C060-E008

SHIMADZU
Excellence in Science

Single Nano Particle Size Analyzer

IG-1000 Plus

Voyaging into the Single Nano Region

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High-Sensitivity Analysis of Single Nanoparticles

Optical signals emitted by the diffraction grating formed by the particles, not scattered light emitted by the particles, is used for measurement, so even in the single nano region, a sufficient S/N ratio can be obtained and stable measurement with good reproducibility is possible.
Moreover, the IG-1000 Plus enables measurement with sensitivity 10 times higher than that obtained with the IG-1000.

Resistance to Contamination

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

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 vagueness of particle analysis in the single nano region. Also, comparison with raw data of diffracted light is possible, so rough validation of the measurement results can be performed simply.

Contents

Voyaging into the Single Nano Region

The IG-1000 Plus Single Nano Particle Size Analyzer: Going Beyond the Single Nano Region and into the Sub-Nano Region

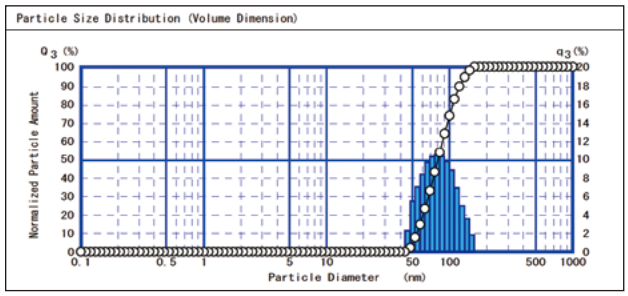
IG-1000 Plus uses the induced grating (IG) method, which is based on a new principle for measuring the size of nanoparticles using the phenomenon of dielectrophoresis and diffracted light.

With light scattering, the conventional method, the light scattered by particles 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 the measurement of particle sizes also becomes difficult. The IG method does not use scattered light; as a result, it is free from these physical restrictions, and does not require the input of the refractive index as a measurement condition. It therefore allows the size of nanoparticles to be measured simply and with high sensitivity, and is particularly effective in the analysis of single nanoparticles.

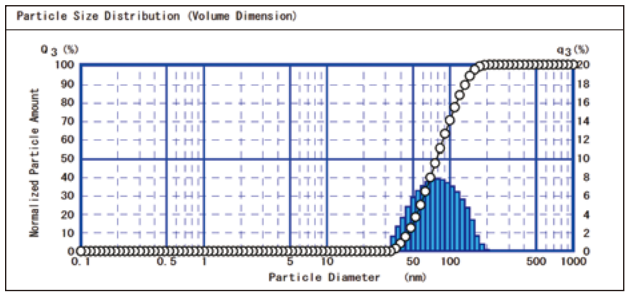
Measurement of Pigmented Ink Nano Particles

Since nano particles tend to aggregate easily, it is important that they remain in a well-dispersed state for a long period of time without aggregating or precipitating.

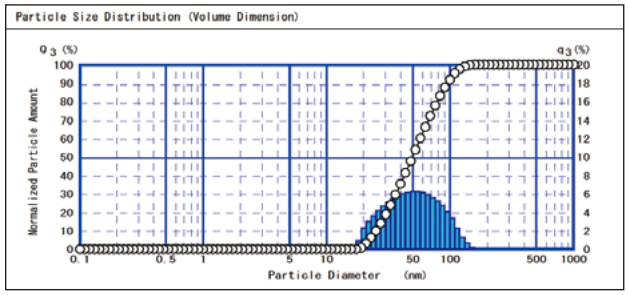
Highly absorbing particles make light difficult to pass through. With a Short Light Pass Cell (standard equipment), which decreases absorption of samples, the IG-1000 Plus overcomes this restriction, making it a powerful tool for quality control in ink and paint industries.



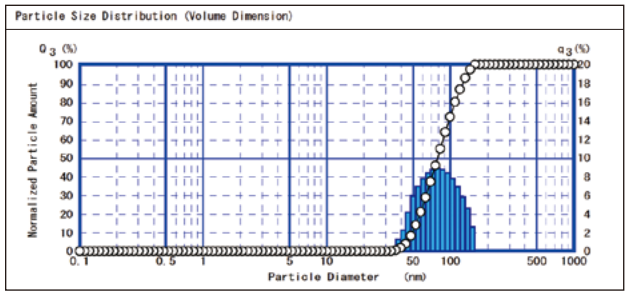
Black



Red



Blue



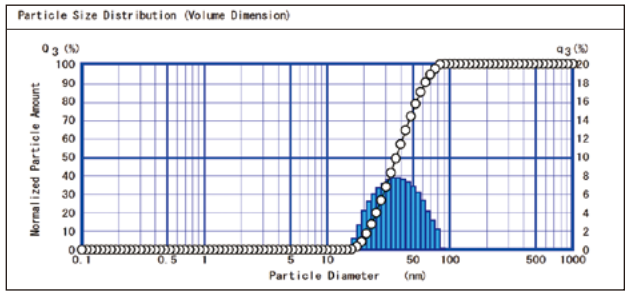
Yellow

Particle Size Distribution Measurement of Pigmented Ink Nano Particles

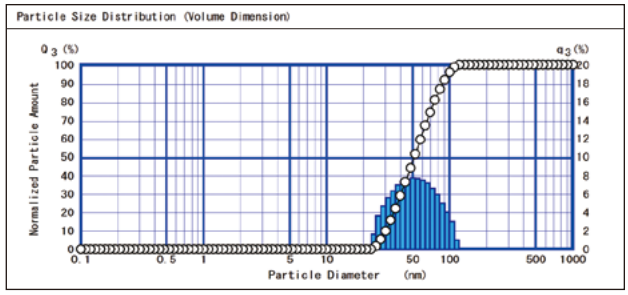
Measurement of Nano Particles Used in Sunscreen

Ultrafine particles (nano particles) made of titanium oxide and zinc oxide, etc. are used in sunscreen to block exposure to ultraviolet rays. The use of such nano particles reduces the scattering of visible light rays, allowing formulation of 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 maintained in a well-dispersed state.



Titanium Oxide



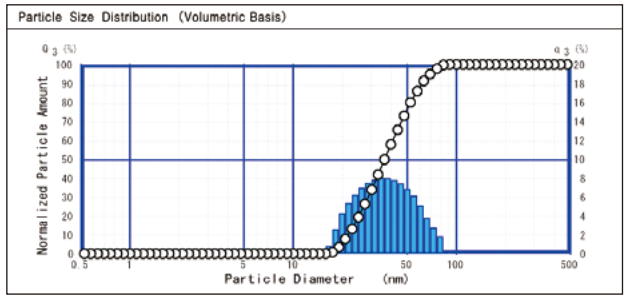
Zinc Oxide

Particle Size Distribution Measurement of Titanium Oxide and Zinc Oxide Nano Particles

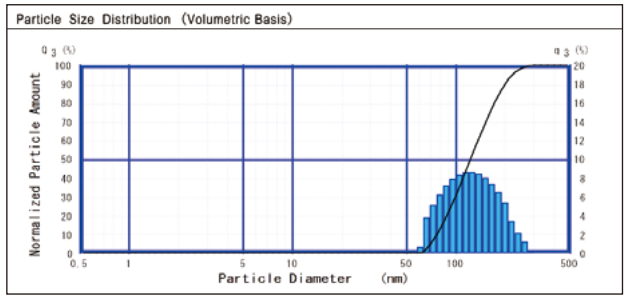
Measurement of Nano Particles Used in Dye-Sensitized Solar Cell

The dye-sensitized solar cell features a simple construction consisting of a plate to which a transparent electrode coated with a thin layer of dye-adsorbed porous titanium oxide dye is affixed, and an iodide electrolyte solution. Low-cost mass-production can be realized 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 maintained in a well-dispersed state, and this is why particle size measurement becomes 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

Detailed Visualization of Reliable Data

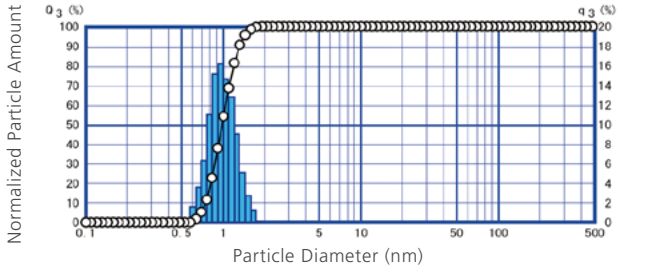
Measurement Data

The following data was obtained by analyzing various sample particle groups of various sizes.

Fullerene Hydroxide

Fullerene hydroxide, a typical material of samples in the single nano region, can be analyzed with high reproducibility.

Particle Size Distribution (Volumetric Basis)

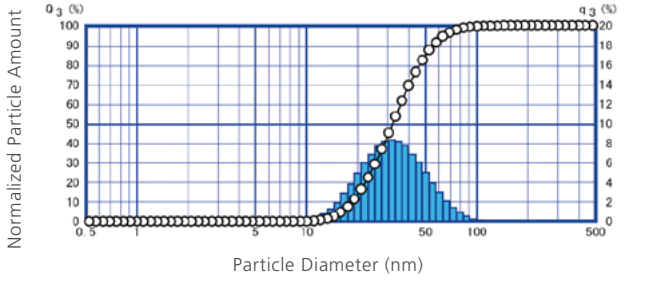


(Sample provided by Prof. Kokubo of Osaka University)

Silica Sample with Broad Distribution

Even with samples covering a wide distribution, there is no bias toward larger particles, and the existence of smaller particles is accurately captured.

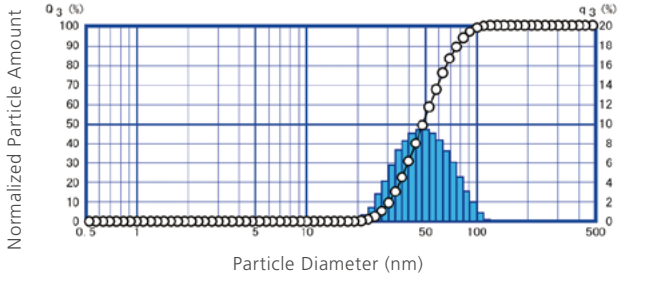
Particle Size Distribution (Volumetric Basis)



Samples Containing Contamination

Measurement results are not affected by minute quantities of contamination. (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)

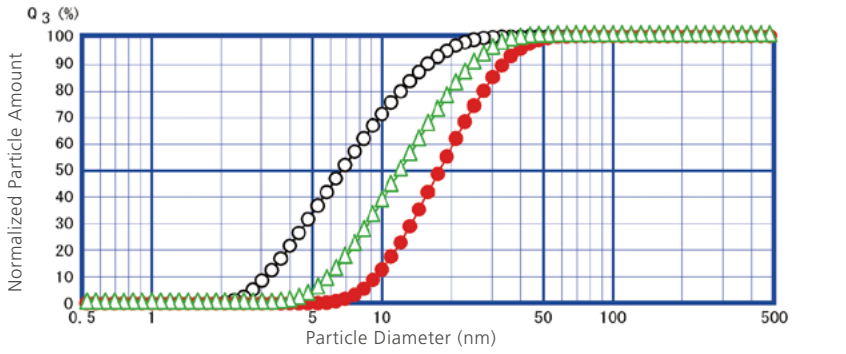


Analysis of Mixed Samples

The IG method uses the diffusion of the diffraction grating created by particles; therefore, the signal size does not depend on the particle size. This means that evaluation of mixed samples is possible. 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.

Colloidal silica

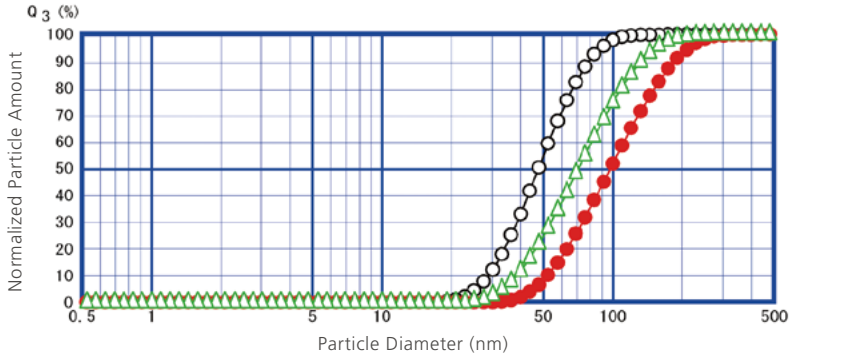
Particle Size Distribution (Volumetric Basis)



○: A ●: B △: A+B

Polystyrene latex

Particle Size Distribution (Volumetric Basis)

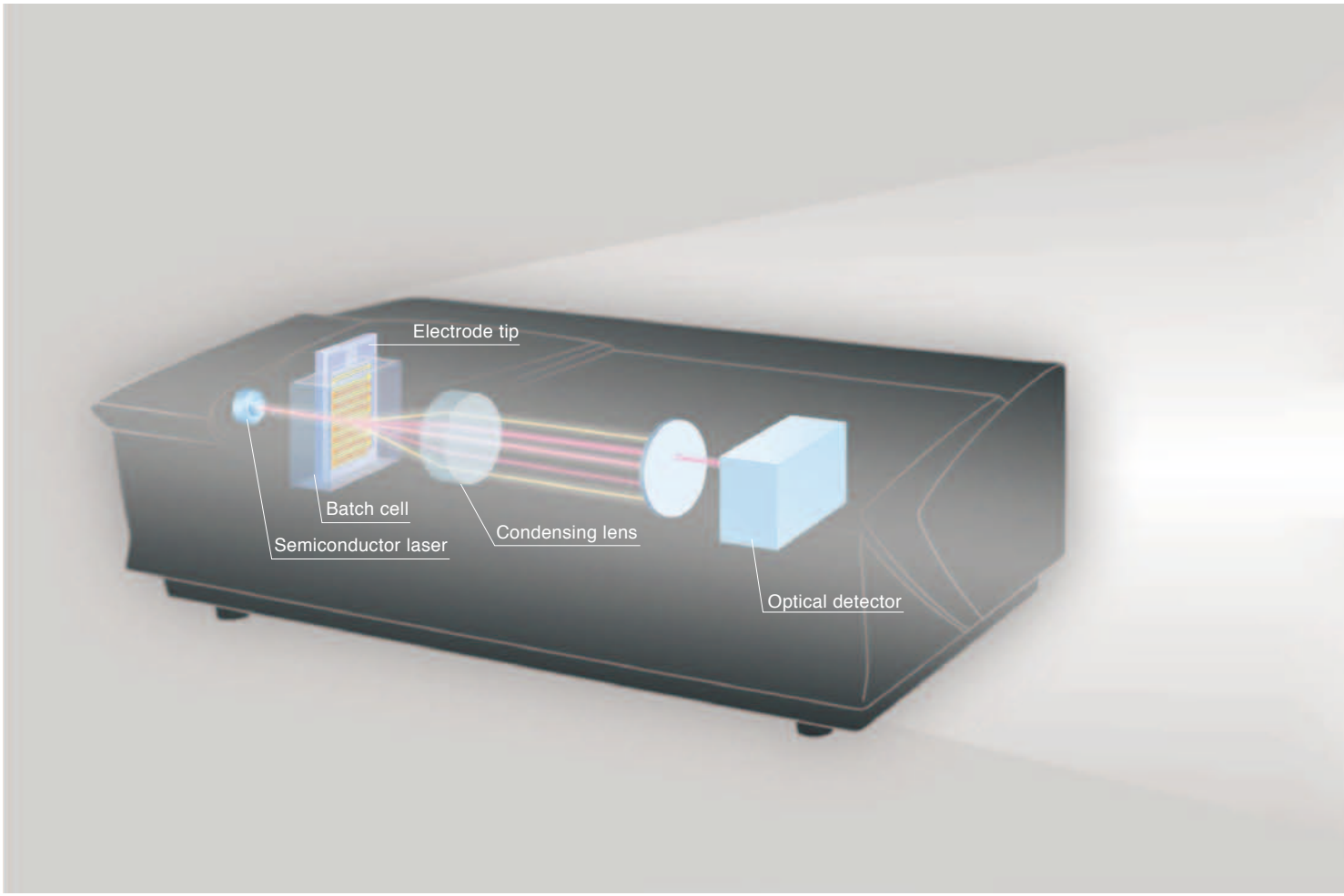


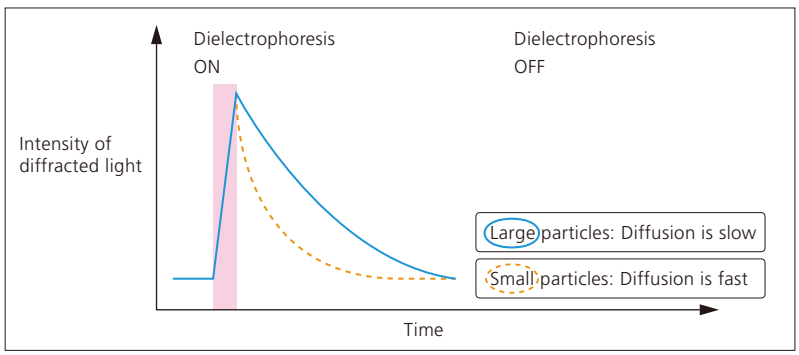
○: 50 nm ●: 100 nm △: 50 nm+100 nm

The Principle 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.

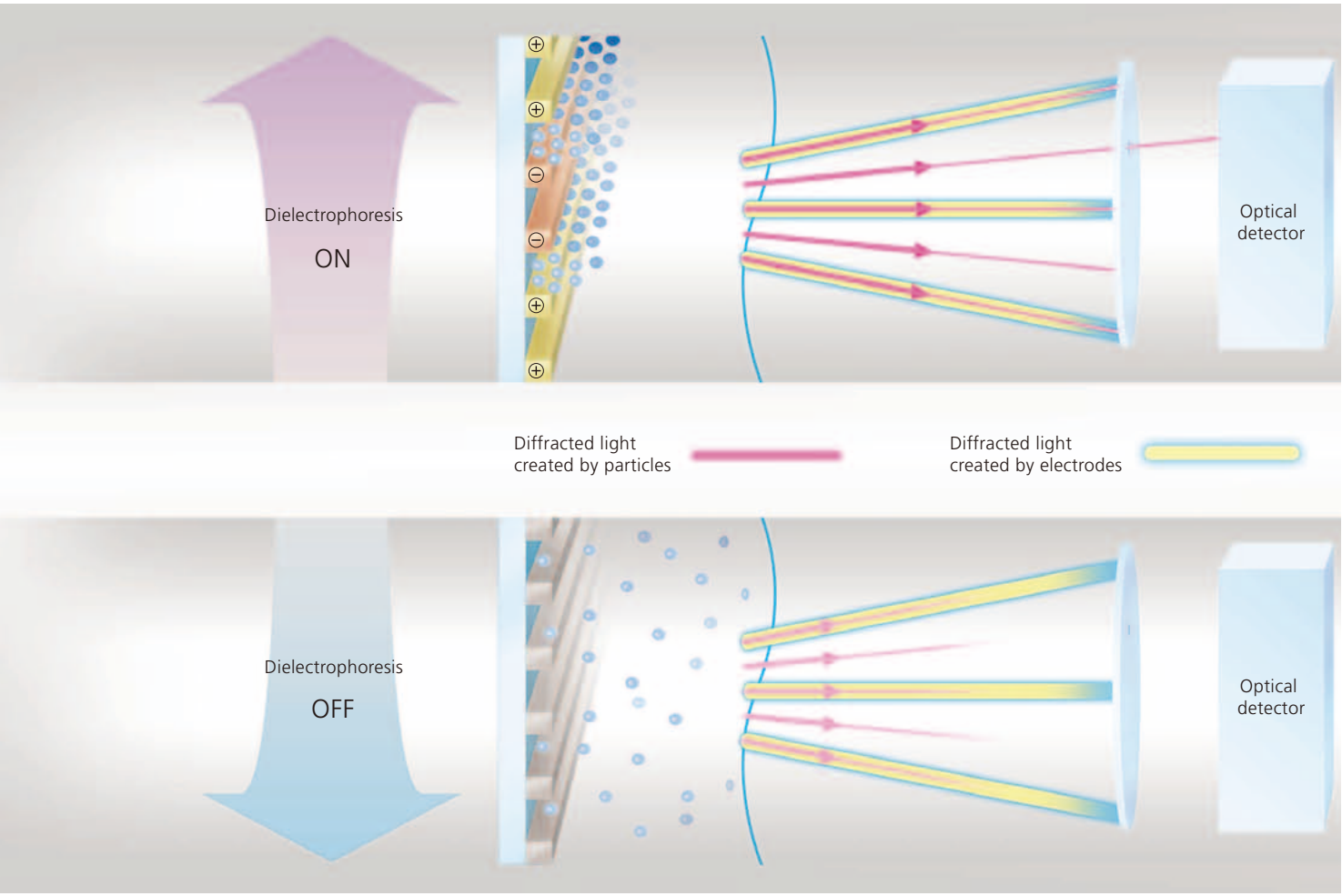


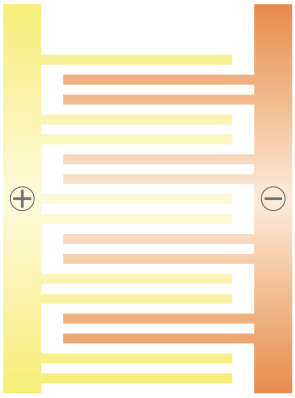


Variation in Intensity of Diffracted Light over Time

Diffraction Grating Consisting of Microscopic Particles 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 (a particle concentration diffraction grating), if the alternating voltage is stopped, the grating diffuses and disappears (patent pending).





Key Point of IG Method

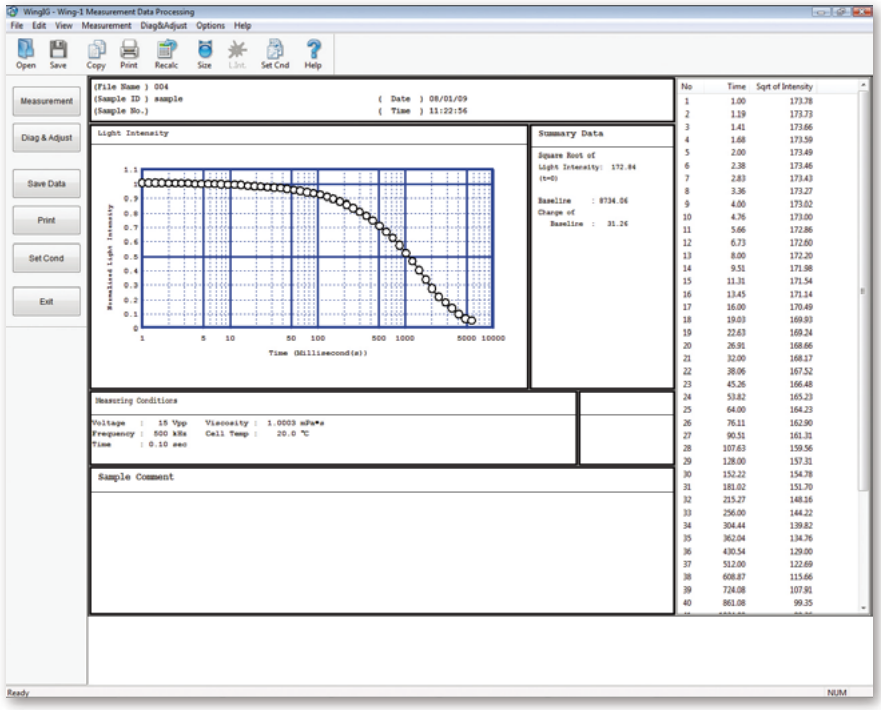
-Precision Measurement Achieved with Modification of Electrode Configuration-

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 Functions Support Measurement

Applying Data on Changes in the Intensity of Diffracted Light (Decay Process)

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



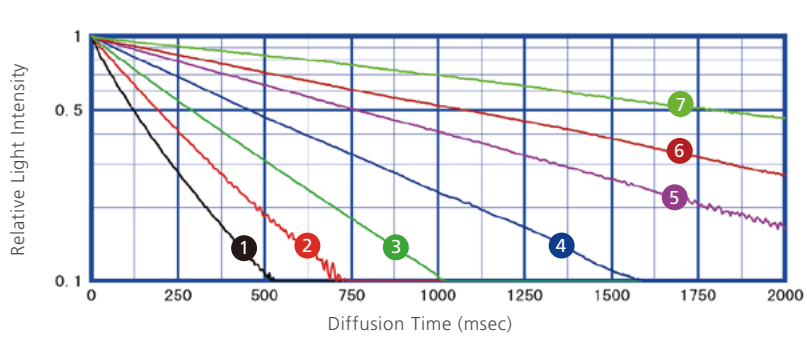
Window of Wing-1 Control Software

Measurement Results Validated Using Changes in the Intensity of Diffracted Light (Decay Process)

If the particles are relatively small, the attenuation gradient is relatively high, whereas if the particles are relatively large, the attenuation gradient is relatively 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



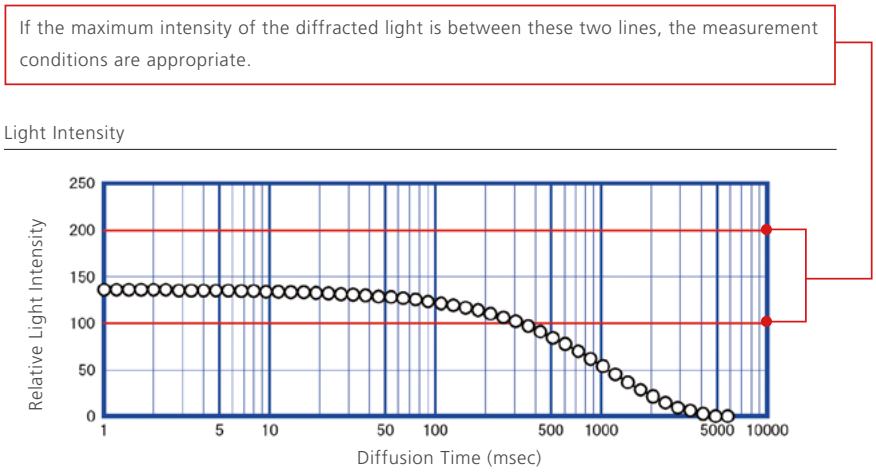
Comparison of Attenuation in Intensities of Diffracted Light

Optimal Measurement Conditions Checked with Intensity of Diffracted Light

Setting the following three parameters is required. The optimum parameters are selected using six levels of condition setting files.

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

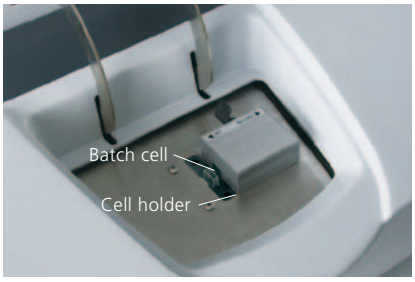
It is possible to check whether or not the optimum measurement conditions are set using the optical intensity level and the upper and lower limit lines displayed on the screen.



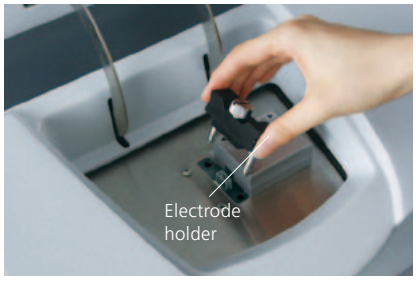
Window for Checking the Level of the Diffracted Light Intensity

Samples Set with Three Simple Steps

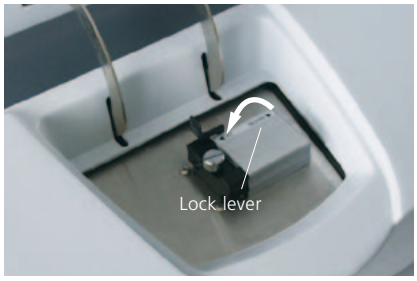
A simple workflow allows measurement to be performed smoothly.



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 from 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-receiving	Photodiode
	Unit	Batch cell (material: Pyrex glass*1)
Output Terminal	Cell	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.

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

PC

OS	Windows 7 or Windows Vista (SP1 or later) or Windows XP (SP2 or later)
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 IG-1000 Plus

* : PC set should be supplied locally.

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)
2 mm Cell	347-61646-02	2 mm cell, short optical path (set of 2)

Parts Required for Installation

Parts Purchased from 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

Parts Provided by the Customer

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

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

Dimensions (mm)

A Particle Size Analyzer That Can Handle Measurement in the Nano to Micron Ranges

Nano Particle Size Analyzer

SALD-7101

Features

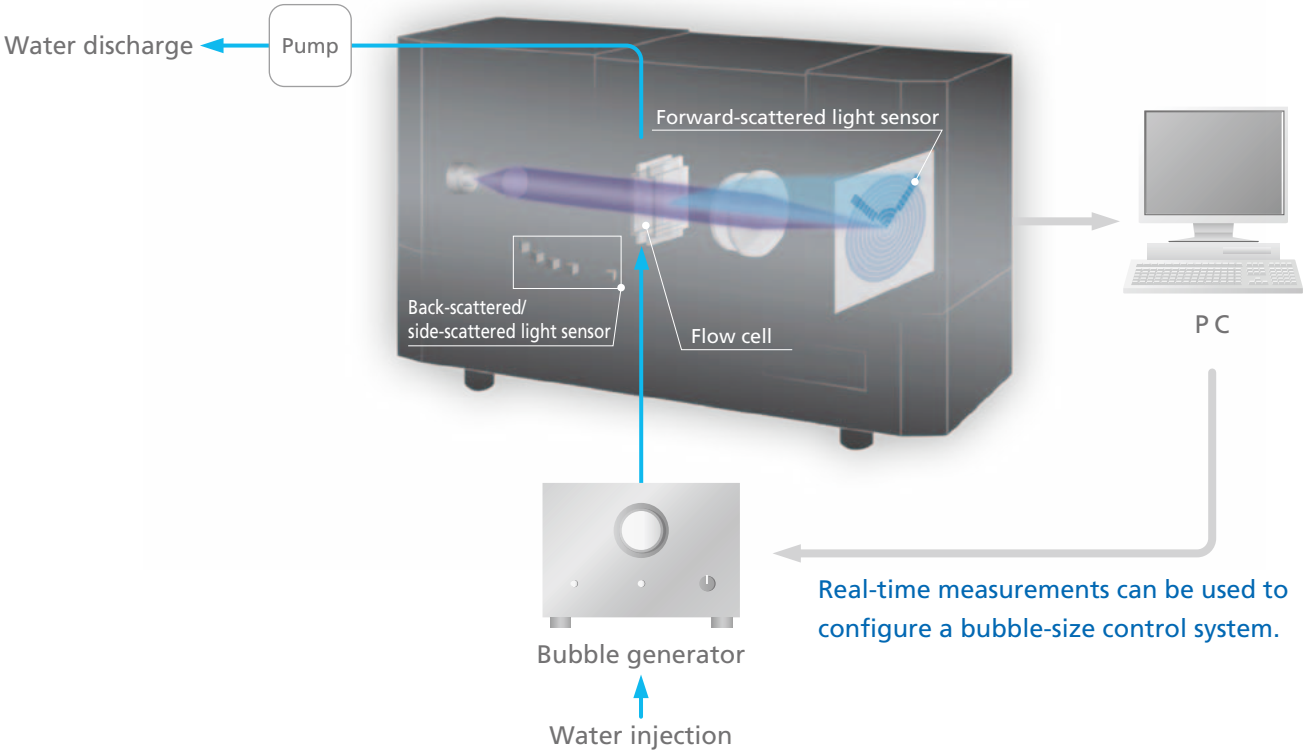
- Particle size distribution can be measured in a range of 10 nm to 300 μm at one-second intervals.
- Particle size distribution can be measured in a wide particle concentration (volume concentration) range of a few ppm to 20%.
- Particle size distribution can be measured in highly viscous liquid media.
- Particles in film can be analyzed.
- The size of microbubbles and nanobubbles can be measured in real time.

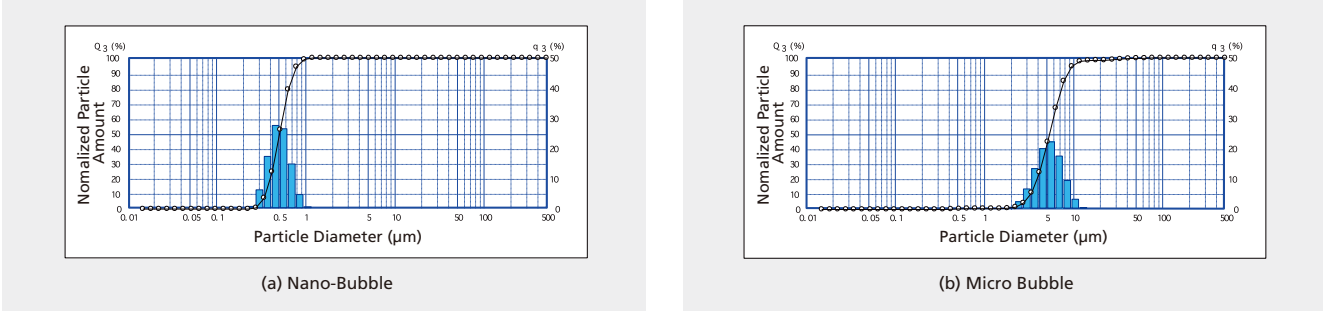
Specifications

Measurement principle	Laser diffraction/scattering method
Measurement range	10 nm (0.01 μm) to 300 μm
Light source	UV semiconductor laser (375 nm wavelength)
Light detector	Detector elements for UV semiconductor laser Total 81 elements (76 forward, 1 side, 4 back)

Microbubble and Nanobubble Size Measurement Using the SALD-7101

- The size of nanobubbles and microbubbles can be measured in one range.
- Its real-time measurement capability enables the instrument to be used as a monitor.





(a) Nano-Bubble

(b) Micro Bubble

Measurememt of Micro Bubble and Nano-Bubble

These results were obtained with the bubble generator and flow cell connected.
Using the SALD-7101, the flow cell and bubble generator are directly connected, as shown in the diagram. This allows online, real-time diameter measurements of the microbubbles and nanobubbles formed, which permits feedback of the bubble diameters.

Nanoparticle Characteristic Evaluation System

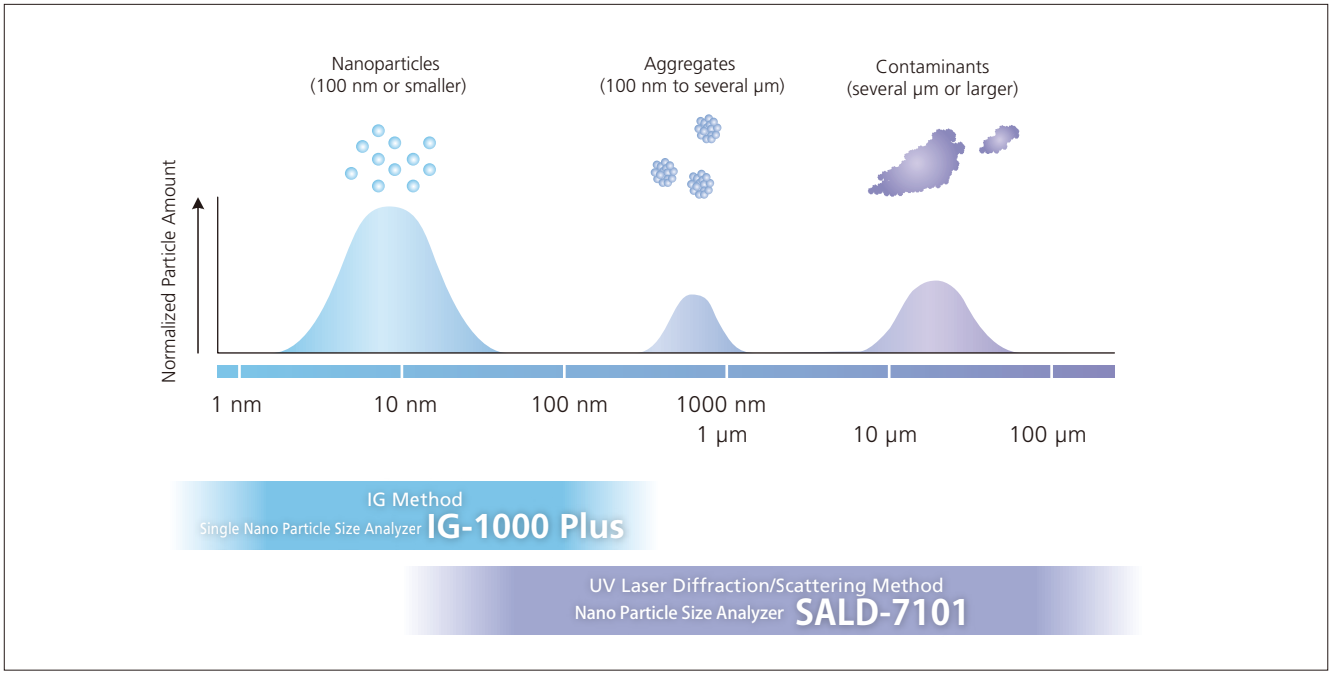
Multifaceted evaluation of dispersion and aggregation characteristics of unstable nanoparticles

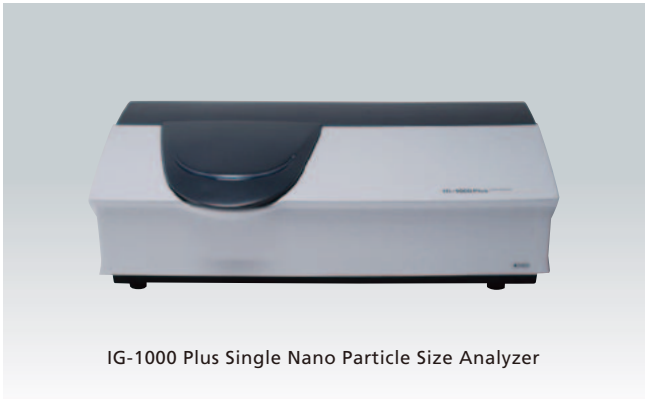
A new nanoparticle evaluation system was created by combining the IG method (IG-1000 Plus Single Nano Particle Size Analyzer) with the UV laser diffraction/scattering method (SALD-7101 Nano Particle Size Analyzer).

Dispersion and aggregation processes of unstable and easily changing nanoparticles can be evaluated with high sensitivity and high reproducibility over a wide range.

- Particle size range evaluated: 0.5 nm to 300,000 nm (300 µm)
- Real-time observation of nanoparticles ranging from 10 nm to 300,000 nm (300 µm)
- In the 10 nm to 200 nm range, more objective and multifaceted evaluation of the state of nanoparticles can be provided by using two measurement principles (IG method and UV laser diffraction/scattering method).

Reliable screening for contaminants and aggregates helps accurately evaluate single nanoparticles.





IG-1000 Plus Single Nano Particle Size Analyzer

SALD-7101 Nano Particle Size Analyzer

Lineup of Particle Analyzers

Laser Diffraction Particle Size Analyzers

SALD-3101	(measurement range: 0.05 to 3,000 µm)
SALD-2301	(measurement range: 17 nm to 2,500 µm)
SALD-301 V	(measurement range: 0.1 to 350 µm)
SALD-201 V	(measurement range: 0.25 to 350 µm)

Shimadzu Corporation
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