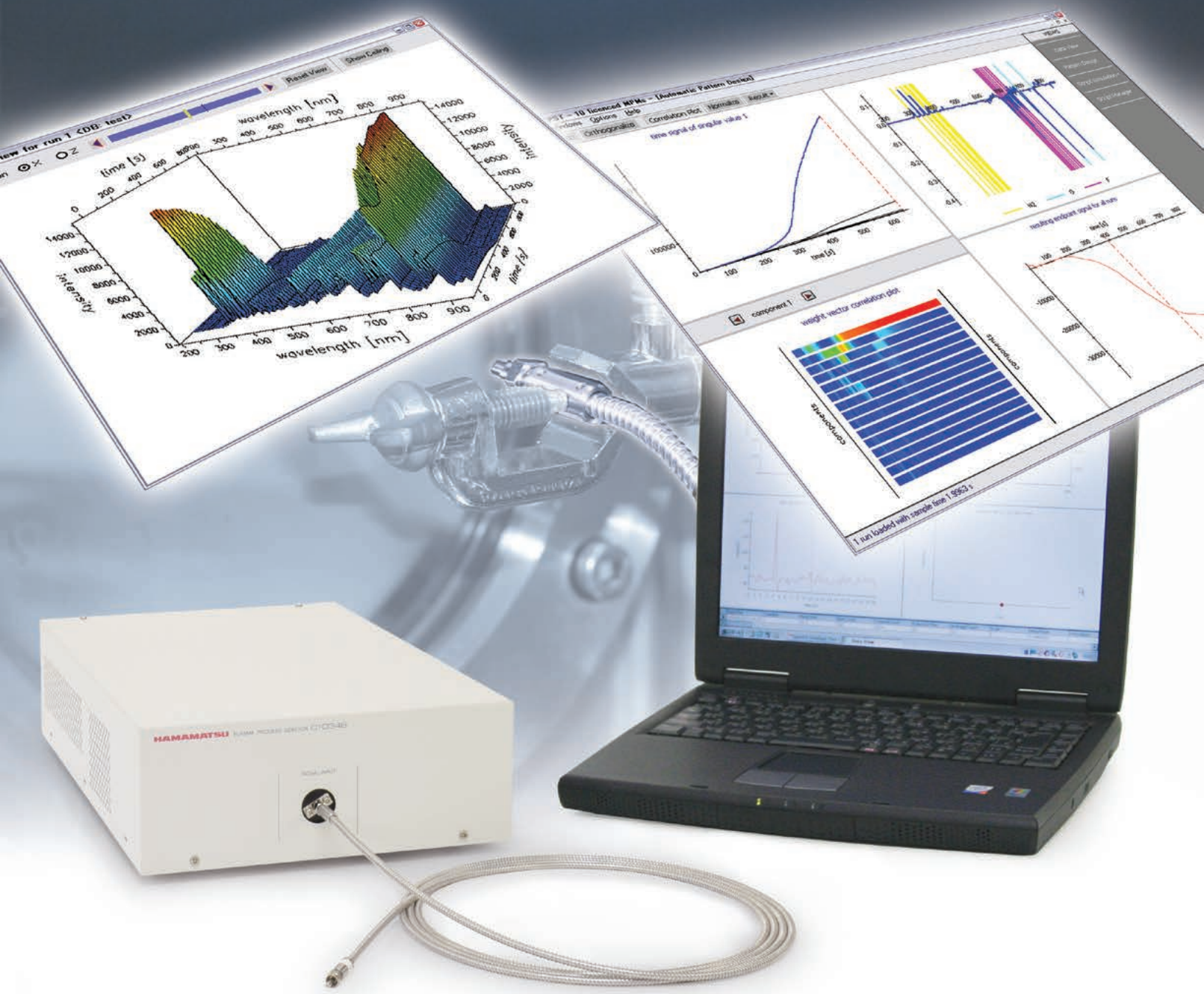
Multiband plasma-process monitor
C10346-01

C10346-01 is a multiband plasma process monitor designed for real-time, monitoring of wide spectrum.



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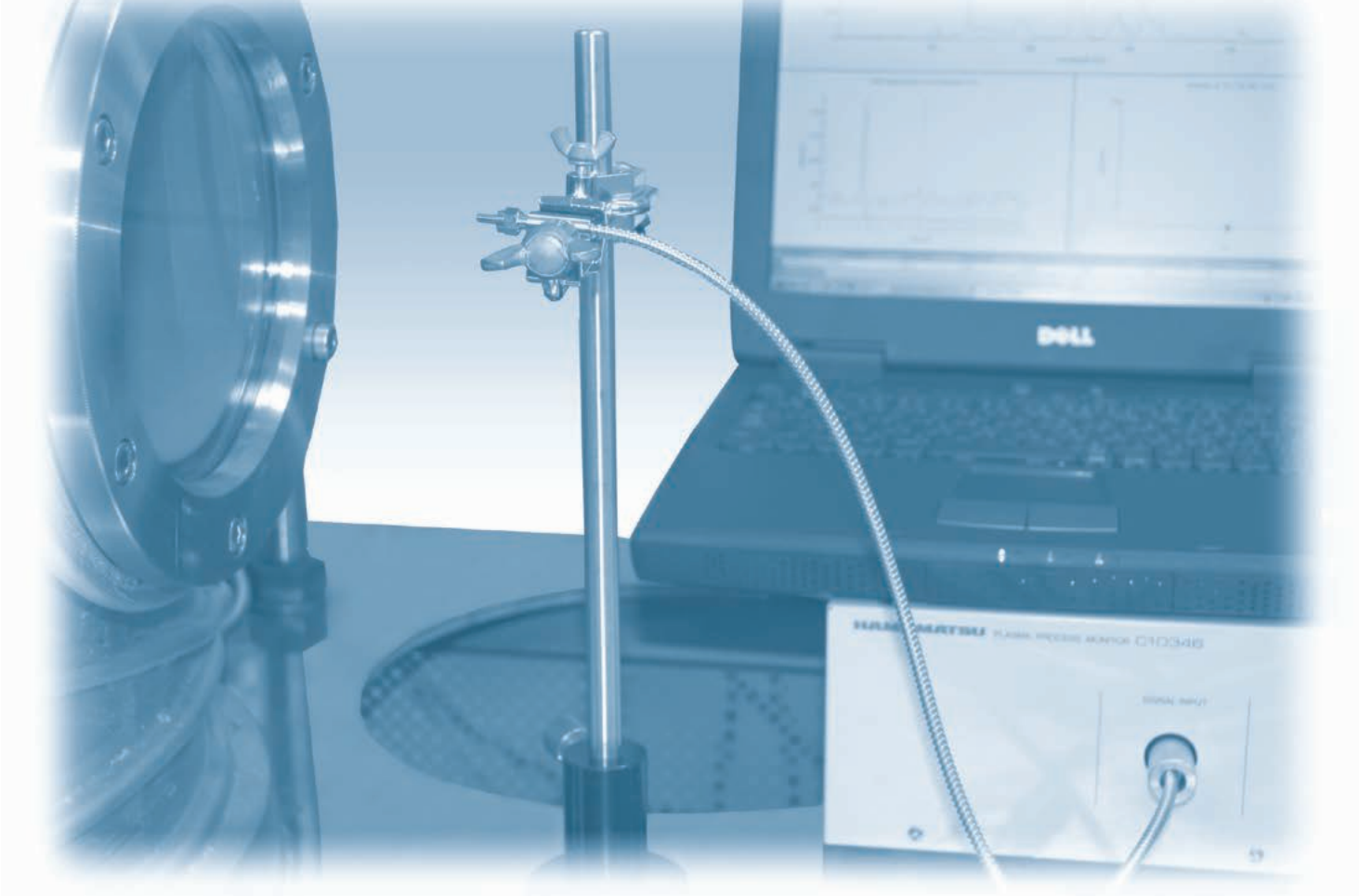


Monitoring Plasma (Emission Spectrum) in Real-Time

C10346-01 is a monitoring system to detect wide spectrum plasma emission during the process of etching, spattering and CVD in semiconductor manufacturing .
With the various analysis functions, it can be used for setting up end-point detection conditions and automatic detection of etching and cleaning, estimation of plasma species and monitoring (plasma) contamination and abnormal discharges.

Features

Simultaneous measurements of wide (plasma) spectrum
Captures wide spectrum (emission) from (plasma) radicals or ions.
C10346-01 : 200 nm to 950 nm

Real-time plasma (emission) measurement
Continuously measures up to 15 000 spectra at an interval of 20 ms (50 ms with concurrent running of detection software)

Highly accurate and reliable measurements
A high resolution spectrometer and a ultra-high sensitive photo detector are firmly locked in position to assure the acquisition of accurate spectrum and precise spectrum responsivity data through sharply focused plasma emission spectrum images.

High-sensitivity detection in UV spectrum region
Detects the UV spectrum region from 200 nm with high sensitivity.

Easy measurement using optical fibers
The equipped optical fiber can be easily attached to plasma chambers through a SMA connector widely used.

Operation with multiple chambers
A single analysis unit can control up to four C10346-01 Multiband plasma-process monitor via a USB 2.0 interface.

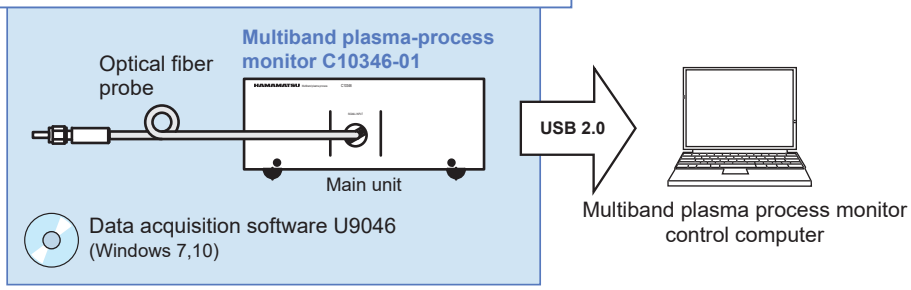
Data acquisition software
The data acquisition software stores the spectrum data into the database during plasma process. This stored data can then be used for spectrum data calculations.

Optional software
High sensitive endpoint detection and real-time monitoring of process abnormality are achieved by creating "detection model".

Instantly measures different types of radicals and ions in plasma

- Plasma Etching
- Deep-RIE
- DLC Coating
- RIE
- Plasma Surface Treatment
- Plasma CVD
- Plasma Ashing
- Sputtering
- Other Processes Using Plasma

Standard system configuration



Easy parameter evaluations to detect etching and cleaning endpoints

Optimal conditions or triggers used for defining endpoints can be set for individual process by analyzing and simulating the timing at which etching and cleaning end.

Automatic detection of etching and cleaning endpoints

Boosts the process throughput and reduces device damage by automatically detecting the endpoint for each ware by utilizing endpoint detection conditions optimized for each process.

Estimation of plasma species during process

Plasma spectrum library allows estimation of plasma species in a process.

Impurity and abnormal discharge monitoring

Constant monitoring of emission bands where no emission occurs in normal processes allows early detection of air leaks, intrusion of impurities, and abnormal discharges.

A host of user-friendly measurement functions

Data measurement

- Measurement parameter evaluations (maximum measurement time, exposure time, number of integration)
- Manual measurement start / stop (start / stop by manual operation)
- Trigger to start automatic measurement (light intensity level, external TTL signal)
- Spectrum monitoring and automatic judgment according to measurement and detection conditions in script

Spectrum data saving

- Storing in Microsoft Access and SQLite file format database
- Storing in Microsoft SQL and Oracle database

Data view

- Spectrum waveform display at any time point
- Time-based waveform display on any wavelength
- Wavelength and intensity readout by just pointing the cursor
- Estimation of plasma species
- 3D Display (wavelength-axis/temporal-axis/intensity-axis)
- File output of measurement data

Script programming

- Four arithmetic operations of spectrum (difference of spectrum / ratio of spectrum etc...)
- Spectrum normalization
- Processing using primary and differential (first order / second order), integral and other function
- Voltage output of calculated results from analog output (0 V to 10 V : 2 channel)
- Judgment result output from digital output (TTL maximum 5 channel)

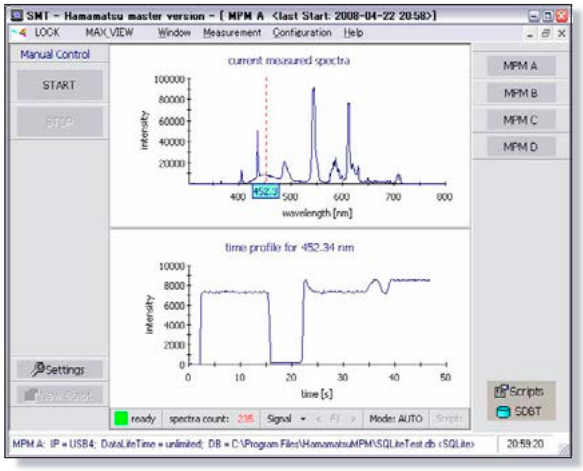
Simulation

- Simulation of scripts using spectrum data stored in database
- Automatic display of judgment time trend-chart

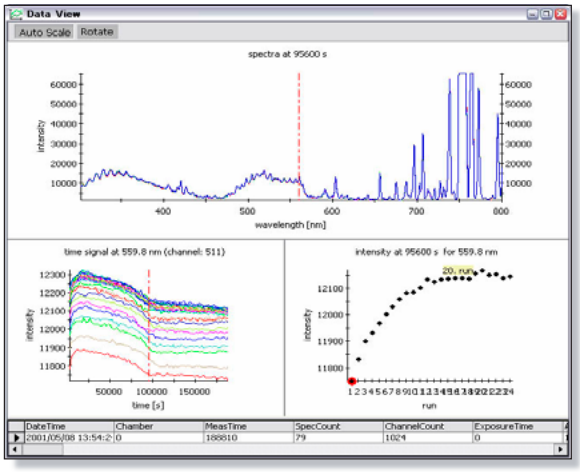
Data analysis

- Time-based spectrum analysis
- Analysis of spectrum patterns generated at endpoint
- Creation and analysis of fault detection models for finding abnormal spectra

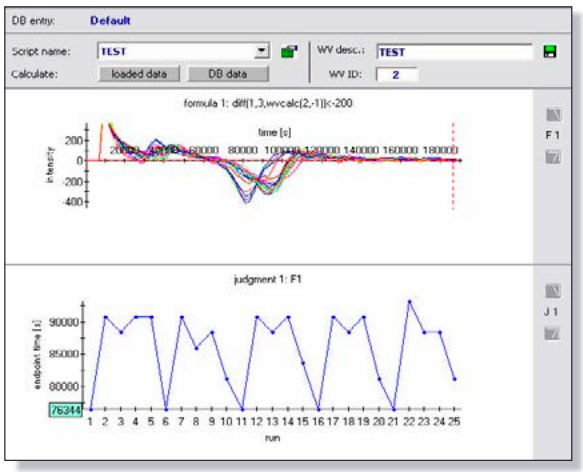
Spectrum data measurement window



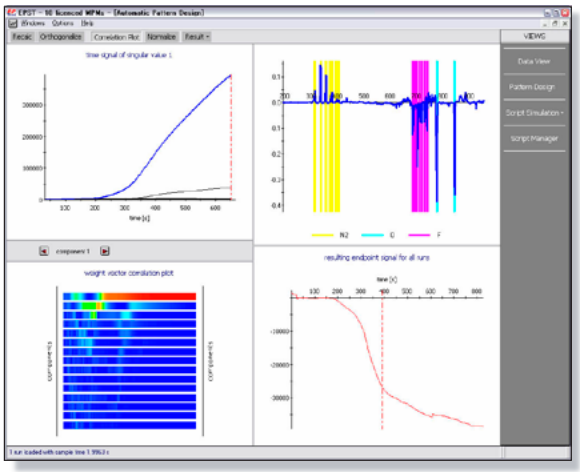
Spectrum data view chart



Simulation chart

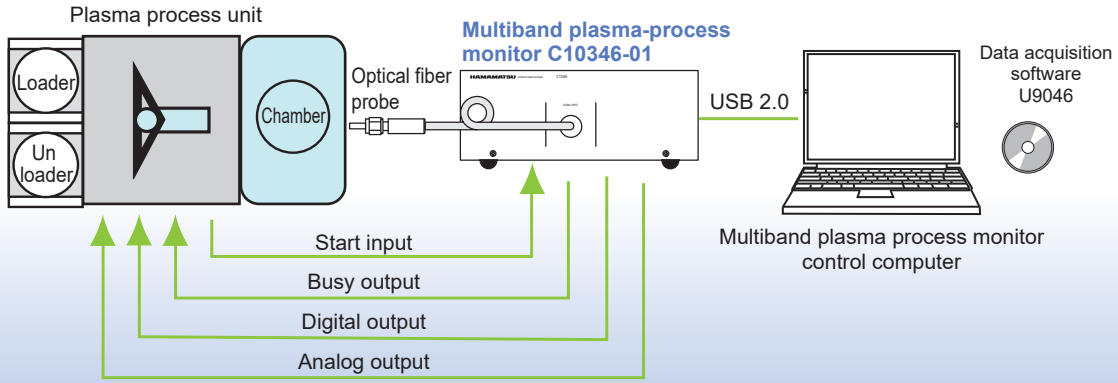


Spectrum pattern analysis at endpoint

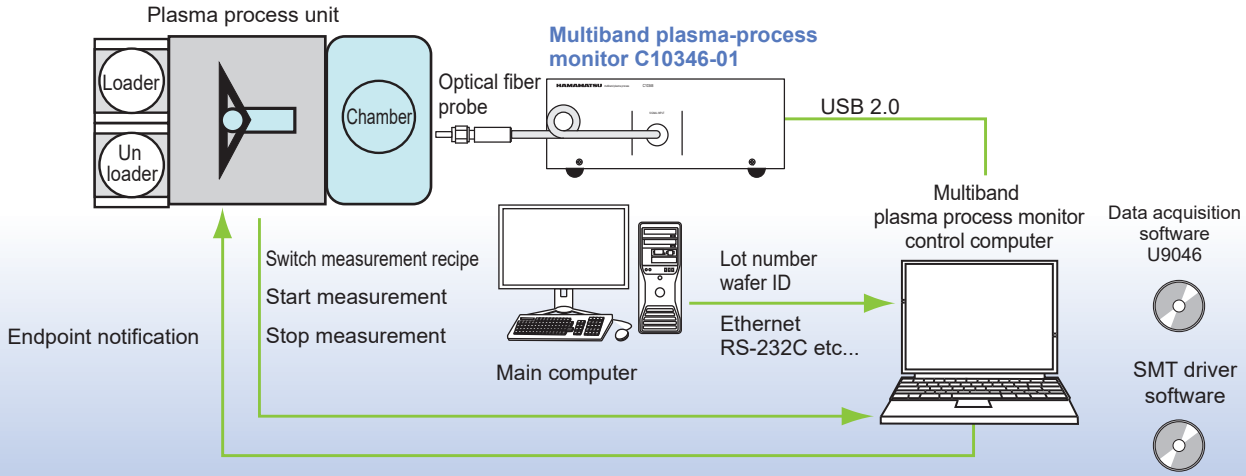


Operation with multiple chambers

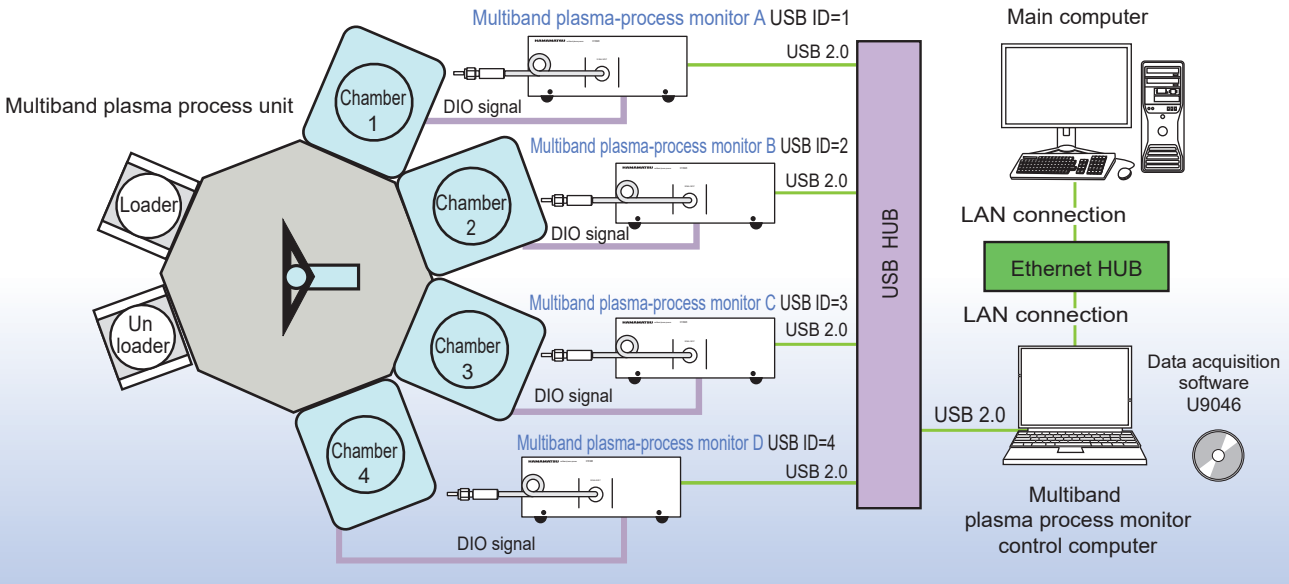
Single chamber configuration



Single chamber configuration (SMT drive software)

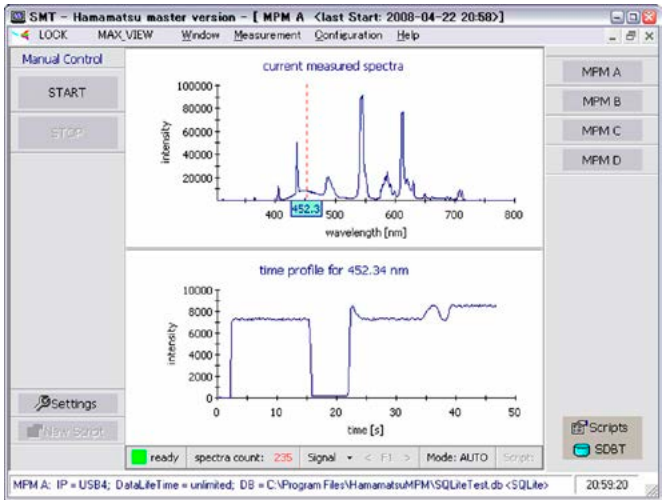


Multiple chamber configuration



Standard software

Data acquisition software U9046



Stores emission spectrum database acquired during the multiband plasma process into a database !

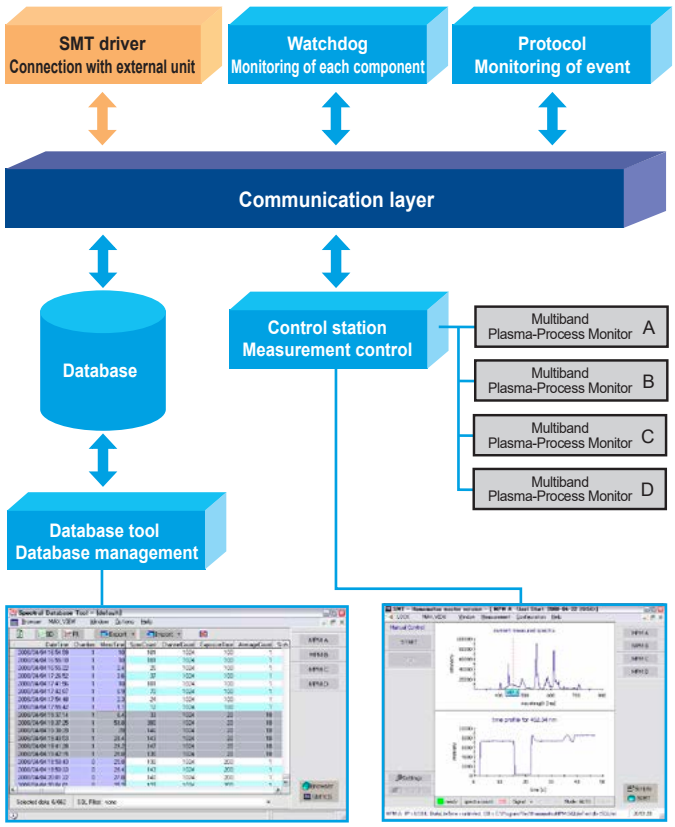
The data acquisition software U9046 is software that simultaneously controls up to four the multiband plasma-process monitors C10346-01 (or previous model C7460) for measuring emission spectra during the plasma process.

The measured spectrum data is automatically stored in the database which can also be accessed from the end point synthesis tool U8851. What's more, the U9046 can detect process faults or abnormalities in real time when linked with the analysis and fault detection tool U9275.

Features

- Simultaneous control of up to 4 multiband plasma process monitors
- Database-oriented data storage
- Data access by SQL
- User-oriented SMT driver allows communication with plasma chambers and factory networks

Configuration



The U9046 consists of several software components to ensure both high flexibility and real-time measurement.

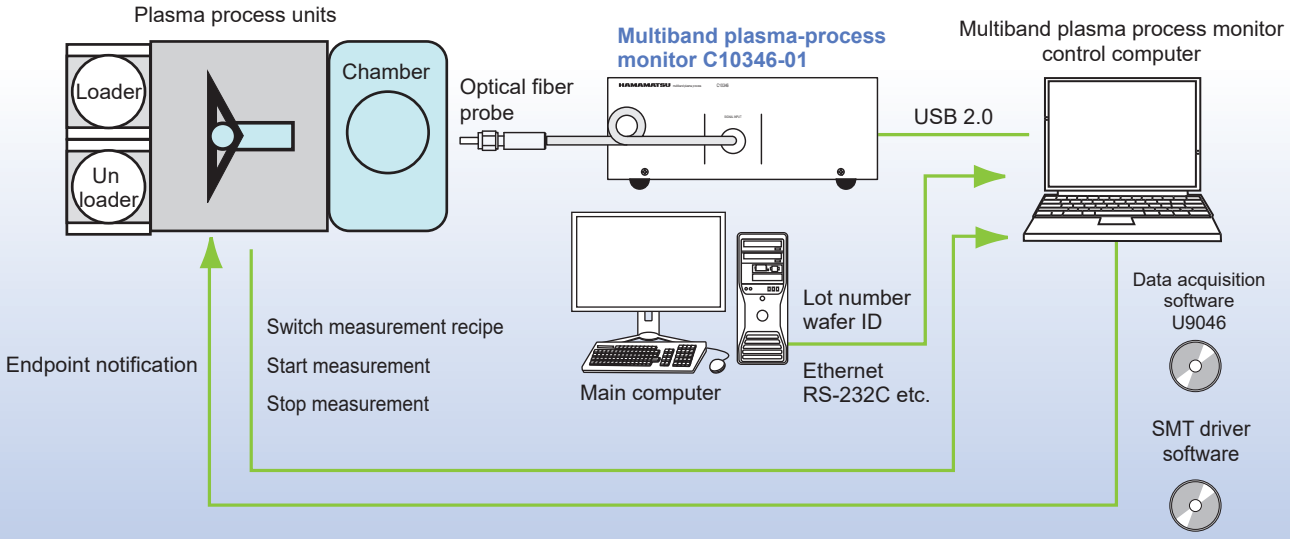
- **Control station (measurement control)**
  The control station operates the multiband plasma process monitor to measure emission spectra. Measurement can start from a trigger signal or optical trigger sent from the plasma chamber. When a measurement ends, the next measurement starts automatically.
- **Database**
  Database measured from the control station is stored in the SQL compatible database.
- **Watchdog (monitoring of each component)**
  The watchdog constantly monitors the software status and sends an e-mail message if an error occurs.
- **Protocol (monitoring of event)**
  The protocol monitors events occurring on each component and records them in a file.
- **SMT driver (connection with external unit)**
  This is software for communicating with the plasma chambers and factory networks. It can be created to orient the user's system requirements.
- **Database tool (database management)**
  This software displays and manages the measured data. It also transfers data to the end point synthesis tool U8851 and analysis and fault detection tool U9275.

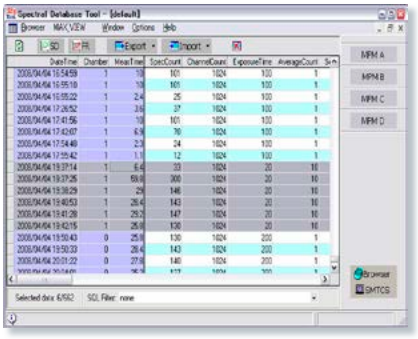
Software that extracts full performance from the multiband plasma process

SMT driver

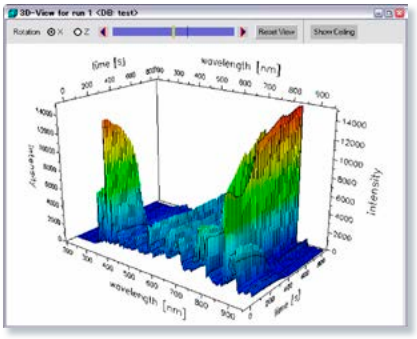
The data acquisition software U9046 communicates with other software through a Microsoft COM interface. Intermediate software created for Microsoft COM interface and other interfaces (RS-232C, Ethernet, etc.) allows the U9046 to communicate with external units. This type of intermediate software for the U9046 is referred to as an SMT driver. The U9046 comes with an SMT driver sample program that was created with Visual Basic. Modifying this sample program allows the user to easily create an SMT driver that orient his system requirements.

The SMT driver also allows storing data such as lot numbers and process ID, which are sent from the external unit, together with the spectrum data. The user can use information sent from the external unit to change measurement conditions or start and stop measurement, etc.

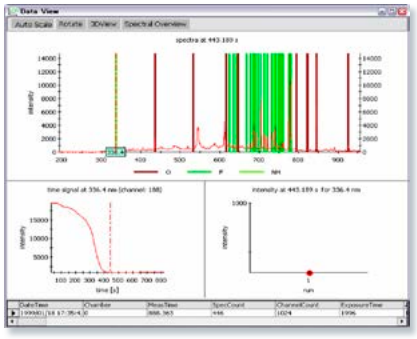




Database browsing using SDBT software



3D spectrum display



Plasma species analysis

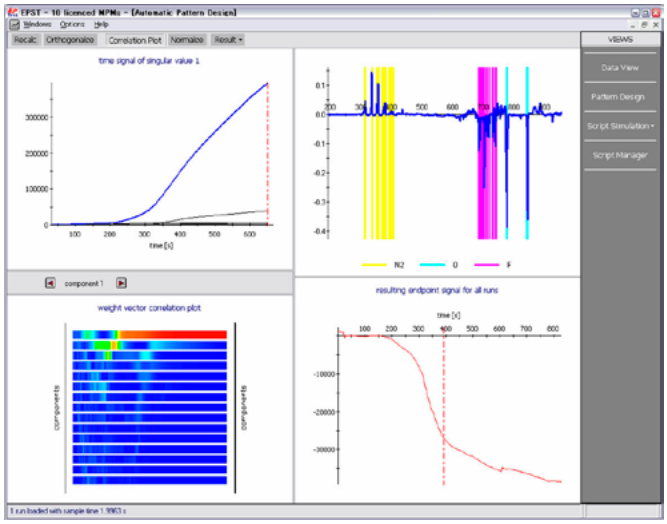
Software license

The U9046 can be installed without a license. However, you can't do measurements and save scripts without the license.
The license is included in C10346-01.

Hardware requirements : Windows 7,10

Option Software

End point synthesis tool U8851



Detects endpoints with high sensitivity, even in small aperture etching !

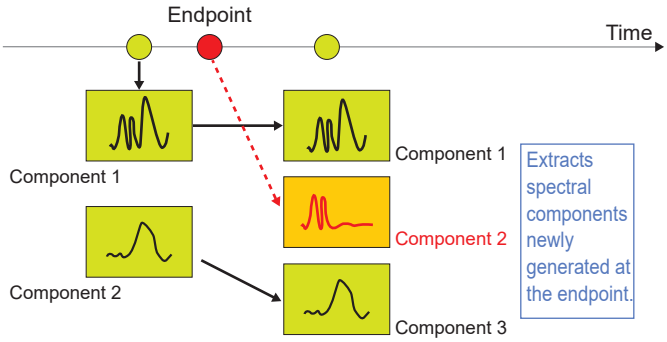
The end point synthesis tool U8851 is software for detecting the endpoint in plasma etching with high sensitivity by using the multiband plasma-process monitor C10346-01(or previous model C7460). The U8851 ensures highly sensitive detection of the endpoint in the small aperture process which until now has been difficult to detect. Process data on multiple wafers can also be analyzed simultaneously, which enhances the reliability of the endpoint detection arithmetic algorithm. This makes it easier to validate the detected endpoint and is also useful for evaluating process stability.

Features

- Endpoint detection in small aperture process
- Improved accuracy via noise (spike, drift)
- Simultaneous multiple wafer analysis cancels out variations between wafers or lots
- Optimization for over-etching
- Stability estimation of process

Overview

Spectrum data acquired with a multiband plasma process monitor can be considered the sum of various spectral components including gas spectra and reaction product spectra.
The U8851 analyzes the spectral components at each time and then extracts the spectral components which are newly generated at the endpoints. Endpoints are detected based on time-course changes in these spectral components. This makes it possible to detect an endpoint while making effective use of a wide spectral range. This is highly accurate detection compared to conventional endpoint detection by single wavelength analysis.



The endpoint signal obtained with the U8851 is given by the following equation. The endpoint is then detected based on the time-course changes in this endpoint signal. Applying smoothing and differential processing to these time-course changes will enhance the detection accuracy.

Equation1 : Equation of endpoint signal

Endpoint signal = Σ [w(λ) × I(l)]
w(λ) : Spectral components acquired by analysis
I(λ) : Spectral data acquired by multiband plasma process

Analysis examples

Optimizing the CVD cleaning (CF_4, O_2) after depositing SiN (SiH_4, NH_3, N_2, Ar) film.

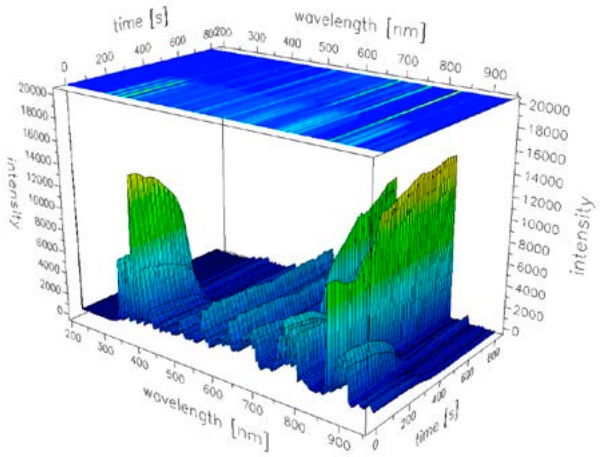


Figure 1: 3D display of CVD cleaning (CF_4, O_2) plasma spectrum after depositing SiN film

Figure 1 shows spectral data acquired with a multiband plasma process during CVD cleaning. Using the U8851 easily creates optimal conditions for detecting and identifying the endpoint from vast amounts of data. Analysis results obtained with the U8851 are shown in Figures 2 and 3.

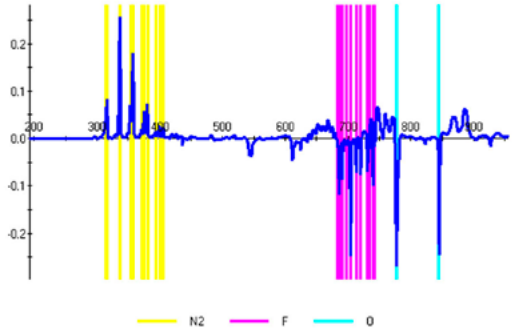


Figure 2: Spectral components generated at cleaning endpoint (Emission wavelengths of N_2, O and F are displayed by marker)

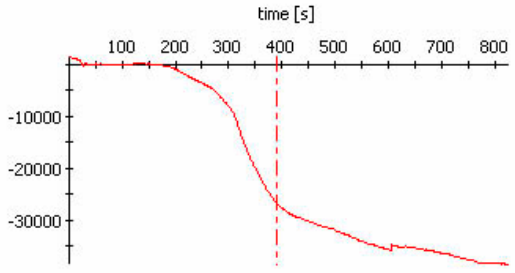


Figure 3 : Temporal changes of spectrum (Figure 2)

The U8851 includes a library of typical material emission wavelengths that allows analyzing what materials have produced the acquired spectral components. In this example, N_2, O and F line spectra appear on spectral components generated at the cleaning endpoint. The N_2 spectral intensity can here be observed to decrease at the endpoint while the O and F spectral intensities increase.

This analysis can be simultaneously performed on two or more wafers. The detected endpoint time for each wafer appears on a graph. The U8851 can also utilize these functions to check the process stability while verifying the endpoint detection. (Figure 4)

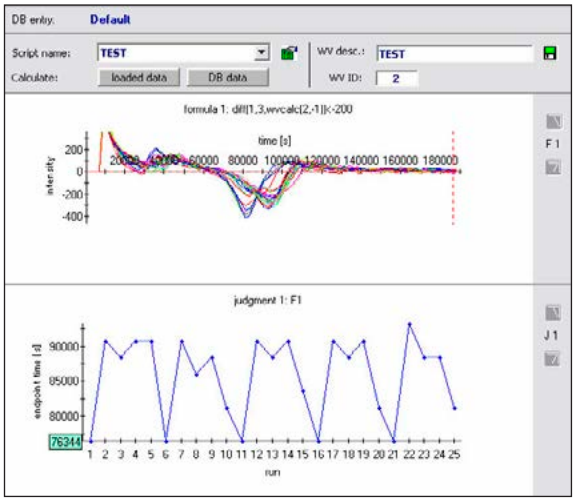


Figure 4 : Analysis window

Endpoint detection conditions acquired this way are stored as a script in the database and can then be used for measurement. During measurement, real-time calculation is performed using equation 1 so that the endpoint is detected in real time.

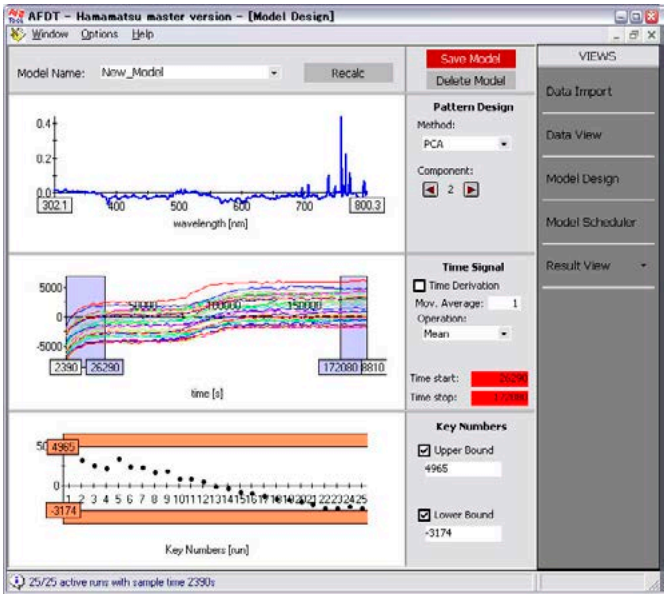
Software license

The U8851 can be installed without a license and used to acquire spectral components by spectrum analysis. However, real-time endpoint detection is impossible due to restrictions on storing the spectral components acquired by spectrum analysis. Conventional endpoint detection can be performed without a license since the U8851 utilizes time-course changes at single wavelengths.

Hardware requirements : Windows 7,10

Option Software

Analysis and fault detection tool U9275



Yields key numbers representing the state of each process (run) and utilizes those changes to detect faults in the process !

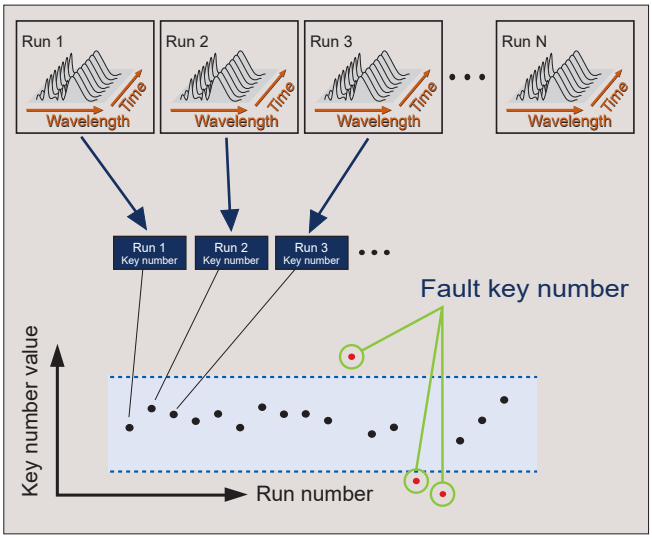
The analysis and fault detection tool U9275 is software for detecting process faults by using a multiband plasma-process monitor C10346-01 (or previous model C7460). Based on spectrum data from each process (run), the U9275 finds key numbers that represent the process state, and then detects faults based on changes in the process state.

Features

- Real-time fault detection
- Past process data analysis
- Alarm transmission to external system

Overview

As mentioned in the U8851 description, spectrum data acquired with a multiband plasma process monitor can be considered the sum of various spectral components including gas spectra and reaction product spectra. The U9275 finds statistical values such as mean and maximum relative to time-course changes in the spectral components being monitored, and assigns them key numbers. A normal range for each key number is also set. If a value exceeding that range is found, it is treated as a fault. By selecting a calculation method for appropriate key numbers, a fault detection model associated with each event such as leak and contamination can be stored in the memory. This detection model can then be applied to online analysis and offline analysis tasks.

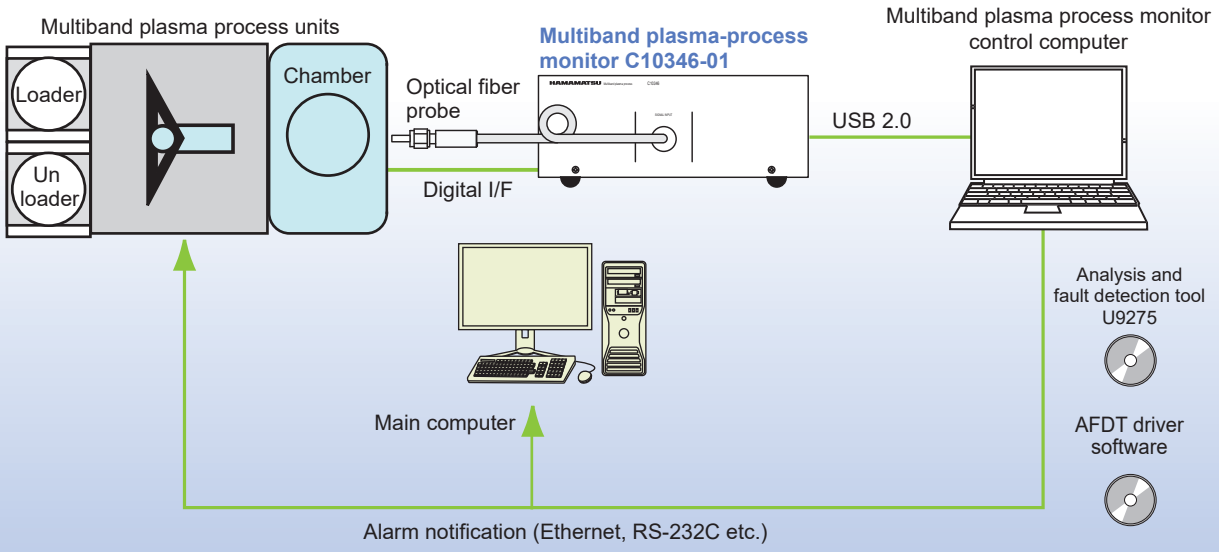


In online analysis, key numbers are derived for the data being currently measured in order to perform real-time fault detection. An external system is then directly sent information on the detected fault or is notified by e-mail. In offline analysis, key numbers are derived for an existing database, and these are used for analyzing data accumulated in past measurements.

Real-time detection of process faults such as leaks and contaminations

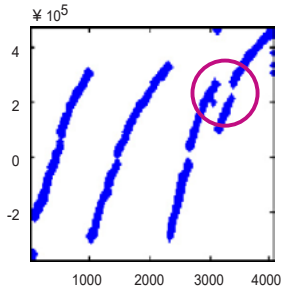
AFDT driver

The analysis and fault detection tool U9275 communicates with other software through a Microsoft COM interface. Intermediate software created for the Microsoft COM interface and other interfaces (RS-232C, Ethernet, etc.) allows the U9275 to communicate with external units. This type of intermediate software for the U9275 is referred to as an AFDT driver. The U9275 comes with an AFDT driver sample program that was created with Visual Basic. Modifying this sample program allows the user to easily create an AFDT driver that orients his system requirements.
The AFDT driver transmits the online analysis results to the external unit.



Detection example1

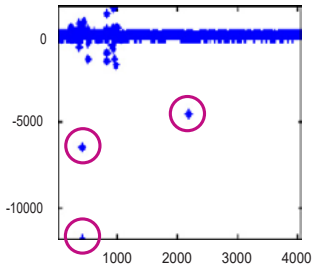
Inadequate cleaning



Effective in setting cleaning periods and checking the cleaning effect

Detection example 2

Incident leak



Detectable phenomena

- Impurity incorporation
- Abnomal discharges
- Changes in plasma component balance
- Contamination in chamber
- Gas composition changes
  RF power changes
  Pressure changes

etc

Software license

The U9275 can be installed without a license. However, online analysis and offline analysis cannot be performed without a license although creating and storing fault detection models is allowed.

Hardware requirements : Windows 7,10

Variety of options available to help expand applications

Specifications

Hardware

Type number	C10346-01
Wavelength range	200 nm to 950 nm
Wavelength accuracy	±0.75 nm
Wavelength resolution (FWHM)	< 2 nm
Power supply	AC 100 V to AC 240 V 50 Hz / 60 Hz
Power consumption	Approx. 70 VA
Digital output terminal (Determinate signal output)	TTL maximum 5 channels (3 channels maximum when measurement trigger signal is used)
Digital input terminal (starting measurement trigger signal)	TTL 1 channel (Using TTL 5 channel)
Digital output terminal (Busy signal)	TTL 1 channel (Using TTL 4 channel)
Analog output terminal	2 channels 0 V to 10 V
Fiber probe connector	SMA
Communicate interface	USB 2.0 Type B
Ambient operating temperature	+10 ˚C to +30 ˚C

Software

Operating system

Windows 7,10

Standard software

Data acquisition software U9046

(Built-in SMT driver • AFDT driver sample program)

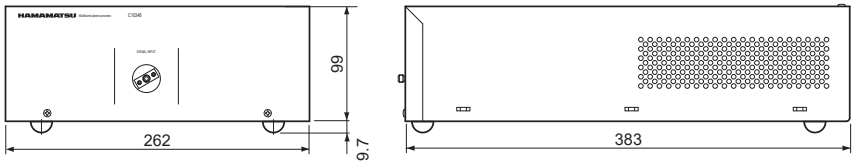
Option

- Data analyzer for plasma process monitor
- End point synthesis tool U8851
- Analysis and fault detection tool U9275
- Software for building into equipment

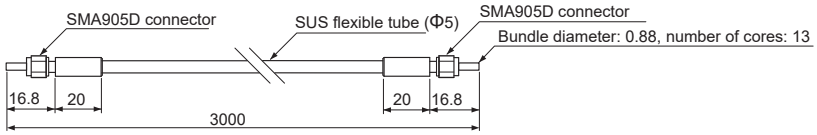
  SMT • AFDT driver software

Dimensional outlines (Unit : mm)

C10346-01(Approx.5.7 kg)



Optical fiber probe(Approx.115 g)



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