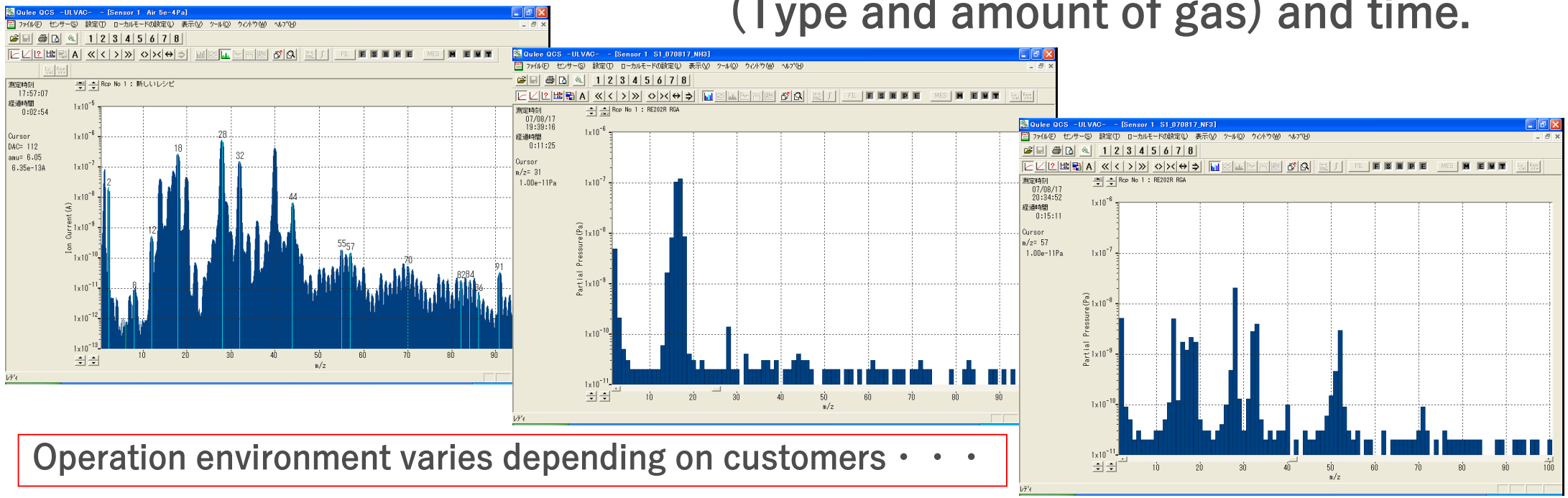




Software for Gas Analyzer Qulee QCS (5)

Analyzer Tube Protection/History Check Function(3)

Life of Consumables: It depends on the operating atmosphere (Type and amount of gas) and time.



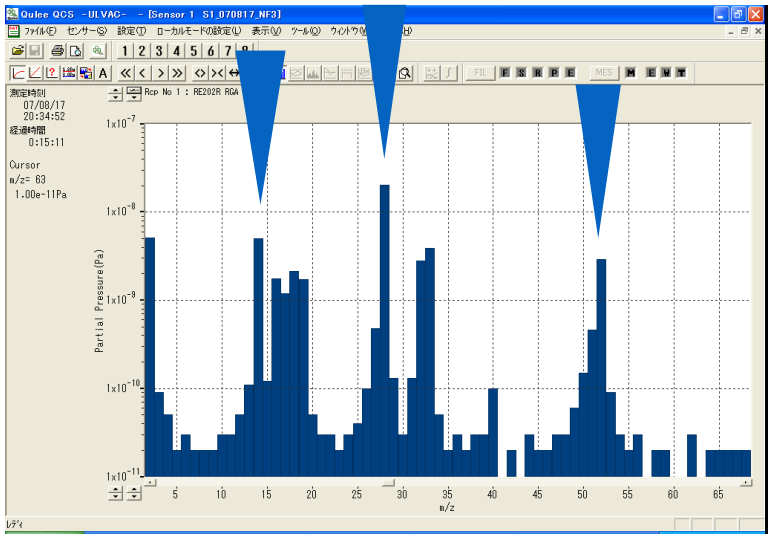
Operation environment varies depending on customers・・・

- Timing to replace consumables is tricky.
  - Early・・・It affects the measurement.
  - Late・・・Extra running costs occur.
- The operation history is unknown.

Software for Gas Analyzer Qulee QCS (6)

Analyzer Tube Protection/History Check Function(4)

Qulee records and updates the peak current value × time of a specific gas in the power supply.



The operation history can be checked.

No.	m/z	ガス名	警告イオン電流値 FC(A)	警告イオン電流値 SEM(A)	FIL/RF/SEMオフ積分値(A*sec)	実測積分値 (A*sec)
1	20	HF	5.00E-10	5.00E-07	0.00E+00	1.08E-07
2	35	Cl	5.00E-10	5.00E-07	0.00E+00	7.43E-09
3	53	NF2	5.00E-10	5.00E-07	0.00E+00	1.98E-08
4	64	CF3	5.00E-10	5.00E-07	0.00E+00	1.75E-08
5	70	Cl2	5.00E-10	5.00E-07	0.00E+00	1.92E-08
6	81	HBr	5.00E-10	5.00E-07	0.00E+00	1.19E-08
7	100	SiH2Cl2	5.00E-10	5.00E-07	0.00E+00	5.67E-09
8	119	C2F5	5.00E-10	5.00E-07	0.00E+00	0.00E+00
9	0	0	0.00E+00	0.00E+00	0.00E+00	3.21E-05
10	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
11	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
14	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
16	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
17	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
18	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
19	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	0	0	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Patent pending
Pat. App. No. 2007-129408

- Prediction of the life of consumables
- Improvement of safety of maintenance workers
- Prevention of disposal of contaminated parts

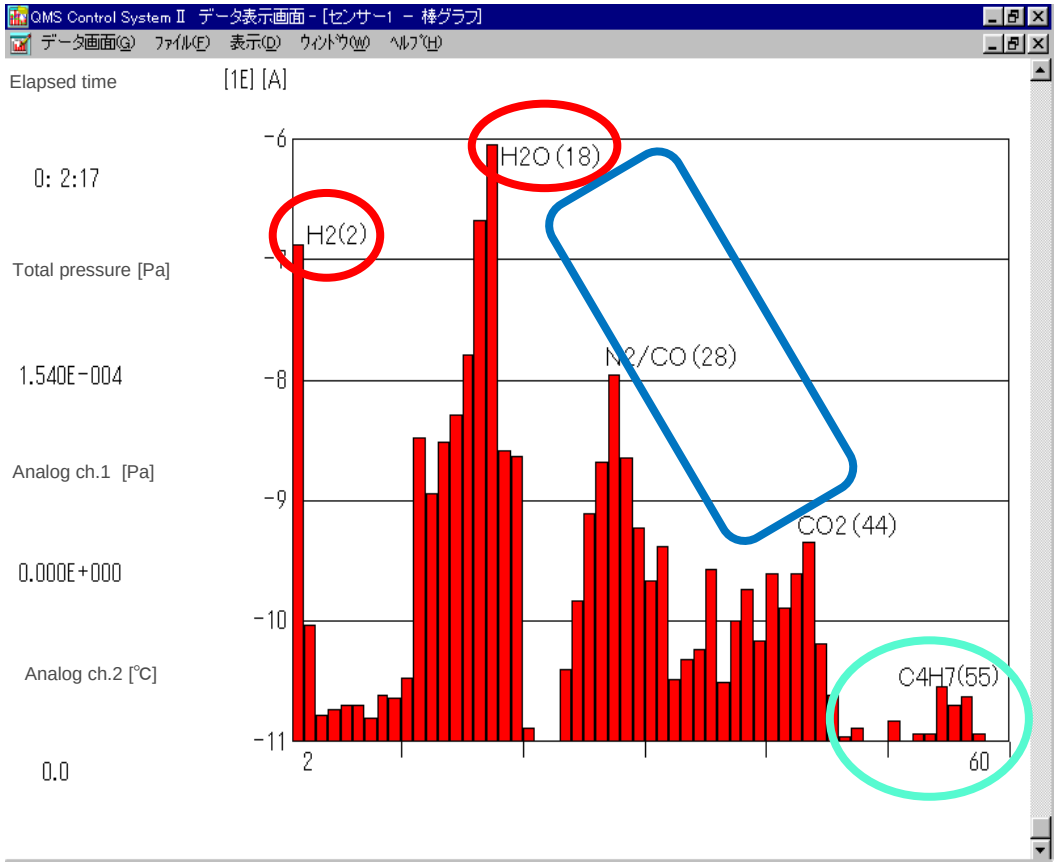
Software for Gas Analyzer Qulee QCS (7)

System operating conditions

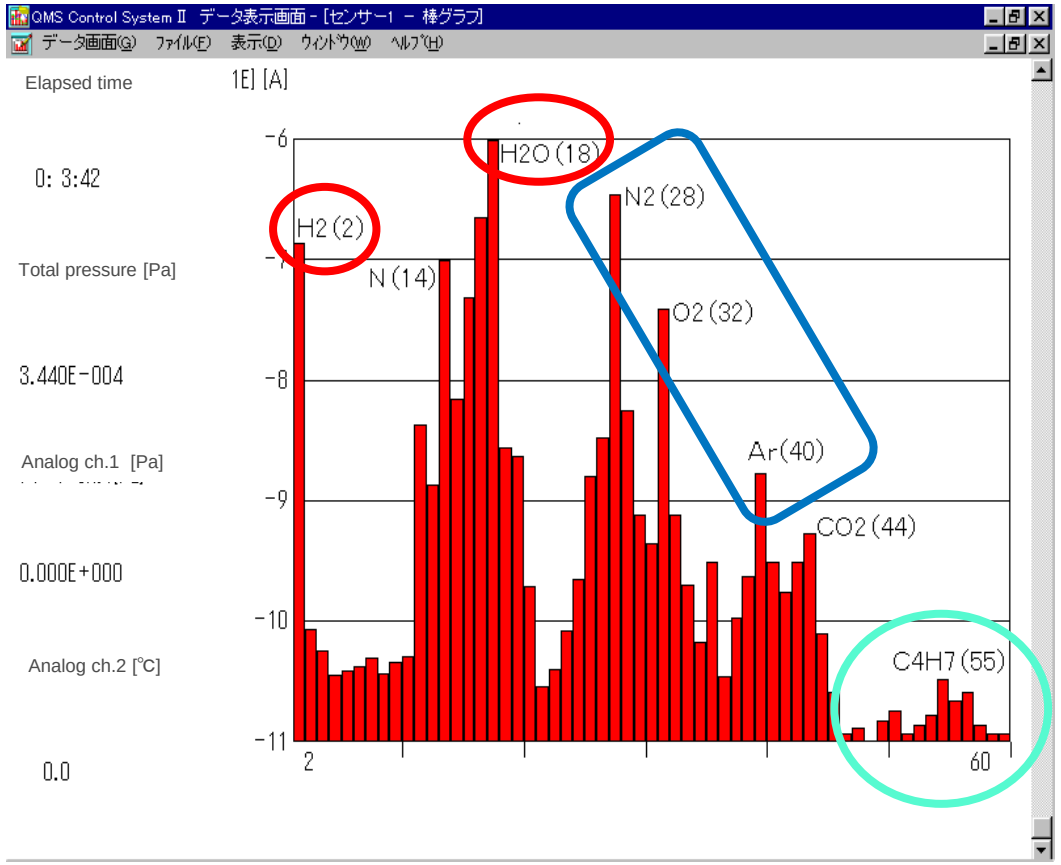
- OS：Windows 7/8/10
- Communication Interface: Ethernet specifications
- CPU:Core i5 or above

  (Core i7 or above is recommended when connecting 8 units or above)
- RAM:256MB or more
- HDD:Approximately 2MB (excluding measurement data)
- Others: CD-ROM drive, display area: 1024 x 768 or more

Deposition system Data (Qulee BGM2-102 Specification)



Not Leaking



Leaking

Atmospheric pressure component

N_2 : 78 %
O_2 : 21 %
Ar : 0.9 %

- Condition: H_2O and H_2 often reach the normal (pumped by Turbopump) high vacuum state.
- Leak: The ion intensities of N_2 (28), O_2(32), and Ar(40) and their ratios can determine if there is a leak or not.
- Residual impurity ： M/e=39,41,43,55,57 (CxHy) determines if there is oil contamination.

Sputtering system (FPD) Data (Qulee CGM2-052 specification)

Process Condition: Qulee CGM2-051 Process Management of Measurement/Sputtering system

① Ar 400 sccm is introduced after 4 minutes from the start of the process

② 1 minute after that,

O2 is introduced: 2 → 4 → 6 → 8 → 10 sccm

Changes in pressure (total pressure)

→ 8e-4Pa (without Gas introduction)

→ 0.21Pa (Ar:400sccm)

→ 0.21Pa (O2:2sccm)

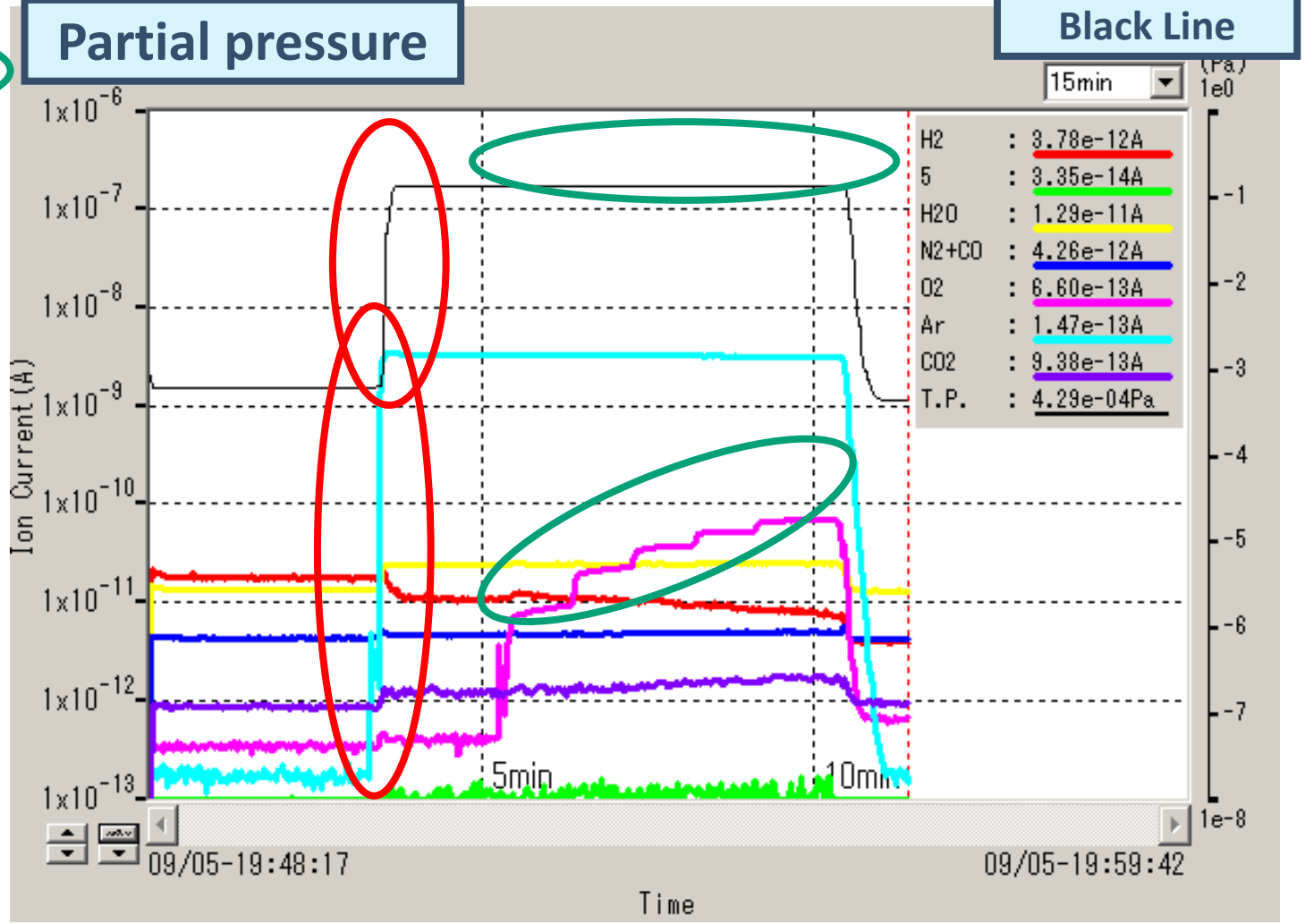
→ 0.21Pa (O2:4sccm)

→ 0.21Pa (O2:6sccm)

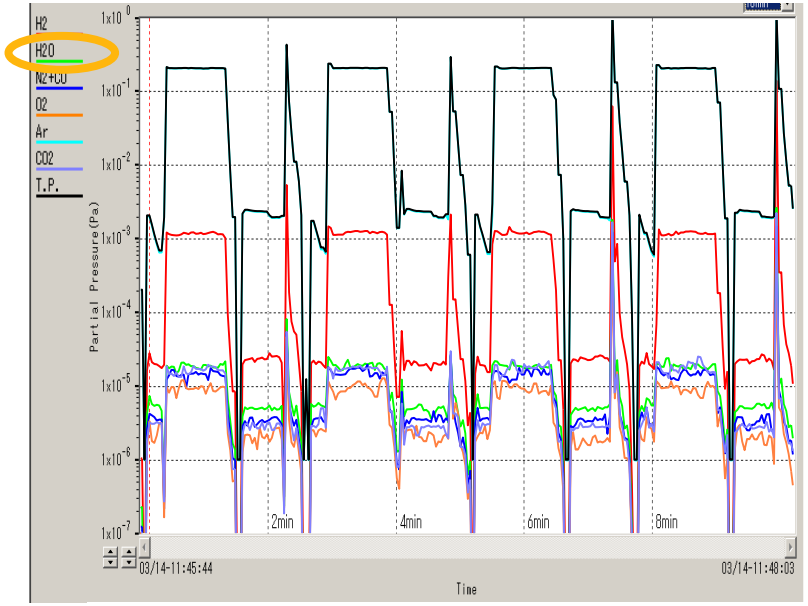
→ 0.21Pa (O2:8sccm)

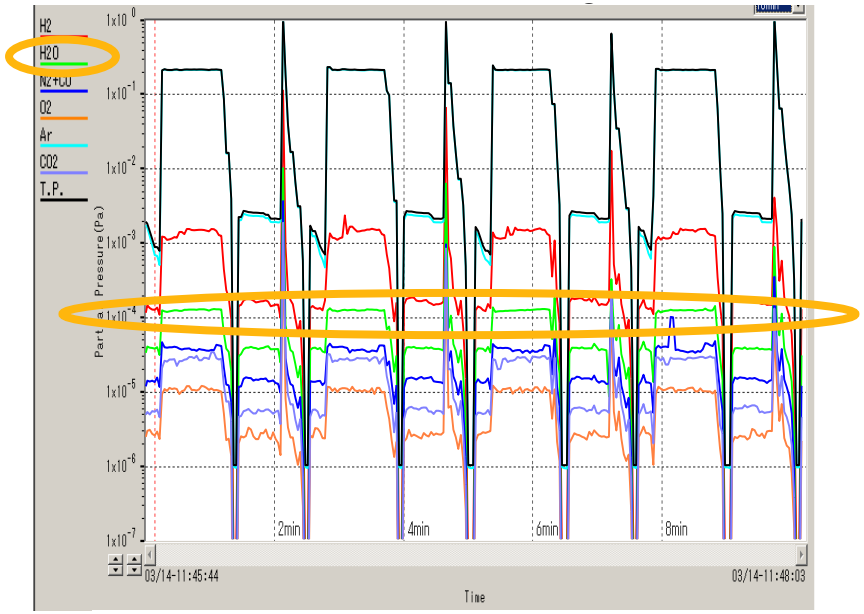
→ 0.21Pa (O2:10sccm)

The process gas monitor has a Dynamic Range, which enables to check of subtle gas fluctuations that a vacuum gauge cannot confirm.

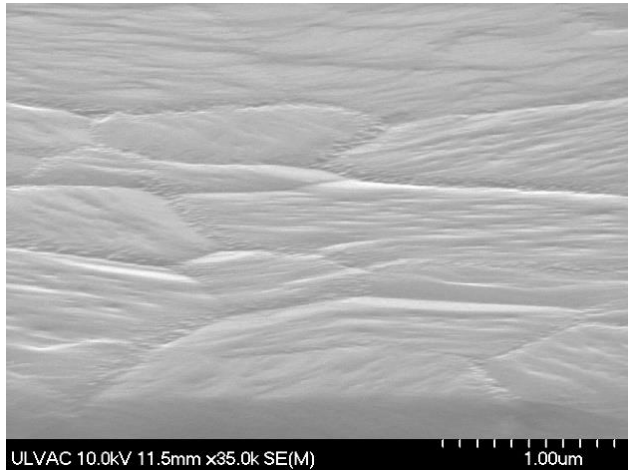


Sputtering system (Semiconductor) Data (Qulee CGM2-052 specification)



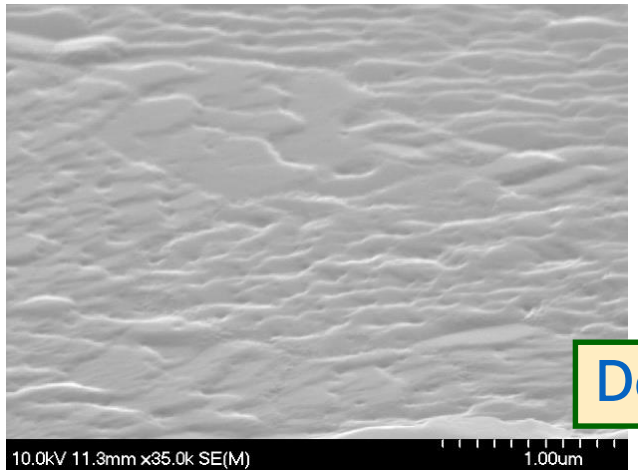


■Optimal Process Condition



In the PVD process, the most crucial point is to check the H2O. Even a single-digit increase in the order of H2O from the optimal process condition significantly changes the final product.

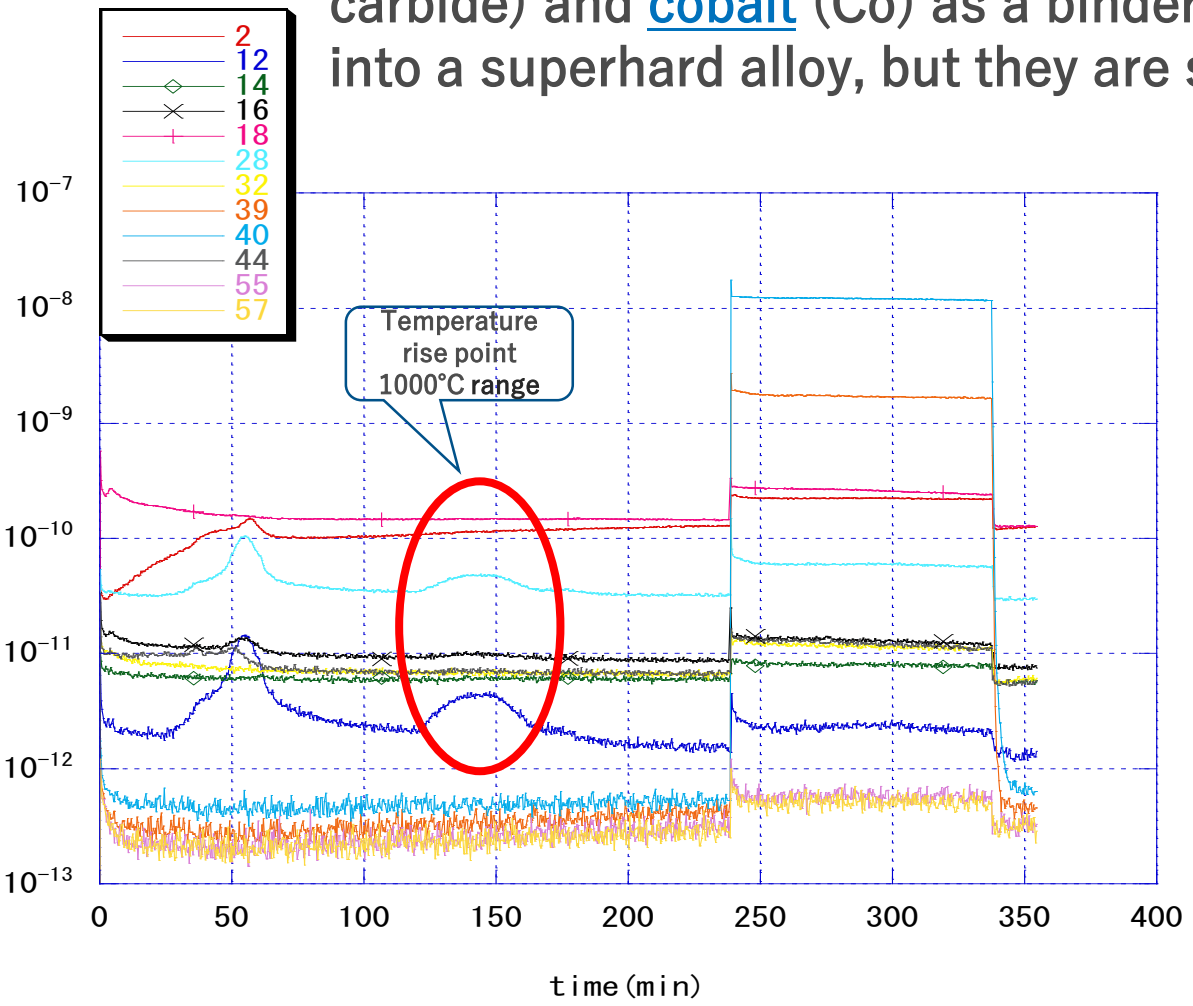
■Process Condition with many impurities (moisture)



Deterioration of crystallinity

Vacuum Sintering Furnace・Gas Data

A superhard alloy is an alloy made by sintering hard metal carbide powder. Superhard alloys are often sintered by mixing tungsten carbide (WC, tungsten carbide) and cobalt (Co) as a binder. This sintering process should solidify them into a superhard alloy, but they are sometimes not sintered and melt into sludge.



Problem

- Incomplete degreasing.
  - Unable to check the hydrocarbon
- The powder cannot be sintered well.
  - The powder is not sintered and melted into sludge
- Uneven sintering.
  - The hardness varies
- No reproducibility of a sintering process.
  - No reproducibility in sintering results even under the same conditions

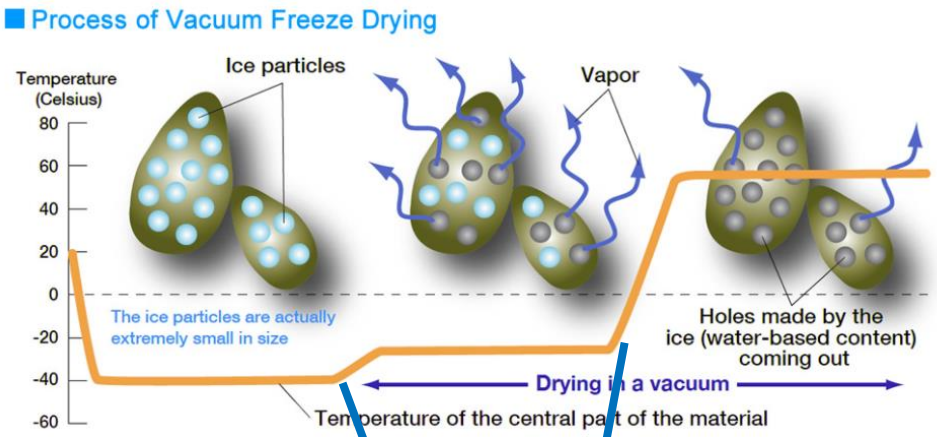
- Residual moisture check.
  - Dry check of H_2O(18)
- Degreasing (hydrocarbon) check.
  - Especially mass number 55, 57, and others check
- Behavior check during a temperature rise, especially at around 1000° C.
  - Mass number 12, 28 check
- Purity check of process gas (Ar).
  - Leak check of gas line and gas purity check

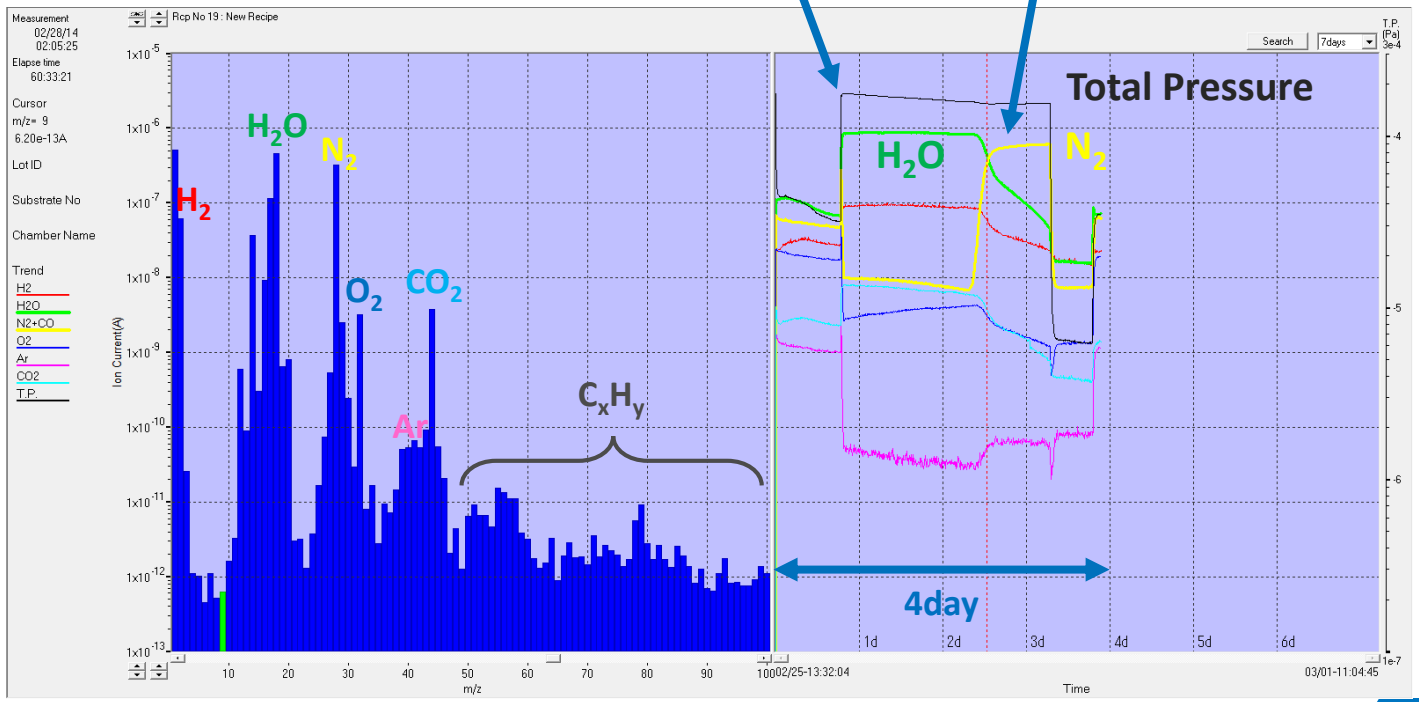
Vacuum freeze-drying furnace (1)

Process Monitoring and Endpoint check

Vacuum freeze-drying equipment manages the temperature and pressure (N2) of the equipment to control the products' drying state (H2O sublimation). Generally, the difference in temperatures between the shelf and a product determines the endpoint.

Qulee can get more information.





✓ **Process Monitoring**

- Stability of sublimation rate (H2O behavior)
- Check for generation of impurities (amount of CxHy)
- Status of pressure control (Whether N2 can control the pressure (total pressure) at a constant level.)

✓ **Endpoint check**

- The decrease in H2O confirms the drying state. The endpoint can be checked more accurately and quickly than by checking using shelf temperature.

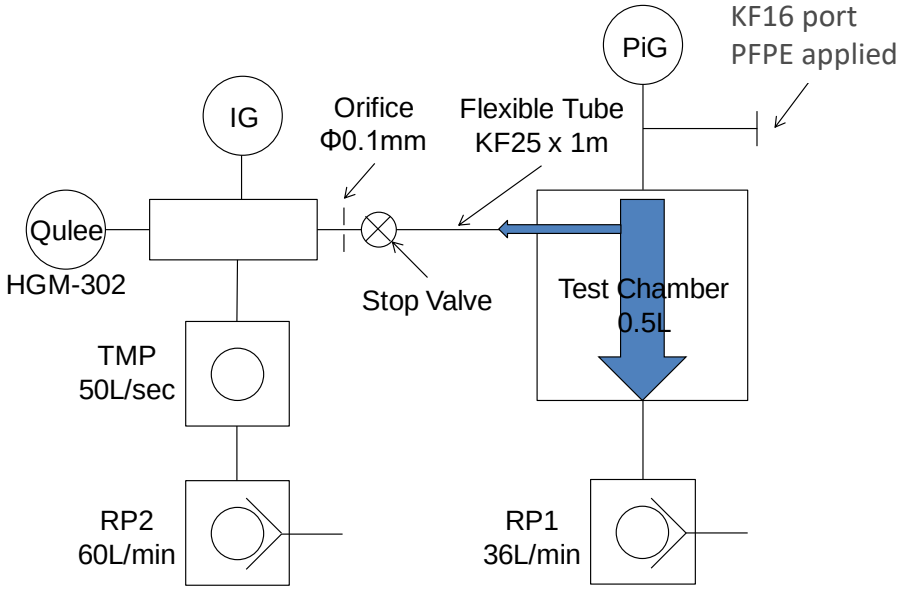
Vacuum freeze-drying furnace (2)

Detection of impurities

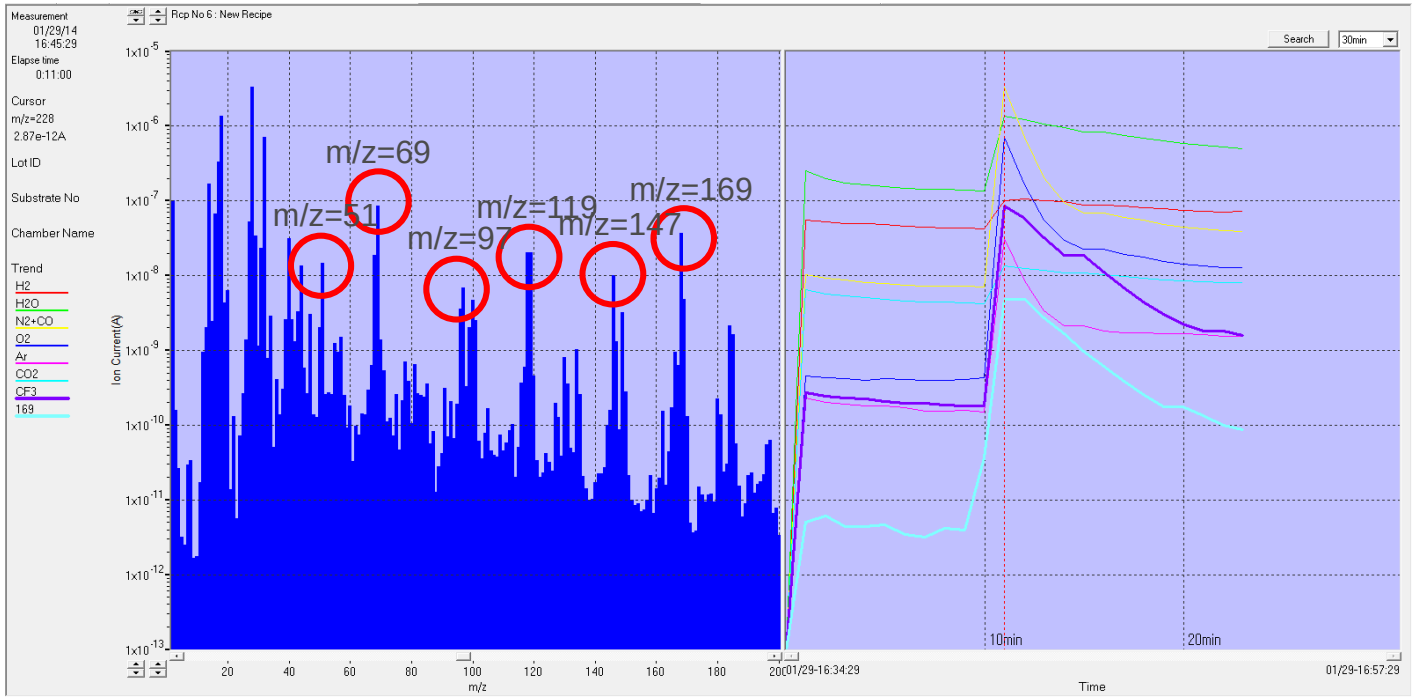
Vacuum freeze-drying equipment sometimes uses Perfluoropolyether PFPE (Galden®) as a refrigerant. If the refrigerant leaks during the process, it can cause defects such as contamination of the product.

Example of PFPE detection in a Vacuum Freeze-Drying Furnace

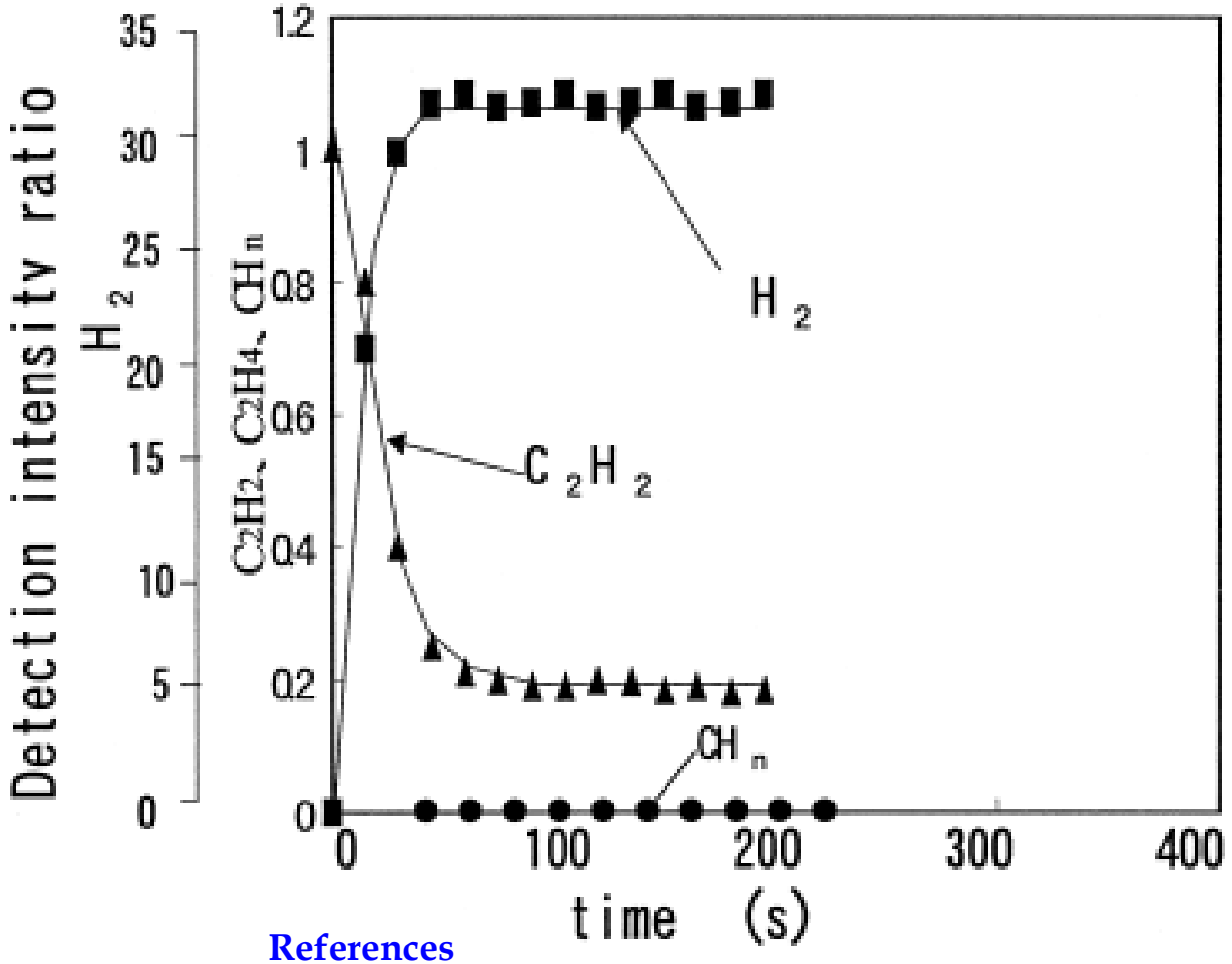
✓ Multiple peaks from PFPE such as m/z=69(CF3) were detected.



Apply 30mg of PFPE to the Freeze-Dry Chamber connected to the Qulee with YTP-H.
Evacuate with RP and open the Stop valve when the pressure drops below 100Pa.



Vacuum Carburizing Furnace・Gas Data



■By introducing acetylene during vacuum carburizing.

- $C_2H_2 \rightarrow 2C+H_2 \Rightarrow 2C[Fe]+H_2$

■When carburizing properly.

- There is no C_2H_4.
- There is no soot.

■When carburizing improperly.

- $C_2H_2 + H_2 \rightarrow C_2H_4$

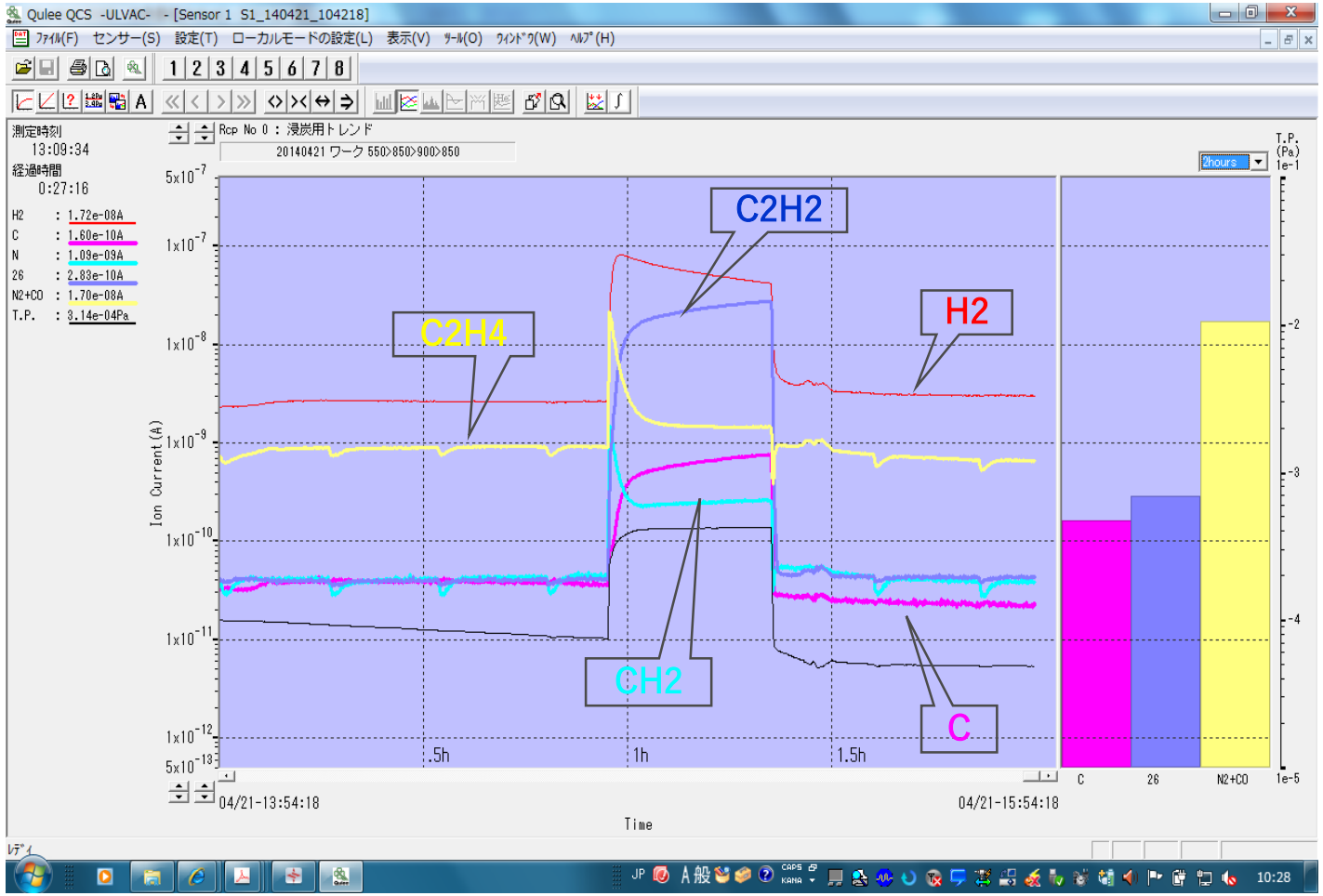
■Endpoint check of the carburizing process.

- Endpoint check of C_2H_2
- Checking CH_n can confirm the formation of soot.

References
Nozomu Okumura, Atsushi Iwase,
“Vacuum Carburizing using Acetylene Gas,”
Denso technical revue Vol.5 No.1 2000

Vacuum Carburizing Furnace・Gas Data

■ Data of changes in furnace environment due to the continuous carburizing method (introducing C_2H_2 continuously)



■The introduction of acetylene during vacuum carburizing initially generates a lot of Ethylene.

$$C_2H_2 + H_2 \rightarrow C_2H_4$$

■When carburizing properly.

- There is no C_2H_4.
- There is no soot.

■The Peak of Mass14 occurs in a similar move as C_2H_4 (28).

■The increase in C suggests that the peak is not N but CH_2 due to C and H being removed from C_2H_4.

- $C_2H_4 \rightarrow 2CH_2$
- $C_2H_4 \rightarrow CH_2 + H_2 + C$

ULVAC Vacuum Components

Oil rotary vacuum pump

Turbo Molecular pump

Spectroscopic ellipsometer

Profiler

Dry vacuum pump

Vacuum gauge

Process gas monitor

Helium leak detector

Deposition controller

RF Power generator

EB GUN & Power generator

DC Power generator