FEATURE ARTICLE

FG-100 Series FTIR Gas Analyzer

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Abstract

There have been yearly increasing needs for measurement of gases used in the semiconductor and liquid crystal production processes. The Fourier transform infrared spectrometer (FTIR) as a tool for this measurement has become known widely. In order to meet the on-site needs for using the FTIR, Horiba has recently developed a compact FTIR gas analyzer, FG-100 series. This paper introduces this product together with its measurement applications.

1 Introduction

In the semiconductor and liquid crystal production processes, gas measurement has been attracting attention for a long time. In order to reduce emissions of perfluorocompounds (PFCs), ones of the global warming gases, the FTIR first started being used, e.g., in the measurement of efficiency of the related industrial abatement equipment and the detection of the end point of CVD cleaning. The FTIR requires shorter measurement time than the gas chromatography-mass spectrometer (GC-MS) and allows quantitative measurement of mixed components selectively by eliminating the interfering effect. These features have made the FTIR recognized as an effective tool for measuring the gases of PFCs. HORIBA has contributed to the activity for reducing the gases of PFCs by releasing the FT-730 G PFCs Concentration Monitor and its applications to the market.

Through this activity, we have received a number of requests for a system that can be used more easily on site and for more diverse gas measurements to control the process equipment. In order to comply with these requests, HORIBA has commercialized a new FTIR gas analyzer, FG-100 series (Table 1: 16 types in total) and started supplying it.

Single Cell Type

Basic model		FG-100					FG-120				
Detector		Liquid nitrogen cooled MCT					Electronically cooled MCT				
Option detector		Liquid nitrogen cooled InSb					—				
Cell Unit	Basic cell model	CU-10		CU-20		CU-30	CU-10		CU-20		CU-30
	Type	Short cell		Medium cell		Long cell	Short cell		Medium cell		Long cell
	Cell length (m)	0.01	0.1	0.8	2.4	10	0.01	0.1	0.8	2.4	10
	Cell model	CU-10H	CU-10L	CU-20H	CU-20L	CU-30	CU-10H	CU-10L	CU-20H	CU-20L	CU-30
Model		FG-111H	FG-111L	FG-112H	FG-112L	FG-113	FG-121H	FG-121L	FG-122H	FG-122L	FG-123
Power consumption(VA)		160		240		260	170		250		270
Size (mm)		450×400×380				450×550×380	450×400×350				450×550×350
Mass (kg)		40				51	40				51

Dual Cell Type

Basic model		FG-100			FG-120		
Detector		Liquid nitrogen cooled MCT			Electronically cooled MCT		
Option detector		Liquid nitrogen cooled InSb			—		
Cell Unit	Basic cell model	CU-40					
	Type	Dual cell					
	Cell length (m)	0.01+0.8	0.01+2.4	0.1+2.4	0.01+0.8	0.01+2.4	0.1+2.4
	Cell model	CU-40H	CU-40M	CU-40L	CU-40H	CU-40M	CU-40L
Model		FG-114H	FG-114M	FG-114L	FG-124H	FG-124M	FG-124L
Power consumption(VA)		310			320		
Size (mm)		600×450×380			600×450×350		
Mass (kg)		54			54		

Table 1 FG-100 Series Specifications for 16 Types in Total

2 Easier Use

The FG-100 series meets the customers' needs for easier use on site as follows.

2.1 Improved Portability

In the semiconductor and liquid crystal production processes, the customers have been waiting for a single system that is applicable for measurement at different points or locations.

2.1.1 More Compact Design

For the FG-100 series, the interferometer, detector, gas cell, and signal processing units have been laid out three-dimensionally. This has achieved footprint equivalent to only 57% of that of our former model FT-730G for the smallest type, and even for the largest type, the achieved foot print is 75% of that of FT-730G. The FG-100 series incorporates the temperature controller for the gas cell and the power supply units, thereby practically providing more space saving than this footprint.

2.1.2 Simplified Setup

Since the FG-100 series has been compactly designed, the cables used to interconnect the units have been reduced. The replacement of the cell unit requires no complicated optical adjustment of the user. If the interferometer and gas cell units are moved to a different location, no misalignment will occur in the optical system.

2.1.3 Dedicated Sampling Unit (Fig.1)

The dedicated sampling unit is provided with casters to further improve the portability of the FG-100 series. It also has a vibration-free mechanism to ensure that the FG-100 series can carry out measurement without any effect of vibrations from the sampling pump and others.

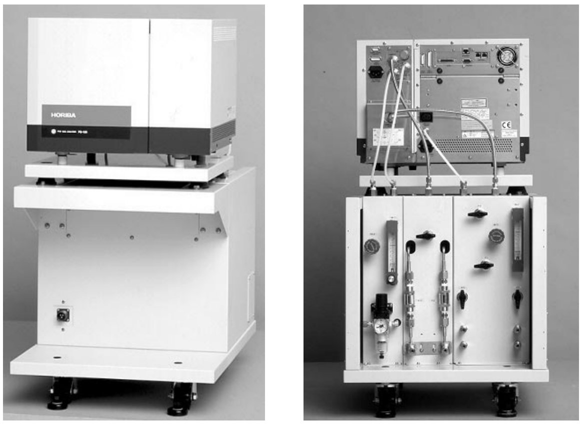

Fig.1 Dedicated Sampling Unit

2.2 Simpler Measurement Procedure

The measurement of gases with the FTIR offers great versatility. The effective use of the system requires the user to take account of various parameters.

In particular, the user needs to choose a gas cell with the optimal optical path and proper infrared absorption peaks used for measurement in accordance with the measurement range. To maintain the accuracy of quantitative analysis, the absorbances of the infrared absorption peaks to be measured are required to be approximately 1 at the maximum.

To minimize such consideration taken by the user, we have proposed measurable components and measurable ranges in main processes using a calibration curve table. In addition, we have added some dual cell types and improved the user-friendliness of the sampling system.

2.2.1 Quantitative Analysis Using Calibration Curve Table

A calibration curve table has been prepared based on the results of our measurement of actual samples. It allows the user to collectively load the calibration curves for quantitative analysis of gases that will be generated from each process.

Immediately after receiving the system, therefore, the user can start measurement without preparing any calibration curve with a standard gas or the like. Our consultation service is available for creating a calibration curve table specific to the customer's process.

2.2.2 Dual Cell Unit

Our original dual cell unit (equipped with two cells of different path lengths, the unit selects either of the cells by PC operation), which has acquired a favorable reputation since the former FT-730G, has been further improved.

The improvements include (a) an optical path can be selected via the operation screen on the personal computer, (b) the combinations of cell lengths have been increased to three types, 0.01m + 0.8m, 0.01m + 2.4m, and 0.1m + 2.4m. This has realized various measurable ranges and applications. Typically, gas types and concentrations at abatement inner side as well as for those emitted from the abatement equipment are quite diverse, depending on the abatement method applied such as catalytic, combustive, or plasmatic. A broad range of concentrations required for this gas measurement can be now fully supported. (Fig.2 shows an example of measurement at catalytic abatement equipment.)

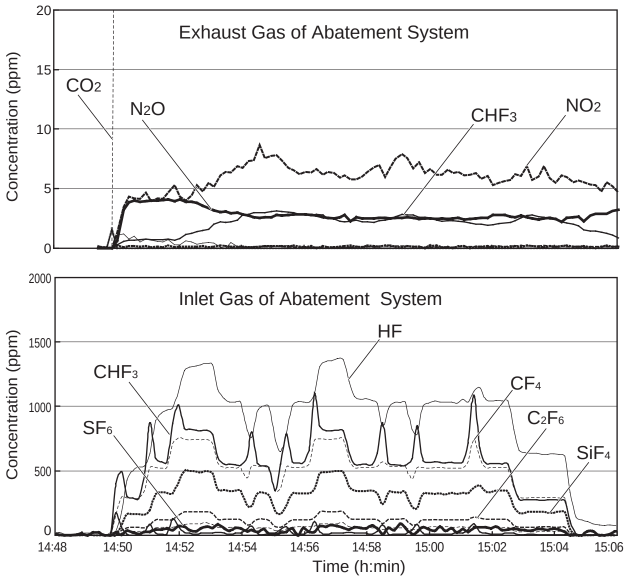

Fig.2 Example of Measurement at Catalytic Abatement Equipment

2.2.3 Sampling System

The FTIR normally requires that nitrogen gas be sent to the gas cell for background measurement before the sample gas is measured. For this purpose, it is necessary to switch between the line for the nitrogen gas to be sent to the cell and that for the sample gas. The FG-100 has a solenoid valve for each line, which can be easily selected from the software.

When combined with the dedicated sampling unit, the FG-100 allows for connecting two sample lines to the gas inlet line.

The use of the dual cell unit allows for carrying out measurement with two different cell lengths without removing the piping for two sample lines. (Fig.3 shows a flow diagram of the FG-100 with dual cell unit.)

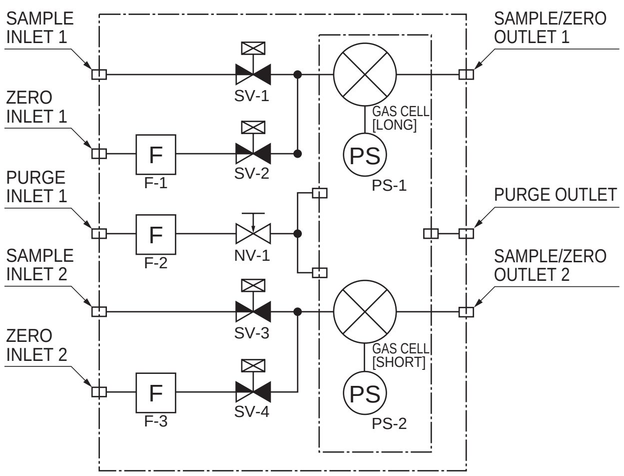

Fig.3 Flow Diagram of the FG-100 with Dual Cell Unit

2.3 Proposed Solutions for Applications

2.3.1 Preventive Measures for Small Particles in Sample

When a sample like exhaust gas from combustion type abatement equipment for PFCs is measured, it contains a large number of small particles. Fig.4 shows an SEM image of small particles collected from the sample line. If such small particles enter the gas cell, they will adhere to the mirror and cell window resulting in deterioration of the measuring sensitivity. For this reason, the sample line of the sampling unit is equipped with a filter to prevent small particles from entering the gas cell. A sintered filter of 2μm is used as standard, but may be changed according to the sample to be measured.

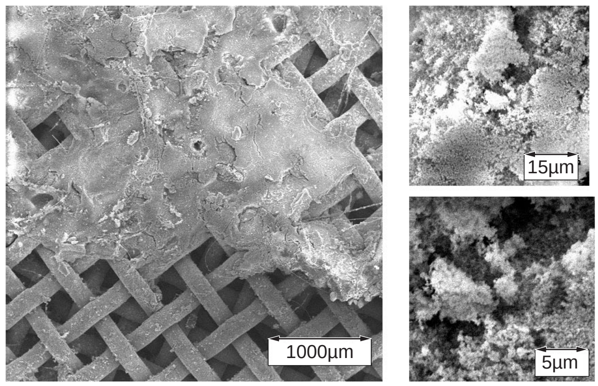

Fig.4 SEM Image of Small Particles Collected from the Sample Line

2.3.2 Safety Countermeasures for Dangerous Gases

The FG-100 with the sampling unit can be optionally modified to include a local ventilation system that ensures the safety for measurement of toxic/dangerous gases.

3 Example of Measurement Using FTIR

3.1 Industrial Abatement Equipment (Plasma Type)

Plasma type industrial abatement equipment requires adjusting the balance between the process chamber and the RF (Radio Frequency to generate plasma) output.

If exhaust gas is measured in real time using the FTIR, the equipment can be efficiently optimized on site. (Fig.5 shows an example of measurement of exhaust gas from plasma type industrial abatement equipment.)

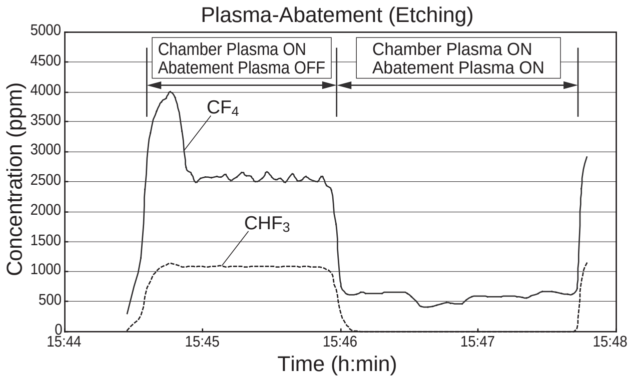

Fig.5 Example of Measurement of Exhaust Gas from Plasma Type Industrial Abatement Equipment

3.2 Dry Etching Process

Fig.6 shows the result of measurement of exhaust gas when plasma was turned ON/OFF in the CF_4 etching process. The result reveals that CF_4 contributing to etching accounts for approximately 50% and half of the supplied gas is exhausted without use. Measurement by the FTIR is useful for optimizing the process that decreases the gas of PFCs supplied and elucidating the etching mechanism when a new gas is used.

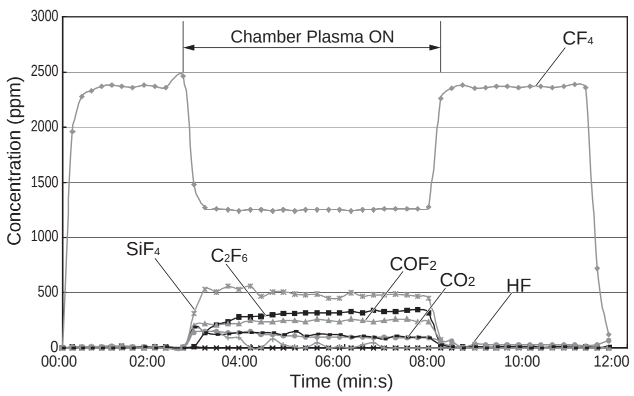

Fig.6 Data on Dry Etching Exhaust Gas

3.3 Monitoring in Clean Room

With the recent advancement of integration and miniaturization levels of products, the importance of monitoring and controlling the components in the atmosphere of a clean room has increasingly become important not only to maintain the safety of the production site, but to improve the productivity and quality.

Fig.7 shows an example of measurement in the atmosphere of a clean room using the FTIR. The result of the measurement at a certain point shows that methane steadily exists and that isopropanol and cooling medium non-steadily increase in concentration.

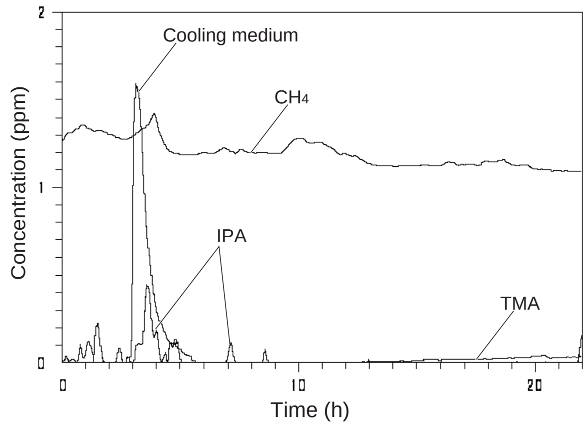

Fig.7 Example of Measurement in the Atmosphere of a Clean room

4 New Needs for Gas Measurement

We are trying to identify the needs for gas measurement in an effort to more actively apply gas measurement to the semiconductor and liquid crystal production processes.

As an activity for this effort, we are now addressing the in-situ monitoring of MOCVD-Pb (Zr, Ti)O_3-based raw material supplied in liquid by using the FTIR, in cooperation with industrial and governmental partners. This monitoring is intended to grasp the state of the raw material used to create ferroelectric thin films when it is in the gas phase, by measurement with the FTIR and then applying the result to the process control.

We will challenge incorporating this capability into a system, although further studies will be required based on the FG-100 series.

5 Conclusion

As one of our activities for addressing global environmental conservation, we develop new products under our own guidelines for eco-friendly design. These guidelines show design policies for improvements of the former products in eight items including weight reduction, longer service life, and recycling. Fig.8 shows the result of evaluation of the FG-100. The FG-100 gains high scores in the items of weight reduction and longer service life. The FG-100 is the first product that has been internally approved as an eco-friendly product developed under the above guidelines. Thus, we are promoting development of eco-friendly products as well as contributions to solutions for environmental problems.

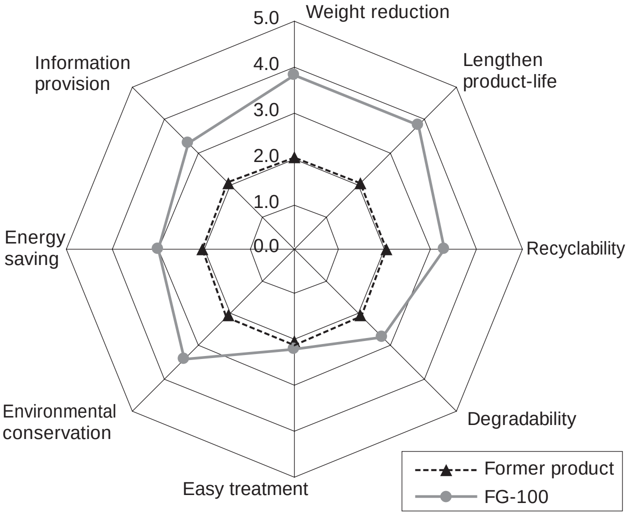

Fig.8 Environmental All-round Evaluation of the FG-100

This paper has introduced the features of the FG-100 series and presented an example of actual measurement and possibilities in the semiconductor and liquid crystal processes. New gases are being daily developed for use in those processes. The infrared spectroscopy is excellent as a method that allows for measuring multiple components while eliminating the interfering effect, and its applications will be expanded. We wish to remain active enough to comply with the customers'f needs and offer easier-to-use systems that enable measurement at high accuracy.

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