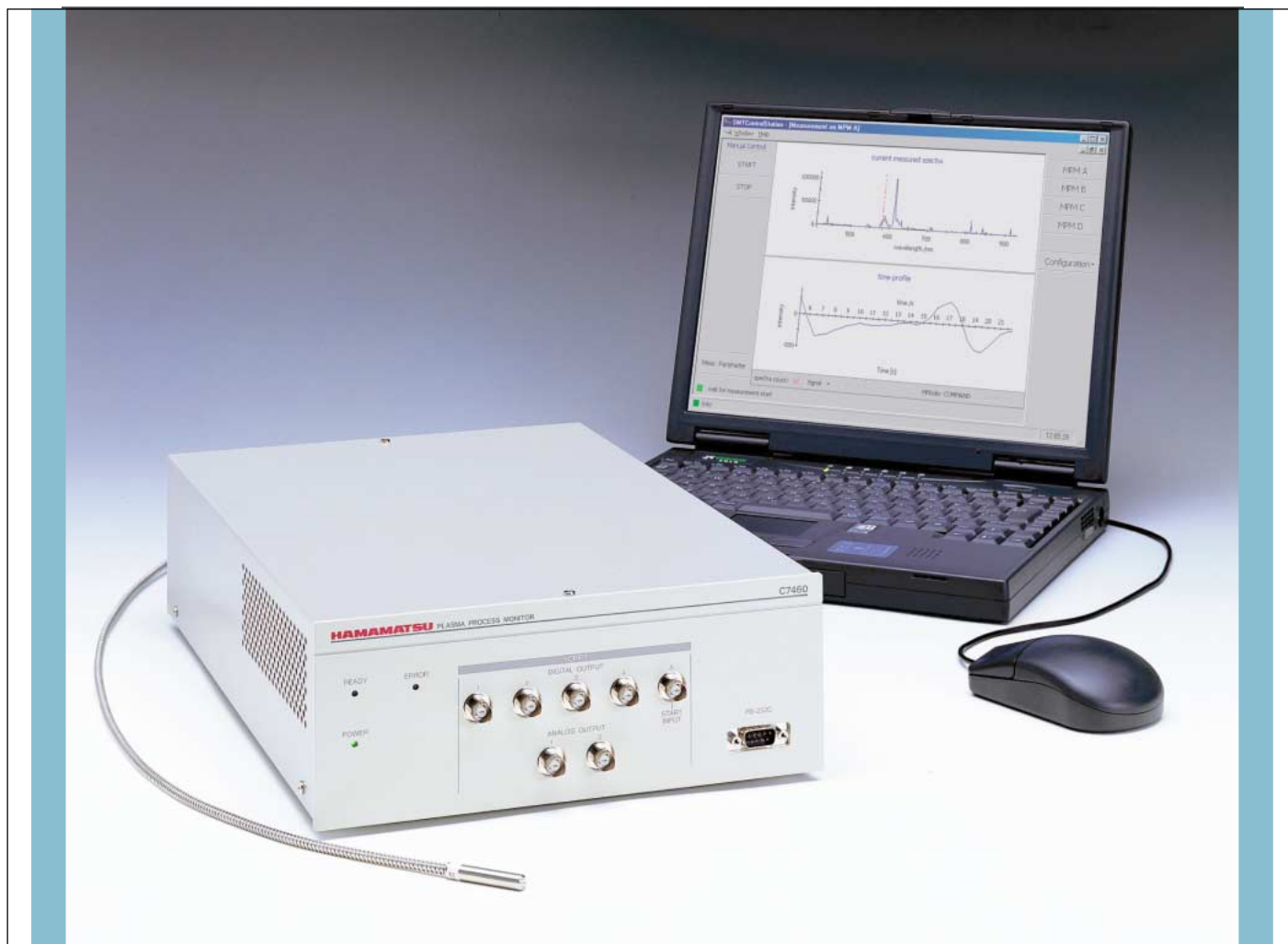


Multiband Plasma-Process Monitor Model C7460



The Multiband Plasma-Process Monitor (MPM) is a system specifically designed for monitoring the optical plasma emissions that are created during the various manufacturing processes of semiconductors including etching, sputtering, cleaning, and CVD. The MPM can handle multi-channel recording in real-time.

- **Simultaneous measurement from 200 to 950 nm**
- **Easy measurement using optical fiber input**
- **High levels of accuracy and reliability**
- **Software for measurement, analysis and factory integration**

HAMAMATSU

Real-Time Plasma Monitoring

BACKGROUND

Up to 60 percent of the time that a piece of semiconductor manufacturing equipment spends in operation is generally for non productive jobs like plasma cleanup, chamber stabilization (seasoning) and system diagnosis. Typical approaches for reducing down-time and repetitive processes like these are to utilize Advanced Process Control (APC) and Sensor Based Process Control (SBPC) technologies with factory LAN services. The MPM allows you to gain full control over processes using information provided by the MPM regarding plasma spectra, etching end-point detection status, plasma fault status, etc. The MPM opens the possibility of significantly increasing the efficiency of manufacturing equipment.

FEATURES

- **Highly Accurate and Reliable**

The MPM employs a high-resolution compact spectrograph and a highly sensitive detector which diagnose plasma with elevated levels of precision. Along with these superior photometric characteristics, the MPM is compact, sturdy and offers the high standards of reliability that are required in a manufacturing environment.

- **Easy to Operate**

The MPM is equipped with a sturdy fiber optic bundle, which can conveniently be combined with the plasma chamber. Due to this, and due to its easy-to use software, the MPM is easy to setup and operate.

- **Intelligent Sensor System**

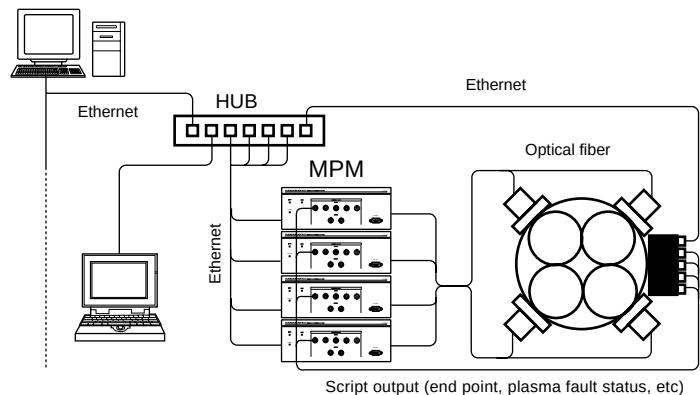
The MPM is not just a spectrograph. It also contains internal data processing capabilities which allow to extract and compress the relevant information from the data.

- **Easy Fab Integration**

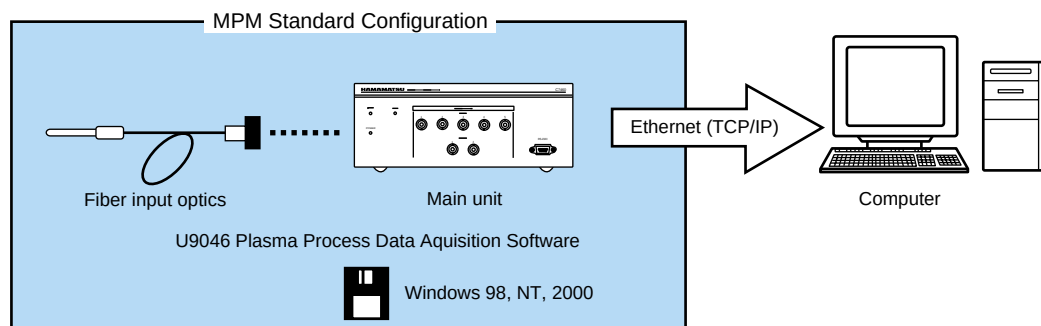
The MPM is equipped with several interfaces including Ethernet and a TCP/IP protocol stack. Together with its very versatile software framework this allows the easy integration into existing fab IT infrastructure.

PLASMA ETCHING
SPUTTERING

CONFIGURATION OF APC WITH MPM (EXAMPLE)



STANDARD CONFIGURATION



Simultaneous Measurement from 200 nm to 950nm

PLASMA CVD CLEANING

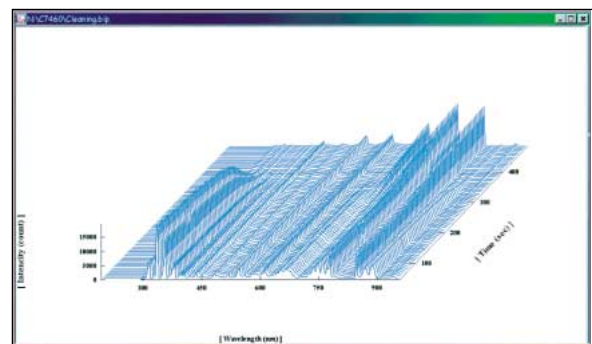
APPLICATIONS OVERVIEW

Due to the high versatility of the hardware and the software framework, the MPM is suitable for various different applications, without any compromise in performance or convenience. These applications can be grouped into the following categories:

- **Engineering Tasks**
Such as process optimization, comparison and matching; trouble-shooting; etc.
- **Endpoint Control**
Advanced, highly specific and sensitive end point control.
- **Fault Detection**
Highly selective automatic fault detection.
- **APC Sensor**
Automatic extraction of highly specific APC key numbers. (Under development)

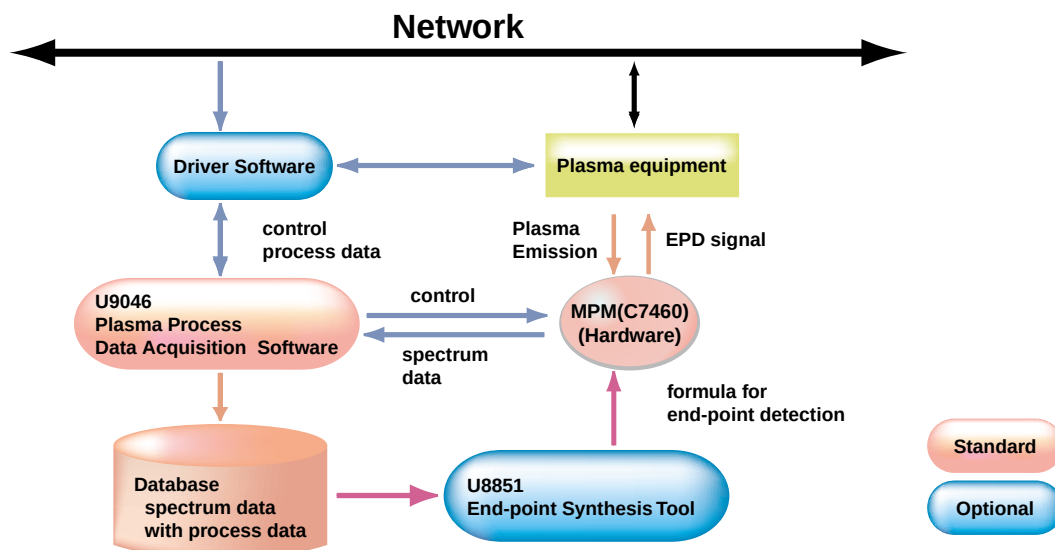
BENEFITS (EXAMPLES)

- **Easy Plasma Status Settings**
Real-time monitoring of the plasma process supports easy to make settings for the volume of introduced gas and plasma power. Product yield is increased through improved processing stability, and the early discovery of abnormalities.
- **Advanced Endpoint Detection**
Powerful scripts can be defined as recipes for each endpoint detection. It is possible to use the information in the whole spectrum by means of the unique spectral patterns method. This allows for advanced endpoint control with unprecedented specificity and precision.
- **Higher Efficiency through Automatic Cleaning Control**
Particularly with CVD, in which the chamber must be cleaned each time a wafer is processed, cleaning time has a major effect on actual operating efficiency. The automatic control features greatly improved throughput, increased productivity, and reduced costs.
- **Monitoring of Impurities and Abnormal Discharges**
Monitoring of the emission band, which does not occur in normal processes, provides warning of impurities and abnormal discharges before they occur, and thus improves yield.



▲ 3-d display of plasma emission of CVD Cleaning (CF, O₂, Ar) of SiN

SYSTEM STRUCTURE



Easy Measurement using Optical Fiber

FUNCTIONS OF HARDWARE

● Measurement Parameter Setting

- Measurement interval
- Exposure time: 20 to 32767 ms
- Data accumulation: 1 to 32767 spectra
- Sensor sensitivity: 3 settings (1x, 2x, 5x)
- Wavelength smoothing: on/off
- Width for wavelength smoothing: any integer value within 1 to 50 nm
- Time smoothing (rolling average): on/off
- Filter for time smoothing: any value within 0 to 100 %
- Trigger : measurement start trigger

● Measurement Script

Scripts contain measurement conditions as well as formula and judgments applied to the data. Results of script processing can be output via the software and via the analog BNC terminal in real-time. Each etch process will be treated by a tailored script. The maximum number of scripts the MPM can store internally is 100, and one of them is selected as the active one. Each script can contain the definition of up to 32 formulas. All script processing is performed inside the MPM and in real-time.

● Script Formula

Script formula can be defined to perform math operations between spectral intensities. Besides the four basic algebraic functions, it is also possible to compute smoothing, differentials as well as the special spectral patterns applied for endpoint and fault detection (see section on U8851 in this brochure).

● Judgments

Judgments are used to detect endpoint or fault conditions. They are defined by thresholds applied to formula, and they can be chained and combined by logical operators.

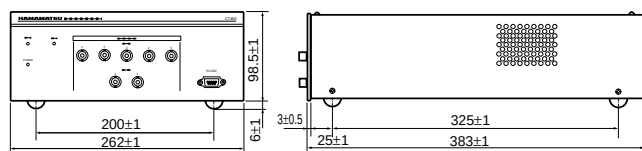


SPECIFICATIONS

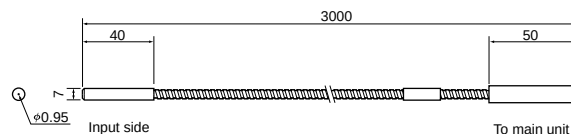
Fiber input optics	Bundle diameter inner: 1 mm; outer: 7 mm Fiber aperture (N.A.) 0.2 Bundle length 3 m
Wavelength range	200 to 950 nm (Measuring range) 235 to 950 nm (Sensitivity-corrected range)
Wavelength resolution	< 2 nm
A/D resolution	16 bit
Analog signal output result of formula calculation	2 outputs BNC; 0 to 10 V
Script output result of judgment calculation	5 outputs (3 outputs for External Trigger) BNC; TTL; High impedance
Busy output	BNC; TTL; High impedance
Start input	BNC; TTL; High impedance; pulse width: min. 40 ms
Interfaces	Ethernet
	Serial
Interface protocol	TCP/IP (for Ethernet only)
Line voltage	AC 100 / 117 / 220 / 240 V $\pm$ 10%; 50 / 60 Hz
Power consumption	90 VA

DIMENSIONAL OUTLINE (Unit: mm)

● Main Unit (weight: approx.7kg)

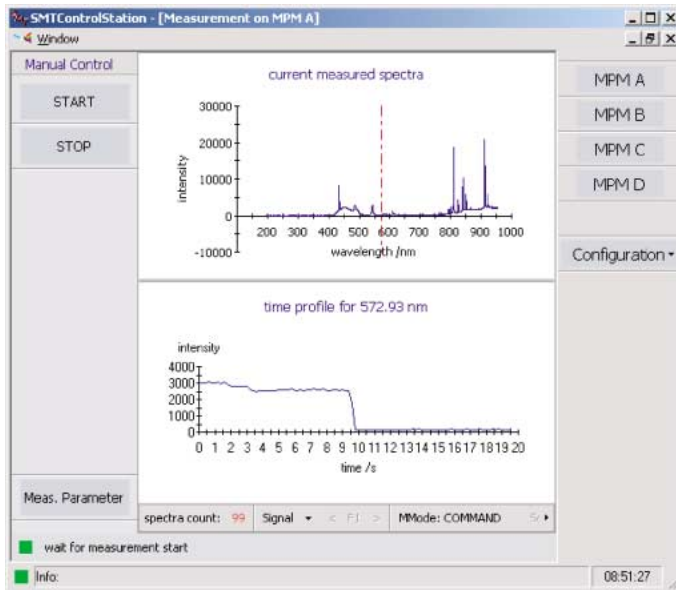


● Fiber Input Optics (weight: approx.100g)



Plasma Process Data Acquisition Software U9046

Standard Software



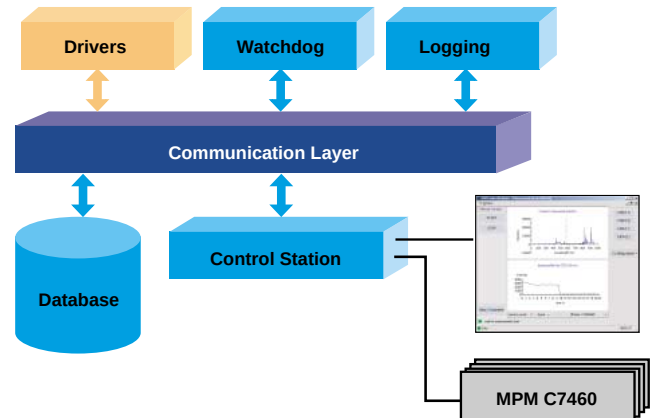
OUTLINE

The U9046 is a software which allows to control up to 4 units of C7460 multiband plasma process monitor simultaneously and observe the spectrum of plasma emission during plasma processes. The observed spectrum data are stored in the database automatically and can be analyzed. The highly sensitive end-point detection software U8851 is an option. And also the fault detection software for Advanced Process Control will be available.

FEATURES

- Up to 4 units of C7460 can be controlled simultaneously, and all of the spectrum data during plasma process can be observed.
- Database oriented data storage is available and a fast SQL based data access is allowed.
- The various ways to trigger the measurement are prepared.
- The drivers to communicate to the plasma chambers or factory network can be optionally provided.

SOFTWARE ARCHITECTURE



U9046 consists of several software components to perform the measurement in real time with great flexibility.

● Control Station

Control Station allows to control C7460s and observe the spectrum data. The measurement can be triggered by the trigger signal from the plasma chamber and also by the optical trigger. The measurement can be repeated automatically during the several wafers' process.

● Database

The spectrum data observed by the Control Station are stored into the SQL compatible Database.

● Watchdog

The Watchdog software component always monitors the condition of the software, and an error will be reported by an e-mail.

● Logging

The Logging component records the history of the software jobs in a file.

● Drivers for the Plasma Chambers

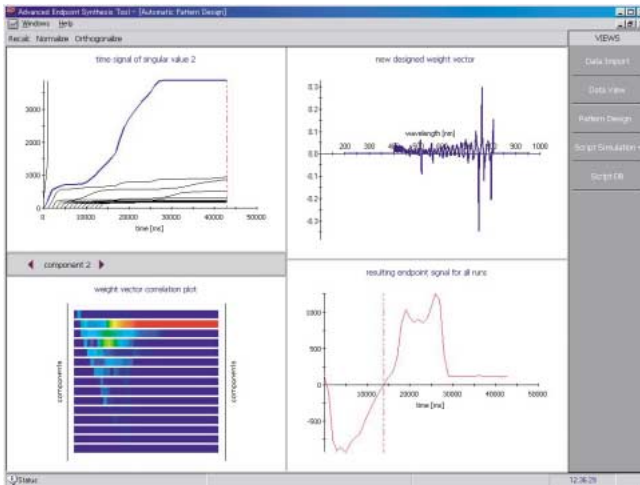
The Drivers software can be provided to make communication to the plasma chambers or factory network. The Drivers can obtain the information about the process like Process ID and Lot No. and so on. Such information can be stored with the observed spectrum data into the Database. Such a driver is needed typically for endpoint and automatic fault detection installations.

● Easy Graphical User Interfaces

The graphical user interfaces (GUIs) used by the process engineer and by the operators are different and dedicated to their respective tasks. Specifically, the operators' GUI is very easy to use, minimizing the risk of human errors.

End-point Synthesis Tool U8851

Optional Software



OUTLINE

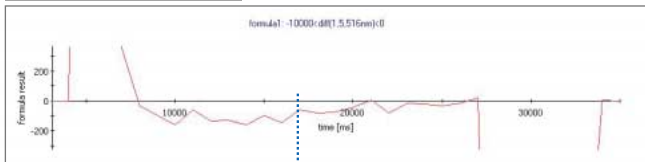
The U8851 is an optional software application that is utilized with the Multiband Plasma-Process Monitor C7460 for end-point detection in plasma etching.

With the U8851, highly sensitive end-point detection of the conventionally difficult small aperture process has been made possible.

In addition, since the process data of several wafers can be analyzed simultaneously, the reliability of the operation formula that performs an end-point detection is improved, the verification of an end-point detection is performed easily, and the stability evaluation of a process can be performed as well.

COMPARISON

Conventional method



U8851

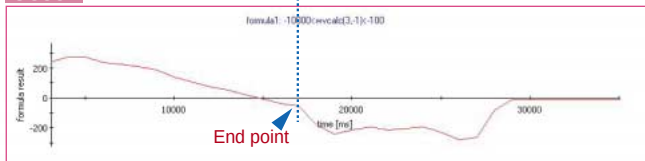


Fig. 1 Comparison of U8851 with conventional method

An example of an end-point detection of oxidation film etching (1% or less of aperture ratio) is shown in Fig. 1. Although it was difficult to detect the end-point of a process from the time changes in spectrum intensity by using the conventional method, detection with sufficient accuracy is possible with the U8851.

FEATURES

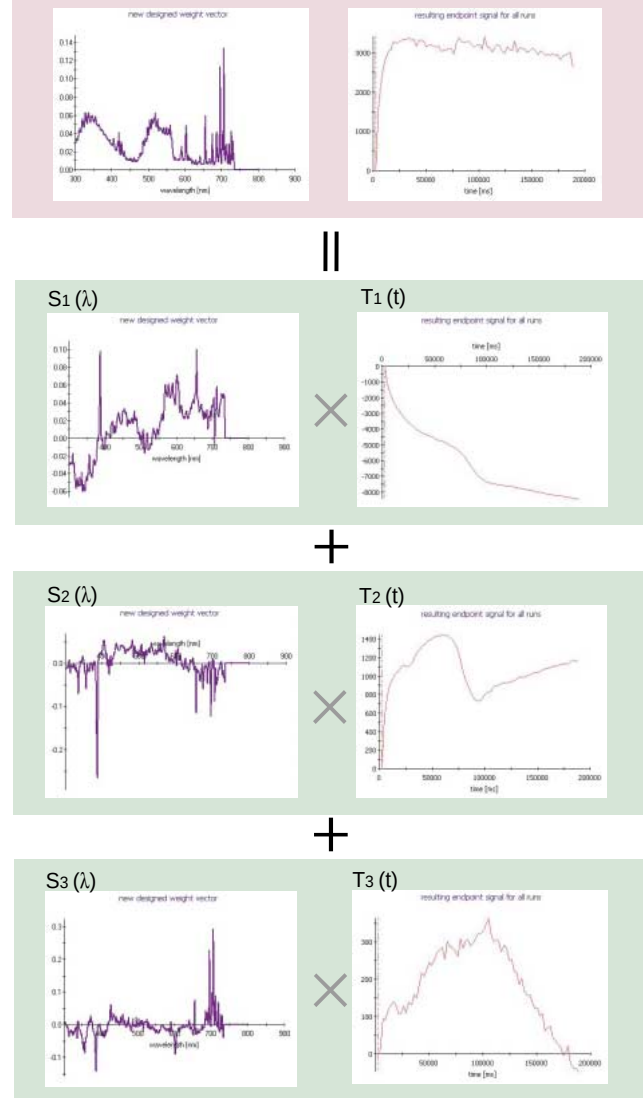
- End-point detection in small aperture process
- Simultaneous analysis of several wafers
- Stability evaluation of a process

OPERATIONAL OUTLINE

Fig. 2 Analysis pattern

- Measurement data $D(\lambda, t)$

$$D(\lambda, t) = \text{Average spectrum} + S_1(\lambda) \times T_1(t) + S_2(\lambda) \times T_2(t) + S_3(\lambda) \times T_3(t)$$



End-point Synthesis Tool U8851

Optional Software

① The data recorded by the Multiband Plasma-Process Monitor C7460 of the changes in the passage of time of the spectrum is loaded onto the End-point Synthesis Tool U8851.

② With the analysis function of the U8851, the spectrum data, which constantly changes, analyzes what kinds of spectrum patterns are shown by addition, and how each spectrum pattern is carrying out time changes.

In Fig. 1 the measured data $D(I, t)$ shows that three spectrum patterns ($S_1(I)$ to $S_3(I)$) are mainly shown with the superposition of data which carried out time changes like $T_1(t)$ to $T_3(t)$, respectively focusing on the average spectrum.

③ The U8851 can perform end-point detection of a process from spectrum pattern changes obtained in the analysis of ② with changes in the passage of time.

It specifies which spectrum pattern can be utilized for end-point detection with changes in the passage of time and smoothes and differentiates waveforms according to changes in the passage of time to detect an end-point.

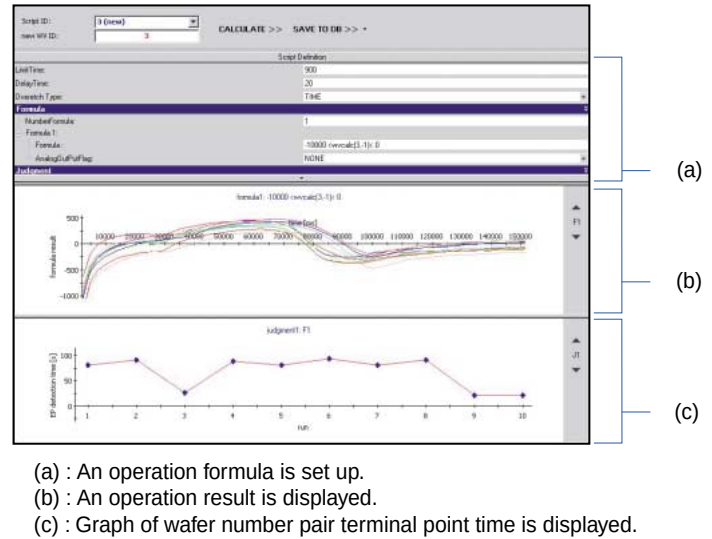
Moreover, analysis of ② and ③ can be simultaneously performed on two or more wafers, and the detected end-point time is displayed on a graph.

While verifying an end-point detection with these functions, the stability of a process can also be evaluated. (Fig.3)

④ The detection operation formula of the acquired end points as mentioned above, can be saved in a file and downloaded into the C7460 as well.

In the C7460, end-point detection like in ③ is performed in real time.

Fig. 3 Example of an analysis display



Optical Attenuator C8066

Optional Hardware



OUTLINE

The C8066 is an optical attenuator for the Multiband Plasma-Process Monitor C7460. It is possible to change the light intensity in five steps (1, 1/10, 1/100, 1/1000, 1/10000) by the button on the front panel or via RS-232C interface.

The optimum light intensity for monitoring the plasma emission can thus be obtained.

Optical Attenuator C8066

Optional Hardware

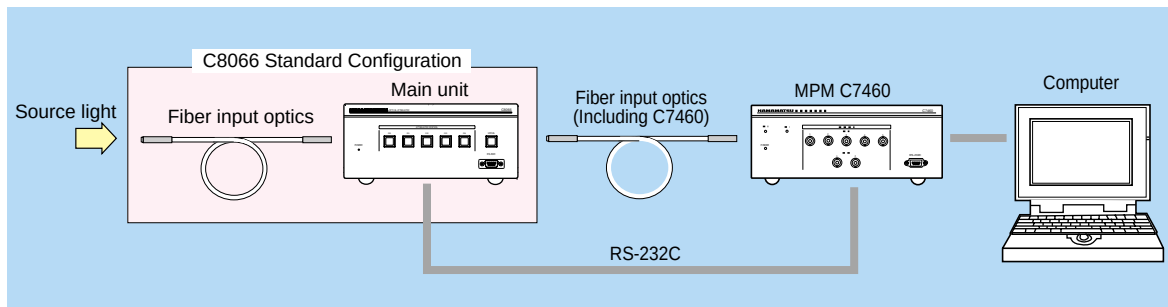
FEATURES

- **Light Intensity Change in Five Steps**
With attenuated filter, the light intensity can be changed in five steps (1 to 1/10000).
- **High-speed and Highly Precise Changing**
The stepping motor is adopted and a high-speed and highly precise filter change of 0.2 s / step is possible.
- **Easy Operation**
The filter can be easily changed via a button on the front panel, or via RS-232C interface.
- **Wide Wavelength Region**
The wide wavelength region from ultraviolet to near-infrared (200 to 1000nm) is covered.

SPECIFICATIONS

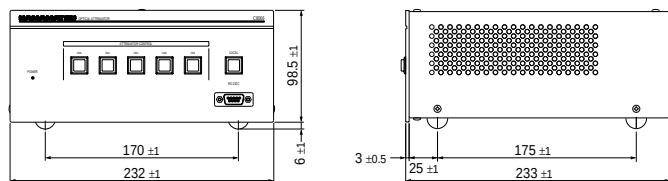
Functions/ Performance	Attenuated ratio	1, 1/10, 1/100, 1/1000, 1/10000
	Wavelength region	200nm to 1000nm
	Operation	Remote operation /Local operation
	Filter changing time	0.2sec/STEP
RS-232C	Baud rate	38400bps
	Data bit	8bit
	Parity	None
	Stop bit	1bit
	Connector	D-sub 9pin
Other	Line voltage	AC100 to 120V / 220 to 240V , 50/60Hz
	Power consumption	50VA max
	Conformity specification	EMC EN55011:1991 Group1,ClassA EN50082-2:1995 Safety EN61010-1:1993+A.2:1995
	Ambient operation temperature	0 to + 40°C
	Ambient storage temperature	+10 to + 50°C

SYSTEM CONFIGURATION

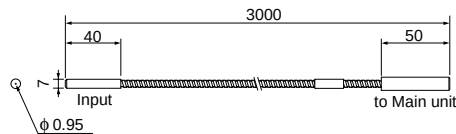


DIMENSIONAL OUTLINE (Unit: mm)

- Main Unit (weight: approx.3.0kg)



- Fiber Input Optics (weight: approx.100g)



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HAMAMATSU

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Cat. No. SSIS1027E04
AUG/2002 HPK
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