SHIMADZU
Excellence in Science

Single Nano Particle Size Analyzer

IG-1000 Plus

Voyaging into the Single Nano Region

IG-1000 Plus

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Single Nano Particle Size Analyzer

High-Sensitivity Analysis of Single Nano Particles

The IG-1000 Plus measures optical signals from a diffraction grating formed by the particles, rather than scattered light being emitted by the particles. This means that even in the single nano region, a sufficient S/N ratio can be obtained and stable measurement with good reproducibility is possible. In addition, the IG-1000 Plus can achieve a sensitivity 10 times higher than the IG-1000.

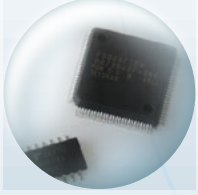
Resistance to Contamination

The new measurement principle is resistant to contamination, so that even if the sample is mixed with small numbers of foreign particles, information about the particles to be analyzed is still captured. Therefore, it is not necessary to filter samples in order to remove coarse particles.

High Reproducibility

The new measurement method ensures high reproducibility and the acquisition of stable data. In particular, high reproducibility for particle sizes of less than 10 nm removes the uncertainty and ambiguity of particle analysis in the single nano region. It is also possible to compare raw diffracted light data as a simple check of measurement result validity.

Contents



Beyond the Single Nano Region and Into the Sub-Nano Region

The IG-1000 Plus Single Nano Particle Size Analyzer

The IG-1000 Plus uses the induced grating (IG) method, which is based on a new principle for measuring the size of nano particles using the phenomenon of dielectrophoresis and diffracted light.

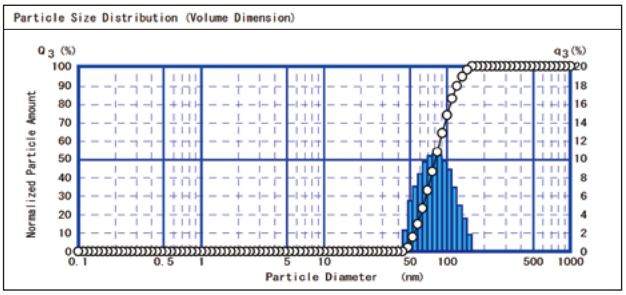
The conventional method measures the light scattered by particles, but this decreases sharply for particle sizes of less than 100 nm. Furthermore, in the single nano region (i.e. particle sizes of less than 10 nm), there are physical restrictions that make it difficult to detect scattered light and thereby measure particle size. The IG method does not use scattered light; as a result, it is free from these physical restrictions, and in addition it does not require the input of the refractive index. It therefore allows the size of nano particles to be measured simply and with high sensitivity, and is particularly effective in the analysis of particles in the single nano range.

Measurement Data Examples

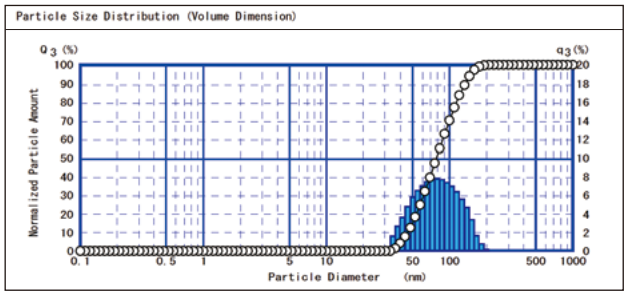
Measurement of Pigmented Ink Nano Particles

Nano particles tend to aggregate easily, but when they are used as pigmented inks it is important that they remain in a well-dispersed state for a long period of time without aggregating or precipitating.

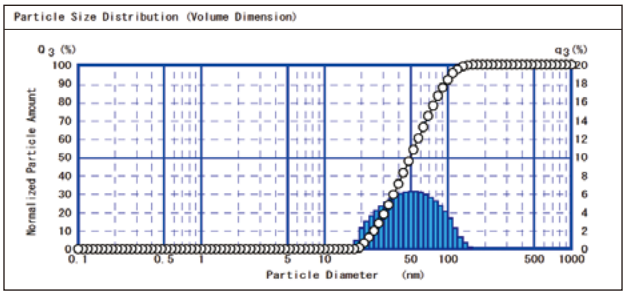
It is difficult for light to pass through highly-absorbent particles. With a short optical path cell (special accessory), which decreases the absorption of samples, the IG-1000 Plus overcomes this restriction, making it a powerful tool for quality control in the ink and paint industries.



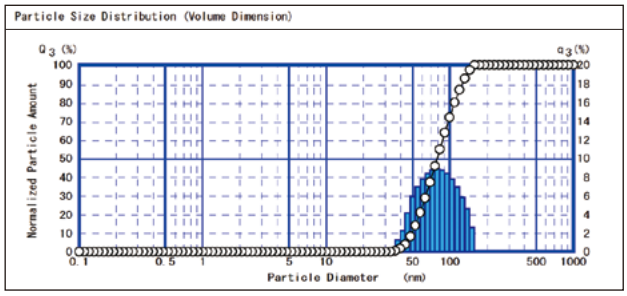
Black



Red



Blue



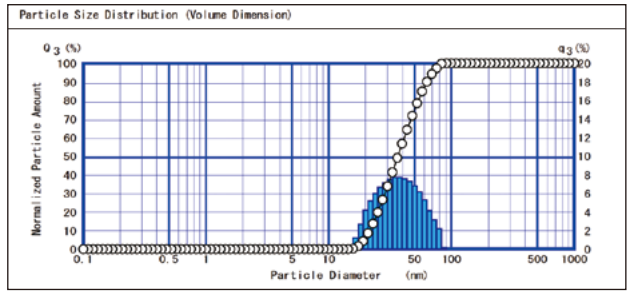
Yellow

Particle size distribution measurement of pigmented ink nano particles

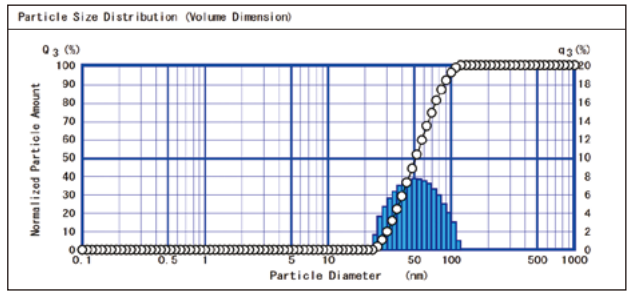
Measurement of Nano Particles in Sunscreen

Ultrafine particles (nano particles) such as titanium oxide or zinc oxide are used in sunscreen to block exposure to ultraviolet rays. The use of such nano particles reduces the scattering of visible light rays, resulting in sunscreens with high transparency that do not turn white upon application.

Nano particles may easily aggregate to form larger particles, which increase the amount of scattered light, resulting in the loss of transparency. Therefore, it is important that the nano particles are kept in a well-dispersed state.



Titanium Oxide



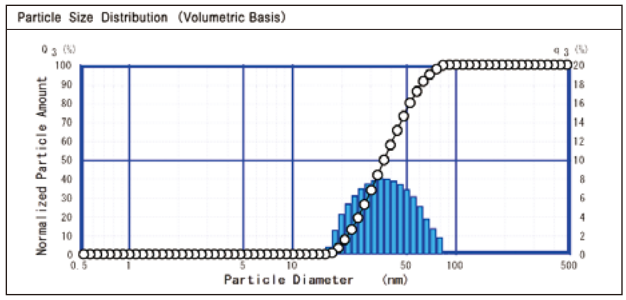
Zinc Oxide

Particle size distribution measurement of titanium oxide and zinc oxide nano particles

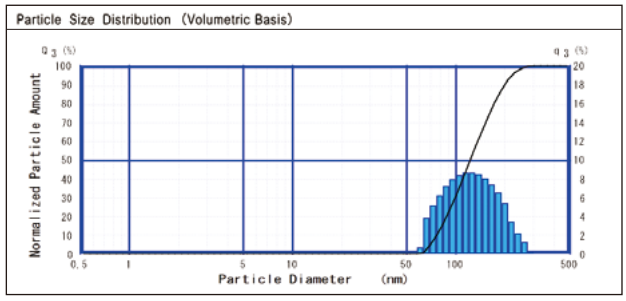
Measurement of Nano Particles in a Dye-Sensitized Solar Cell

The dye-sensitized solar cell consists of an iodide electrolyte solution and a transparent electrode, coated with a thin layer of dye-adsorbed porous titanium oxide, affixed to a plate. Low-cost mass-production is possible because this type of solar cell does not require large-scale equipment, which is necessary for conventional silicon-based solar cell manufacturing.

The porous titanium oxide film is made by coating the plate with titanium oxide nano particles and then baking the coated plate. To ensure that a uniform film is created, the nano particles used to make the film must be kept in a well-dispersed state, making particle size measurement critical. The high-sensitivity IG-1000 Plus can easily measure dye-adsorbed materials.



Titanium Oxide A



Titanium Oxide B

Particle size distribution measurement results for two types of titanium oxide nano particles

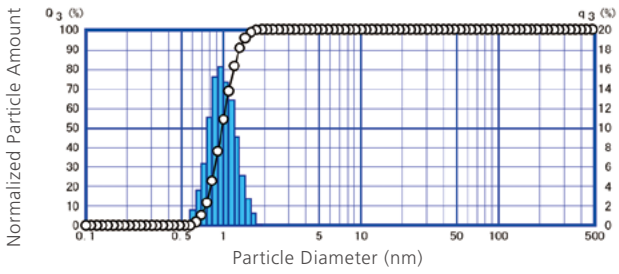
Further Data Examples

The following data was obtained by analyzing various sample particle groups of various sizes with the IG-1000 Plus.

Fullerene Hydroxide

Fullerene hydroxide, an example of a substance in the single nano region, can be analyzed with high reproducibility.

Particle Size Distribution (Volumetric Basis)

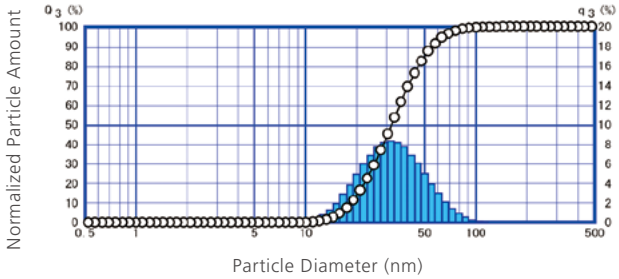


(Sample provided by Prof. Kokubo of Osaka University)

Silica Sample with Broad Size Distribution

Even with samples containing a wide range of particle sizes, there is no bias toward larger particles, and the existence of smaller particles is accurately captured.

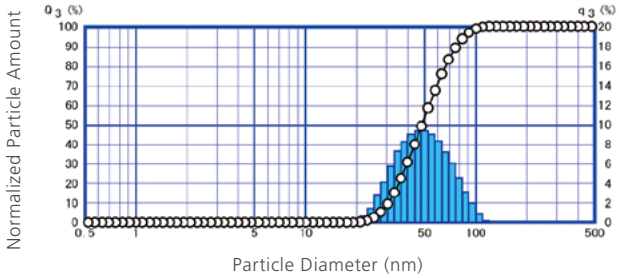
Particle Size Distribution (Volumetric Basis)



Samples Containing Impurities

Measurement results are not affected by slight impurities. (The example shows the results obtained for a sample with a distribution centering on a diameter of 50 nm that contains a 1% concentration of 1-μm particles.)

Particle Size Distribution (Volumetric Basis)

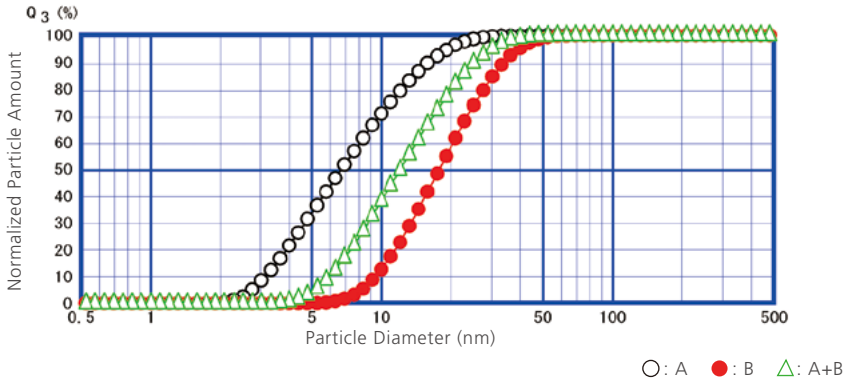


Analysis of Mixed Samples

With methods based on scattered light, even if the volume is the same, the signal size is proportional to the cube of the particle diameter, making evaluation of mixed samples difficult. The IG method uses the diffusion of the diffraction grating created by particles; therefore, the signal size does not depend on the particle size, allowing the analysis of mixed samples.

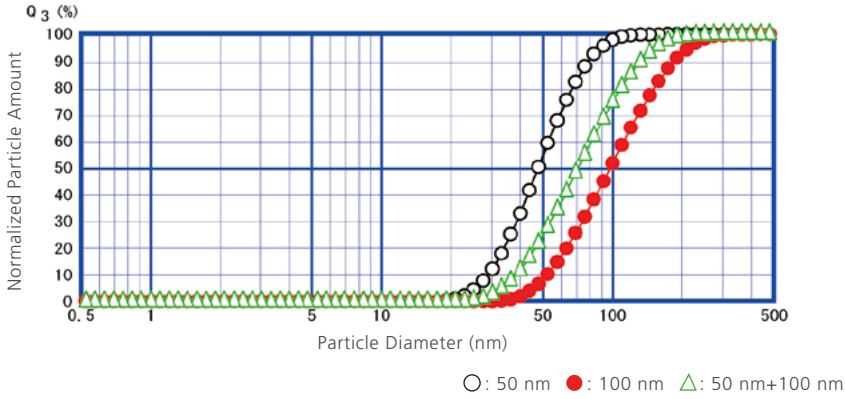
Colloidal silica

Particle Size Distribution (Volumetric Basis)



Polystyrene latex

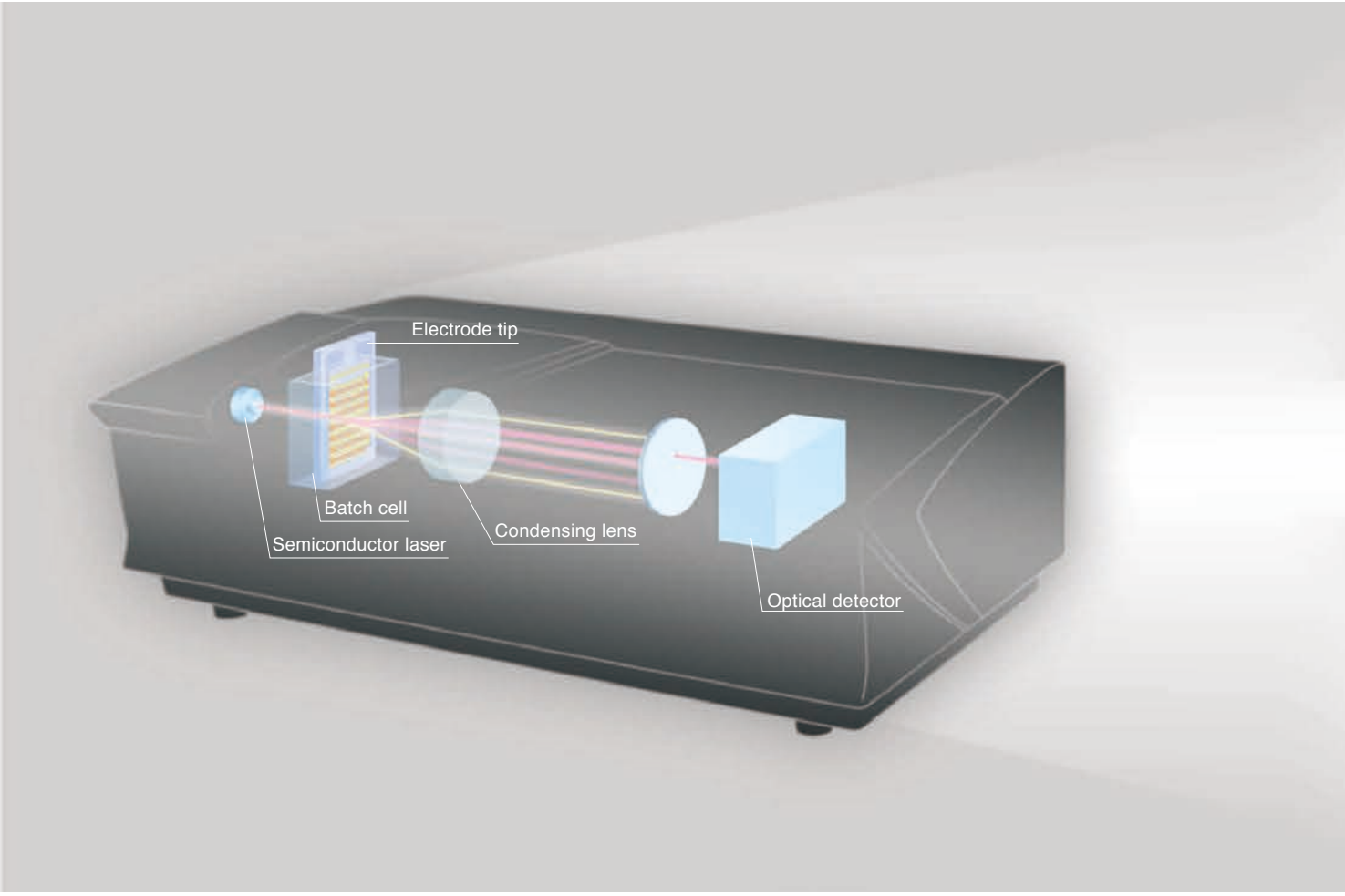
Particle Size Distribution (Volumetric Basis)

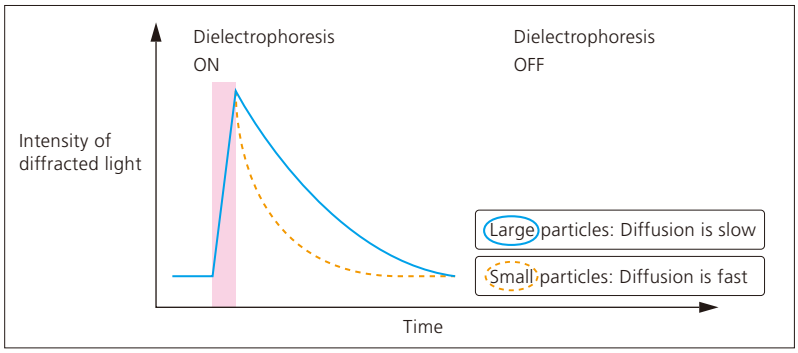


The Science Behind the Clarity

What Is the "Induced Grating Method"?

A periodic concentration distribution of particles formed in a medium by an external force functions as a diffraction grating. When the external force is removed, the particles spread out and the diffraction grating disappears. The IG method measures the decay of the particle density diffraction grating through changes in intensity of the diffracted light, and determines the diffusion coefficient.

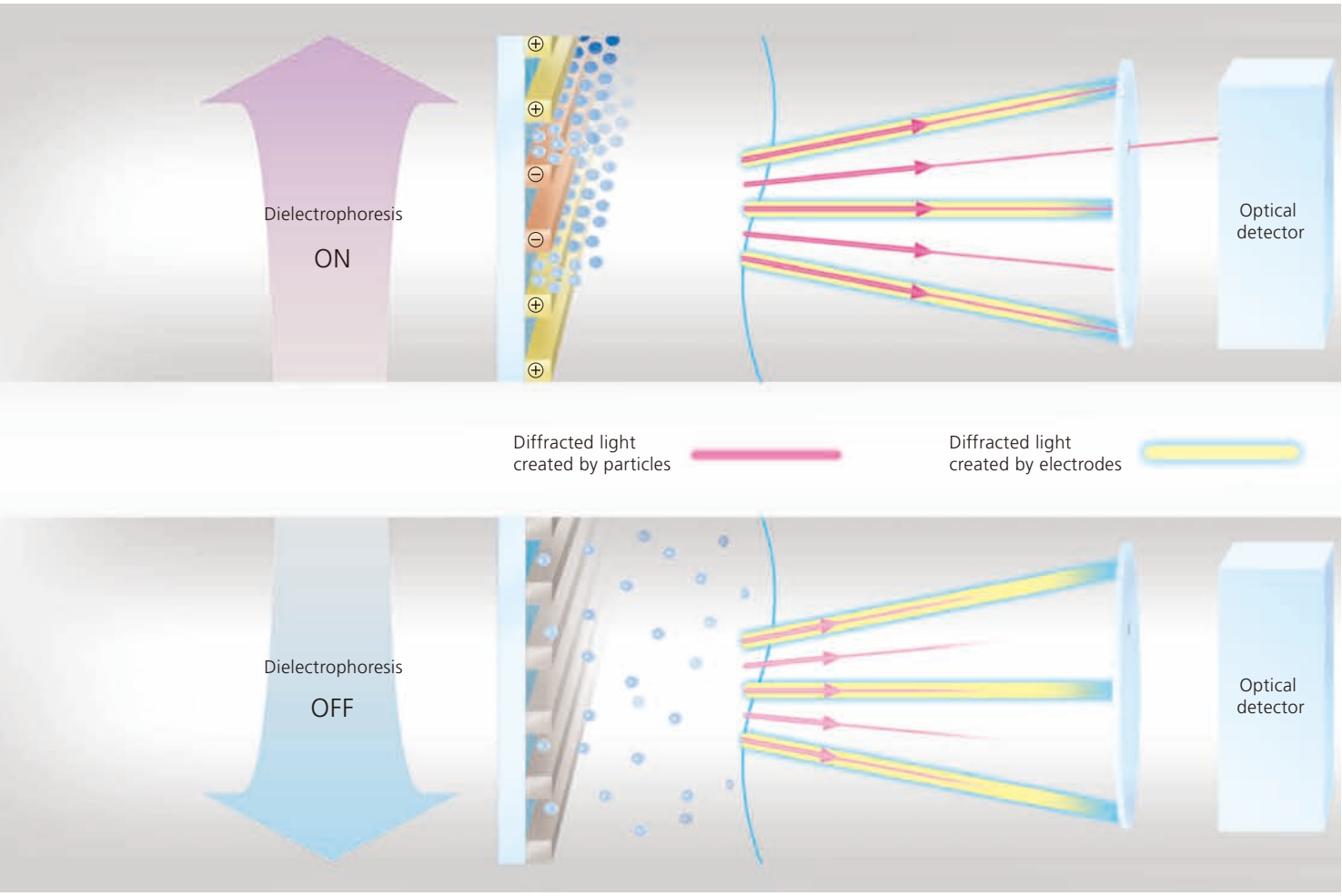


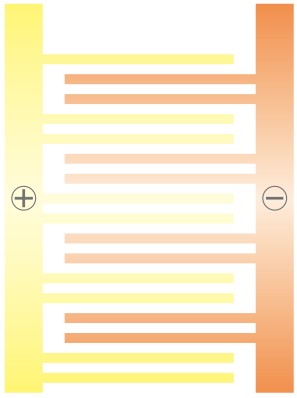


Variation in intensity of diffracted light over time

Diffraction Grating Formed by Dielectrophoresis

An alternating voltage is applied to cyclically arranged electrodes, and a cyclic concentration distribution of microscopic particles is formed in the liquid by dielectrophoresis. Although the cyclic concentration distribution of microscopic particles acts as a diffraction grating, if the alternating voltage is stopped, the grating diffuses and disappears (Patent No. 4375576).





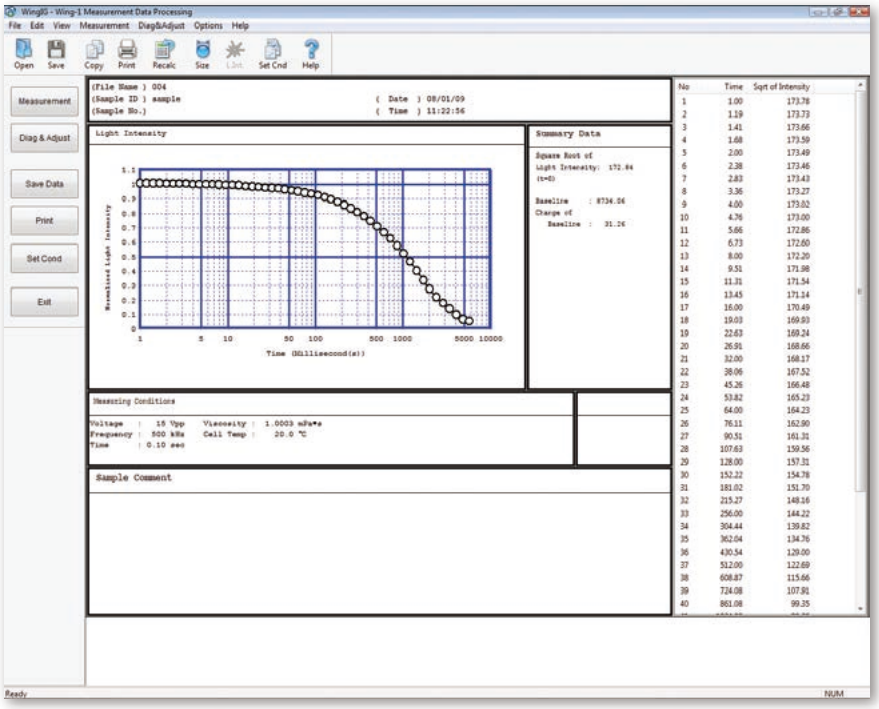
-Precision Measurement By Changing Electrode Configuration-

The cyclically arranged electrodes also function as a diffraction grating. The diffracted light created by this electrode diffraction grating is weaker than the diffracted light created by the particle concentration diffraction grating. In order to precisely measure the changes in the primary diffracted light resulting from the diffusion of the particle concentration diffraction grating, it is essential that the positions of the two forms of primary diffracted light do not coincide. For this reason, the electrode configuration has been modified as shown in the figure so that the pitch of the electrode diffraction grating is half that of the particle concentration diffraction grating (Patent No.4270070).

Powerful Measurement Functions

Applying Attenuation Data

In addition to the measurement results for particle size distributions, data on changes in the intensity of diffracted light (i.e. attenuation) can also be used. This data can be output to Excel, allowing users to try out their own analytical techniques.



Wing-1 Software Interface

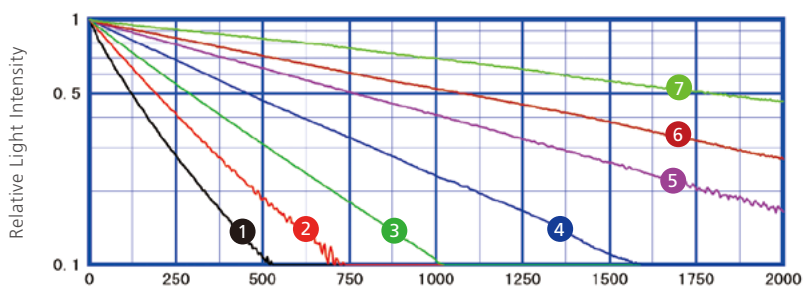
Validate Results Using Attenuation Data

If the particles are small, the attenuation gradient is high, whereas if the particles are large, the attenuation gradient is small. This means that the relative (average) sizes of particles can be ascertained at a glance.

Particle Size

1. 5 nm
2. 8 nm
3. 18 nm
4. 28 nm
5. 46 nm
6. 60 nm
7. 100 nm

Light Intensity



Attenuation of diffracted light

Check Measurement Conditions With Intensity Data

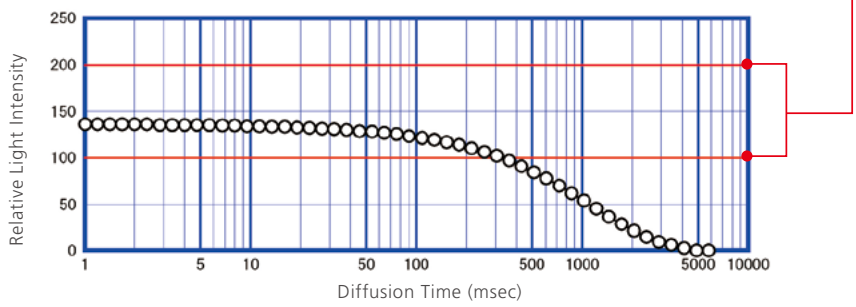
It is necessary to set the parameters below.

Application duration: 10 to 1,000 ms
Applied voltage: 5 to 35 Vpp
Frequency: 1 kHz to 1 MHz

It is possible to check whether or not these are the optimum measurement conditions using the optical intensity level and the upper and lower limit lines displayed on the screen.

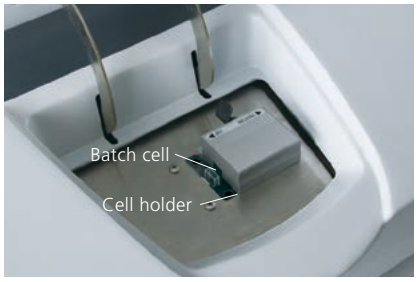
If the maximum intensity of the diffracted light is between these two lines, the measurement conditions are appropriate.

Diffracted Light Intensity Check



Input Sample In Three Simple Steps

A simple workflow allows measurement to be performed smoothly.



1. Inject the sample (a liquid containing dispersed microscopic particles) into the batch cell, and insert the batch cell into the cell holder.

2. Insert the electrode holder directly above the batch cell.

3. Move the lock lever to the "set" position. After this, simply close the lid and press the measurement button to start operation.

Specifications

Hardware

IG-1000 Plus		P/N:347-61500-42/44
Measurement Principle		Induced grating (IG) method
Measurement Range		0.5 to 200 nm
Measurement Time		30 sec (from the start of measurement to the display of results)
Sample Liquid Volume		250 to 300 µL
Measurement Unit	Light Source	Semiconductor laser (wavelength: 785 nm; output: 3 mW)
	Light Detector	Photodiode
	Cell	Batch cell (material: Pyrex glass*1)
Output Terminal		Serial output (connector type: D-Sub, 25 pin, female)
Operating Environment		Temperature: 15°C to 35°C
		Humidity: 20% to 80% (without condensation)
Power Supply		AC 100V / 115V / 230V ±10%, 50/60 Hz
Size and Weight		600 (W) x 400 (D) × 200 (H) mm, approx. 15 kg

*1: Do not use solvents that may damage Pyrex glass.

Note : Measurement is possible as long as the conductivity of the sample liquid does not exceed 400 mS/cm (microsiemens per centimeter). For example, saline solution and seawater cannot be analyzed unless they are greatly diluted.

PC

OS	Windows 10 (64 bit)
CPU	Must satisfy requirements of operating system.
Memory	Must satisfy requirements of operating system.
Display	Must satisfy requirements of operating system.
Printer	Must satisfy requirements of operating system.
Hard disk drive	Must satisfy requirements of operating system.
CD-ROM drive	Required for software installation
Serial port	1 port for connecting with the IG-1000 Plus

Standard Accessories

Part Name	Part Number	Quantity
Power Cable (for 100 V or 115 V / for 230 V)	071-60815-04 / 071-60814-05	1
Fuse, 2A (100 V / 115 V / 230V) / 1A (230 V)	072-02034-03	2
RS-232C Cable	088-50913-11	1
Electrode Tips (set of 5)	347-61530	1
Cells (set of 2)	347-61531	1
Cell Packing	347-61389	5
Electrode Cleaners (set of 50)	347-61561-02	1
Electrode Holder/Cell Stand	347-61372	1
Electrode Cleaning Receptacle	347-61373	1
Air Blower	086-78801-01	1
Cell Cleaners (set of 50)	347-61562-02	1
Wipers, 15 × 15 cm (set of 150)	086-72609-01	1
Coupler (hose side)	035-60929-18	2
Hose Band	037-61019-01	4
Instruction Manual	347-06903	1

Special Accessories

Part Name	Part Number	Notes
Micropipette	046-00337-01	Volume adjustable in the range of 10 to 1,000 µL, 1 box of pipette tips (set of 96)
Replacement Pipette Tips	046-00331-14	1 box of pipette tips (set of 96)
Short Optical Path Cell	347-61646-02	Cell with 2 mm optical path (set of 2)

Parts Required for Installation

Provided by Shimadzu

Part Name	Part Number	Notes
Reference Sample Set	347-61015-02	Reference samples (particle size: 50 nm), 2 vials
WingIG	347-64470	Specialized IG-1000 Plus software

Other Necessary Parts

Name	Specifications
Micropipette*	Required to inject samples into the cell. A micropipette that can measure out 200 µL within an accuracy of 5%.

* Sold by Shimadzu as a special accessory and can therefore be ordered from Shimadzu if necessary.

Dimensions (mm)

Lineup of Particle Analyzers

Laser Diffraction Particle Size Analyzers

SALD-2300	(measurement range: 17 nm to 2,500 μm)
SALD-7500nano	(measurement range: 7 nm to 800 μm)
SALD-201 V	(measurement range: 0.25 to 350 μm)