Optical Gauge series

Optical NanoGauge Thickness measurement system

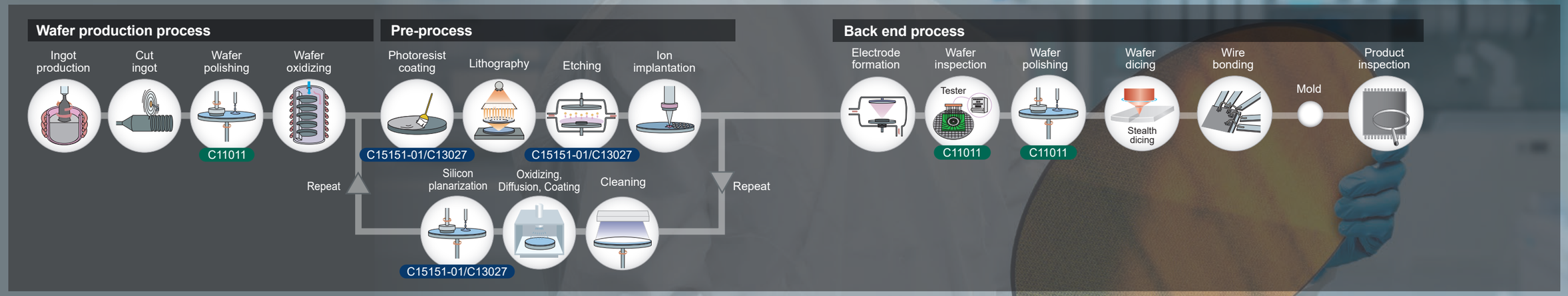
Optical MicroGauge Thickness measurement system

HAMAMATSU

PHOTON IS OUR BUSINESS

Provides solutions for deposition monitoring and wafer thickness control during the semiconductor device manufacturing process

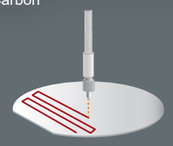
The Optical Gauge series is used in the various manufacturing processes of semiconductor devices, where metal wiring is more multi layered. These processes use a lower voltage and are increasingly miniaturized. This contributes to improvement in the yield and shortens the time required to start a process.



Semiconductor Application Examples

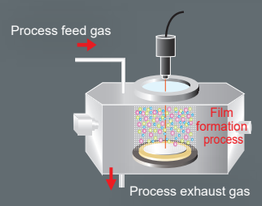
On-wafer film thickness measurement

- **Film thickness measurement after deposition process**
- **Thin film measurement after CMP**
- Metal-oxide coating such as SiO_2, SiC film, Si film, TiO_2 etc.
- Nitrided film, Wet state film, Resist film
- Silicon residual film thickness, Optical disk, DLC, Carbon



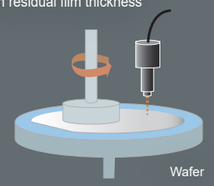
In-situ measurement

- **Film formation process monitor**
- **Dry and wet etching measurement**
- Metal-oxide coating such as SiO_2 and Si



Wafer thickness measurement

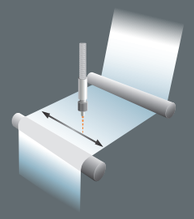
- **Thickness control after wafer grinding**
- **Thickness control after wet processing**
- SiO_2, Si film, Wet state film
- Silicon residual film thickness



Other Application Examples

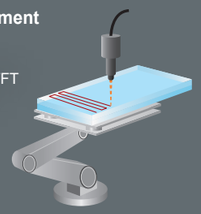
Film

- **Coating film**
- **Plastic film**
- **Object color measurement**
- AR coating, PET, Coating layer
- PE, PMMA
- Coating film, Evaporation film, Functionality film
- Ag Nanowire, Acrylic resin, Video head



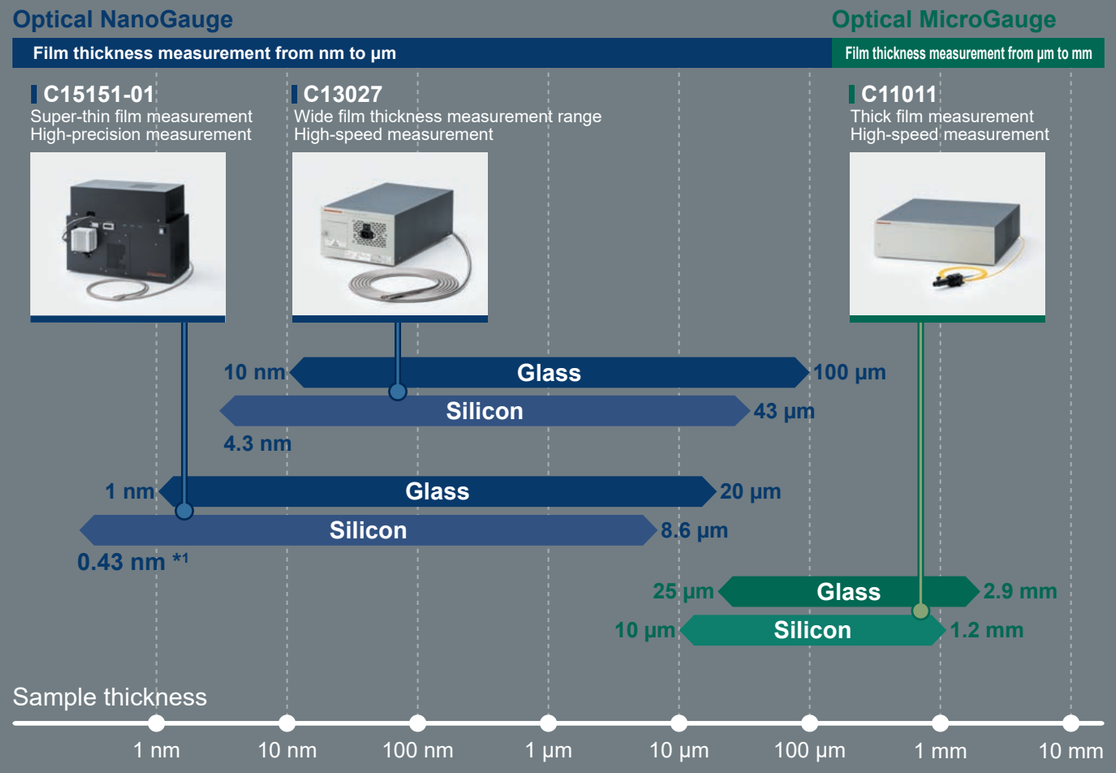
FPD

- **Film thickness and color measurement of flat panel**
- Cell gap, Organic EL film, Alignment film, TFT
- Ag Nanowire, ITO, MgO, Resist film on glass substrate, Polyimide
- High-functioning film, Color film for FPD



Line-up

- The refractive indices in this catalog are 1.5 for glass and 3.67 for silicon.



*1: This is a calculated value converted to the refractive index of silicon (3.67).

Optical NanoGauge Thickness measurement system

0.43 nm — 1 nm — 100 nm — 1 µm — 10 µm — 100 µm — 1 mm

C15151-01

C13027

The Optical NanoGauge Thickness measurement system is a non-contact film thickness measurement system utilizing spectral interferometry.

Our systems are capable of high-precision spectroscopic measurement, which enables to measure accurate reflection spectra. Analysis of the reflection spectrum enables various film thickness measurements from the nanometer order to the micrometer order. It also calculates optical constants with high accuracy.

C15151-01
High-end model
for super-thin films
▶P06-07

C13027
Compact standard model
▶P08-09

Five Key Features

1. Reliable film thickness measurement based on state-of-the-art spectrometry technology

Hamamatsu Photonics has been developing multichannel spectrometers for many years. We have applied our highly sensitive spectroscopic measurement technology to the measurement of film thickness resulting in highly accurate measurement.

2. Wide range of solutions from the nanometer order to the micrometer order

We have a line-up of models that can accurately measure film thicknesses from 1 nm. Select the Optical NanoGauge Thickness measurement system that best suits your application.

3. Support in-line measurement

It is compatible with sequencer connection. The small size allows for easy integration into manufacturing and inspection equipment.

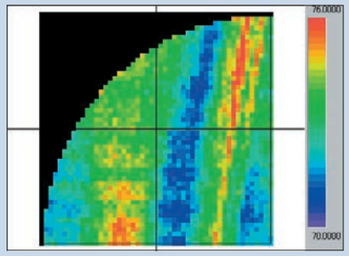
4. High-speed measurement contributes to shorter takt time

High-speed measurement at speeds of up to 200 Hz reduces takt time, contributing to higher productivity.

5. Mapping measurements (option)

Unevenness within the wafer surface often occurs during the wafer processing. The optional mapping stage enables thickness distribution measurement, which can be used to check the in-plane uniformity of etching and grinding characteristics. It is also ideal for quality control following wafer processing.

■ Thickness distribution of a wafer

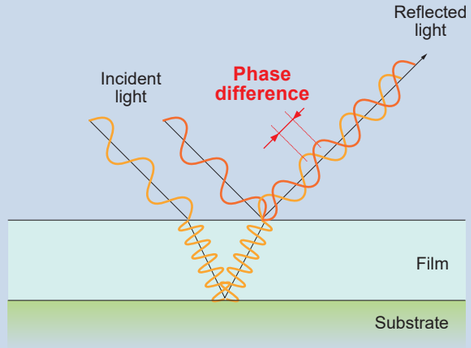


* Display from 70 µm to 76 µm
Sample: 8-inch Si bare wafer
(Protective film/after grinding process)

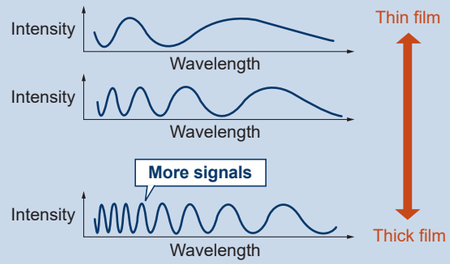
Measurement Principle

Spectral interferometry is used for film thickness measurement

Multiple reflections occur inside the thin film as light enters a thin film sample. These multiple-reflection light waves boost or weaken each other along with their phase difference. The phase difference of each multiple-reflection light is determined by the light wavelength and optical path length. Therefore, the reflected or transmitted spectrum from the sample shows a specific spectrum determined by the film thickness.
Spectral interferometry is a technique for measuring film thickness by analyzing that particular spectrum. The Optical NanoGauge Thickness measurement system utilizes spectral interferometry to analyze a target spectrum by the curve-fitting or FFT (Fast Fourier Transform) method that matches your application.

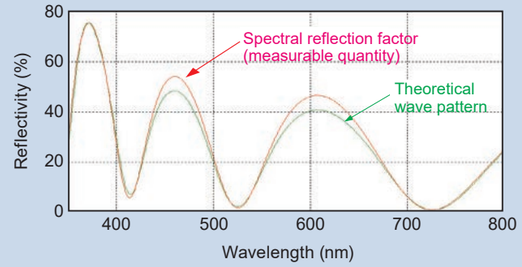


The number of signals is increased as the film thickens. The signal intervals in short wavelength range appears more often than those in the long wavelength range.



Analysis by curve fitting — For measuring less than 1 µm film thickness

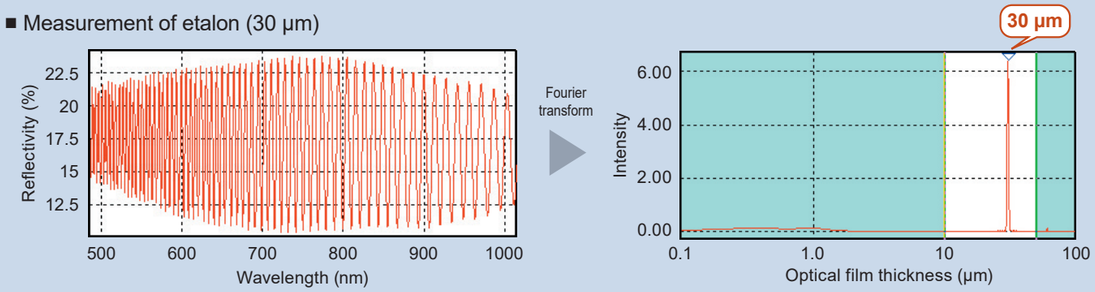
■ Interference spectrum measurement of transparent electrode (ITO film: 350 nm)



The analyzed film thickness is the theoretical value, which is the least RMS (Root Mean Square) value of the theoretical wave pattern and measurement reflection pattern.

Analysis by FFT (Fast Fourier Transform) — For measuring more than 1 µm film thickness

■ Measurement of etalon (30 µm)



C15151-01

High-end model for super-thin films

Super-thin film measurement **High-precision measurement**

The Optical NanoGauge Thickness measurement system C15151-01 is a non-contact film thickness measurement system utilizing spectral interferometry. The high-power, highly stable white light source enables precise measurement of film thicknesses, even of super-thin films. The Optical NanoGauge series offers rapid measurements up to 200 Hz, making it an ideal choice for high-speed production lines.

Measurable range **Glass:** 1 nm to 20 µm
Silicon: 0.43 nm* to 8.6 µm

*This is a calculated value converted to the refractive index of silicon (3.67).

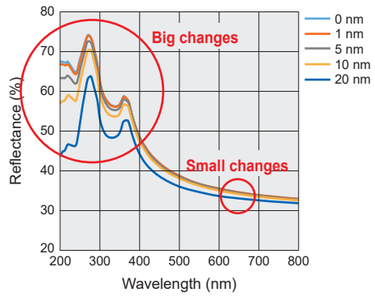
Features

- **For super-thin film measurement (Glass: from 1 nm, Silicon: from 0.43 nm)**
- **High accuracy (Measurement reproducibility: ≤ 0.1 nm) *When measuring SiO_2 of 2 nm thickness**
- **Uses a high-power white light source**
- **Long service life (Maintenance cycle: more than 1 year)**
- Supports PLC connections
- Shortening of cycle time (Max. 200 Hz)
- Covers broad wavelength range (200 nm to 790 nm)
- Simplified measurement is added to the software
- Capable of both surface analysis
- Better measurement stability against distance fluctuations
- Analyze optical constants (n, k)

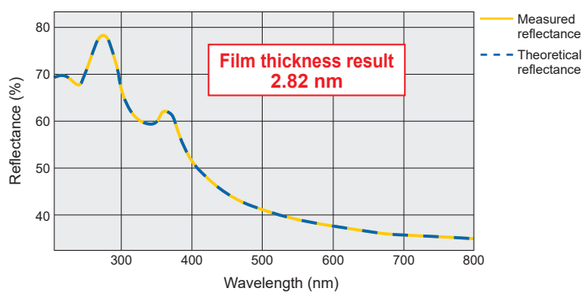
Advantages of using a high-power, highly stable white light source

Effective use of the ultraviolet range allows super-thin films to be measured with high precision.

■ Use of ultraviolet light with large changes in reflectance.

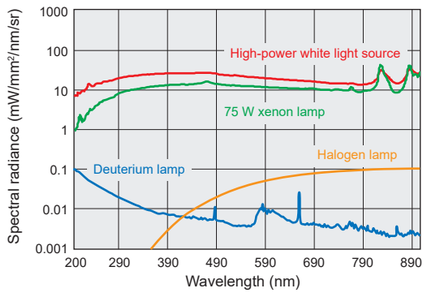


■ Measured value close to theoretical value

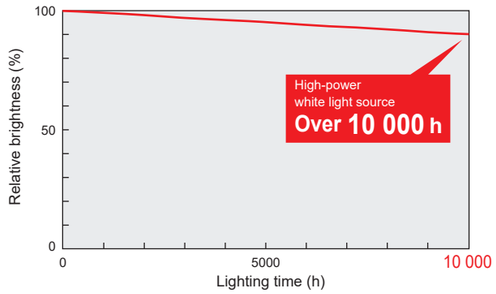


Applicable to a variety of environments for in in-line operation.

■ Higher brightness than other lamps



■ Long service life of over 10 000 hours.



Specification

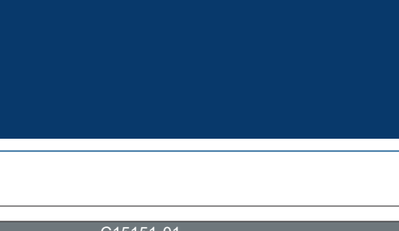
Product number		C15151-01
Measurement film thickness range	glass *1	1 nm to 20 µm
	silicon *2	0.43 nm*3 to 8.6 µm
Measurement reproducibility	glass *4 *5	0.1 nm
	silicon *6	1 nm
Measurement accuracy *5 *7 *8		±0.4 %
Light source		High-power white light source
Measurement wavelength range		200 nm to 790 nm
Spot size *5		Approx. Φ1 mm
Working distance *5		From 10 mm
Number of measurable layers		Max. 10 layers
Analysis		FFT analysis, Fitting analysis, Optical constant analysis
Shortest takt time		< 2 ms/point
External communication interface		RS-232C, Ethernet
Output signal	Analog output	0 V to 10 V / High impedance 3-channel (Max. 3 layers)
	Alarm output	TTL/High impedance 1-channel
	Warning output	TTL/High impedance 1-channel
Input signal	Measurement start signal	TTL/High impedance 1-channel
Power supply voltage		AC100 V to AC240 V, 50 Hz/60 Hz
Power consumption		Approx. 130 VA
Light guide connector shape		FC

*1: When converted with the refractive index of glass = 1.5.
*2: When converted with the refractive index of silicon = 3.67.
*3: This is a calculated value converted to the refractive index of silicon (3.67).
*4: Standard deviation (tolerance) when measuring 2 nm thick glass film.
*5: Depending on optical system or objective lens magnification to be used.
*6: Standard deviation (tolerance) when measuring 30 µm thick etalon.
*7: Range of measurement guarantee as recorded in the VLSI Standards measurement guarantee document.
*8: When measuring silicon.

Configuration examples

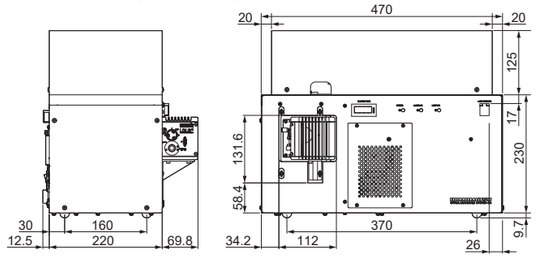
■ C15151-01 Example of system configuration (off-line)

■ C15151-01 Example of system configuration (in-line)

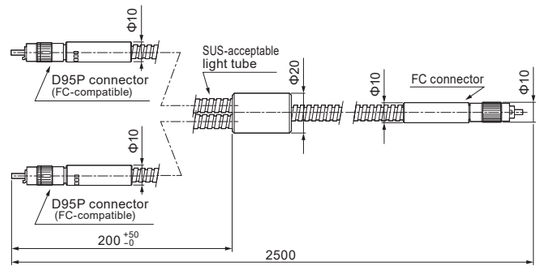


Dimensional outline (Unit: mm)

■ Optical NanoGauge Thickness measurement system C15151-01 (Approx. 14.3 kg)

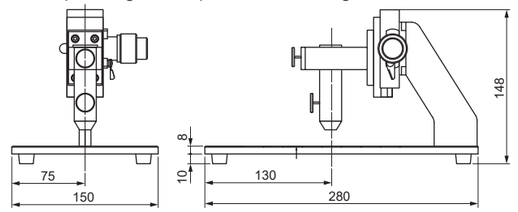


■ Two split light guide



*The bending radius of the fiber is R100 mm or more.

■ Sample stage for Optical NanoGauge A10192-10



C13027

Standard model with wide film thickness measurement range and compact size

Wide film thickness measurement range **High-speed measurement**

The Optical NanoGauge Thickness measurement system C13027 is a non-contact film thickness measurement system utilizing spectral interferometry. The C13027 can be connected to a sequencer and is compact for easy installation into equipment. It is capable of a wide range of film thickness measurements.

Measurable range

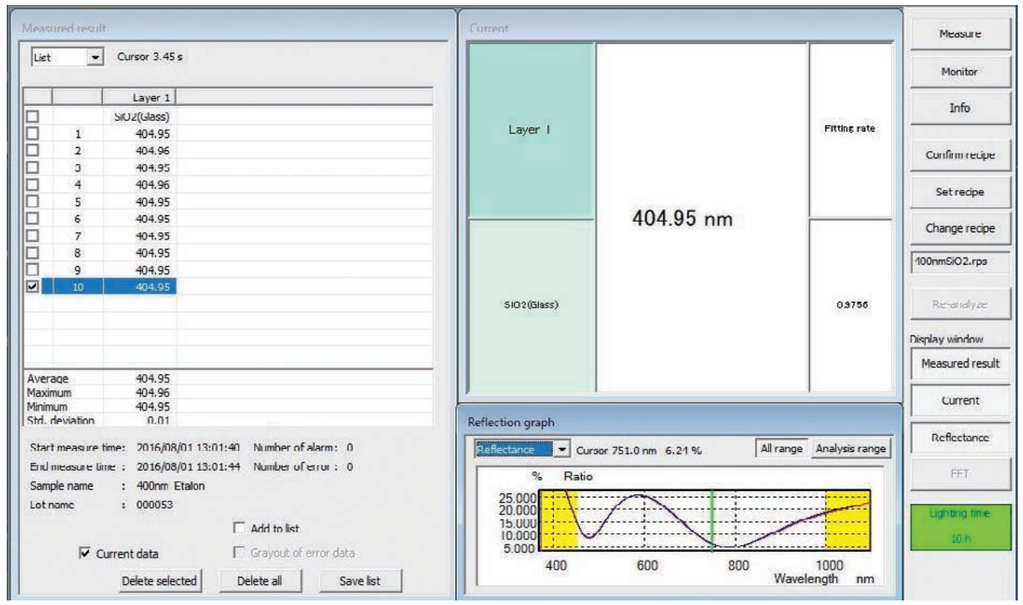
Glass: 10 nm to 100 µm
Silicon: 4.3 nm to 43 µm

Features

- Supports PLC connections
- Shortening of cycle time (max. 200 Hz)
- For ultra-thin film measurement (Glass: from 10 nm, Silicon: from 4.3 nm)
- Compact
- Covers broad wavelength range (400 nm to 1100 nm)
- Simplified measurement is added to the software
- Capable of both surface analysis
- Better measurement stability against distance fluctuations
- Analyze optical constants (n, k)
- Mapping function (Option)

Measurement example

■ Measurement example of standard oxide film (400 nm)



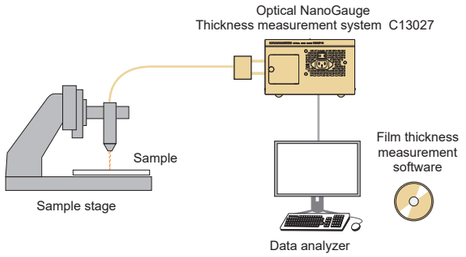
Specification

Product number		C13027-12
Measurement film thickness range	glass *1	10 nm to 100 µm
	silicon *2	4.3 nm to 43 µm
Measurement reproducibility	glass *3 *4	0.02 nm
	silicon *5	1 nm
Measurement accuracy *4 *6		±0.4 %
Light source		Halogen light source
Measurement wavelength range		400 nm to 1100 nm
Spot size *4		Approx. Φ1 mm
Working distance *4		10 mm
Number of measurable layers		Max. 10 layers
Analysis		FFT analysis, Fitting analysis, Optical constant analysis
Shortest takt time		< 3 ms/point
External communication interface		RS-232C, Ethernet
Output signal	Analog output	0 V to 10 V / High impedance 3-channel (Max. 3 layers)
	Alarm output	TTL/High impedance 1-channel
	Warning output	TTL/High impedance 1-channel
Input signal	Measurement start signal	TTL/High impedance 1-channel
Power supply voltage		AC100 V to AC240 V, 50 Hz/60 Hz
Power consumption		Approx. 80 VA
Light guide connector shape		FC

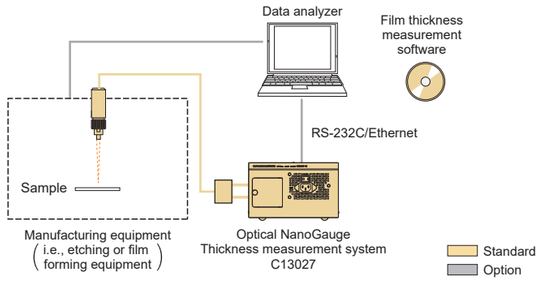
*1: When converted with the refractive index of glass = 1.5.
*2: When converted with the refractive index of silicon = 3.67.
*3: Standard deviation (tolerance) when measuring 400 nm thick glass film.
*4: Depending on optical system or objective lens magnification to be used.
*5: Standard deviation (tolerance) when measuring 30 µm thick etalon.
*6: Range of measurement guarantee as recorded in the VLSI Standards measurement guarantee document.

Configuration examples

■ C13027 Example of system configuration (off-line)

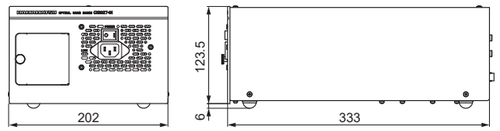


■ C13027 Example of system configuration (in-line)

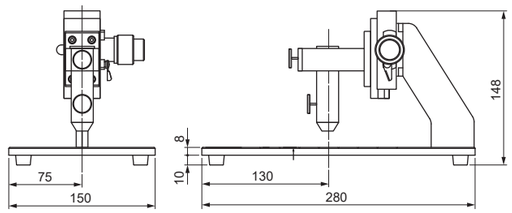


Dimensional outline (Unit: mm)

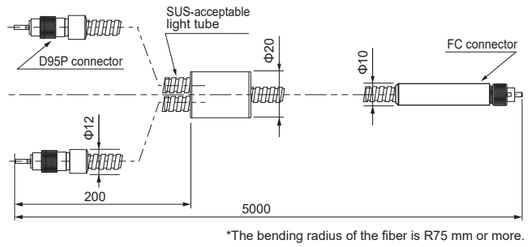
■ Optical NanoGauge Thickness measurement system C13027-11 (Approx. 4.7 kg)



■ Sample stage for Optical NanoGauge A10192-10



■ Two split light guide



*The bending radius of the fiber is R75 mm or more.

Optical MicroGauge Thickness measurement system

10 µm — 100 µm — 1 mm — 2.9 mm

C11011

The Optical MicroGauge Thickness measurement system utilizes laser interferometry.

Our system is suitable for thickness measurements from a dozen micrometers to the millimeters. It can be used to measure the thickness of various types of wafers, such as patterned wafers and bonded wafers.

C11011
In-line compatible, high-speed model capable of measuring up to 2.9 mm
▶P12-13

Five Key Features

1. Reliable wafer thickness measurement

Highly accurate measurements are possible using laser interferometry, which calculates thickness based on the wavelength of light. The thickness is converted using the interference signal of the laser reflecting the layer structure, enabling accurate measurement even in structures where layers of similar thickness overlap.

2. Various types of wafers can be evaluated, including patterned and bonded wafers

The Optical MicroGauge Thickness measurement system uses infrared light as the probe light. It can measure the thickness of semi-transparent semiconductor wafers, such as Si, GaAs, and InP without contact. It is also possible to evaluate wafers with patterns or protective films.

3. Wide range of wafer thickness control from a dozen micrometers to millimeters

In the semiconductor manufacturing process, including silicon manufacture, wafers must be maintained at a uniform thickness according to purpose. In addition, wafer thickness must be controlled to meet standards at the wafer manufacturing site. Our Optical MicroGauge Thickness measurement system can be used to measure thickness in a wide range of processes, from 10 µm to 2.9 mm.

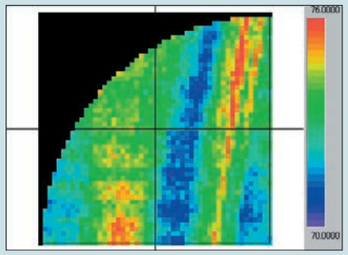
4. Supports in-line measurement

The Optical MicroGauge Thickness measurement system is capable of in-line high-speed measurement at 60 Hz in processes where rotating or flowing fluids are used. The measurement point deviations are minimized allowing highly accurate measurements to be achieved.

5. Mapping measurements (option)

Unevenness within the wafer surface often occurs during the wafer processing. The optional mapping stage enables thickness distribution measurement, which can be used to check the in-plane uniformity of etching and grinding characteristics. It is also ideal for quality control following wafer processing.

■ Thickness distribution of a wafer

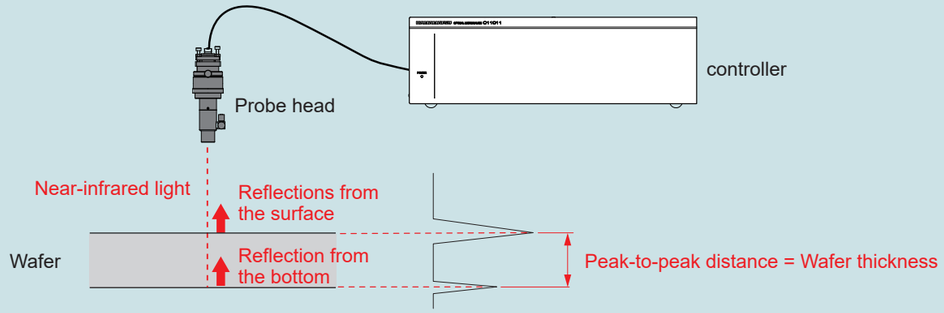


* Display from 70 µm to 76 µm
Sample: 8-inch Si bare wafer
(Protective film/after grinding process)

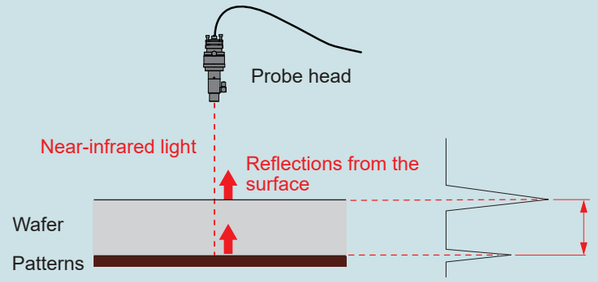
Measurement Principle

Laser interferometry is used for film thickness measurement

The probe head irradiates the sample with near infrared light which reflects back from the front surface of the film. Some of the light transmits through the film and reflects back from the boundary on the opposite side. The controller internally processes each reflected light to detect the position on the film boundary where light was reflected. The controller then calculates the film thickness from the distance between the detected peaks.

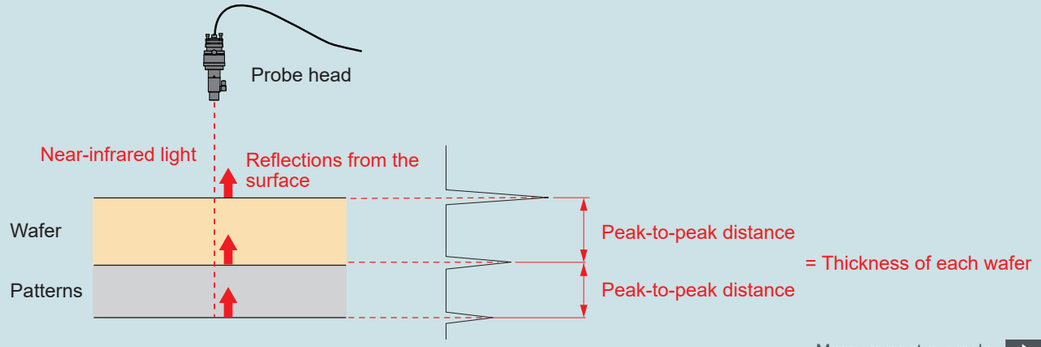


For wafer with patterns — Measures wafer thickness without penetrating metal patterns



Measurement example ▶P12

For bonded wafer — Measures the thickness of each wafer



Measurement example ▶P12

C11011

High-speed, in-line compatible model capable of measuring up to 2.9 mm

Thick film measurement **High-speed measurement**

The Optical MicroGauge Thickness measurement system C11011 series utilizes laser interferometry for high-speed measurement at 60 Hz. This makes it ideal for inline measurement in factories. Prototype thickness distribution measurement is archived by combining with the optional mapping system.
The C11011 series can be used in a wide variety of applications, from monitoring manufacturing processes to quality control.

Measurable range
Glass: 25 µm to 2.9 mm
Silicon: 10 µm to 1.2 mm

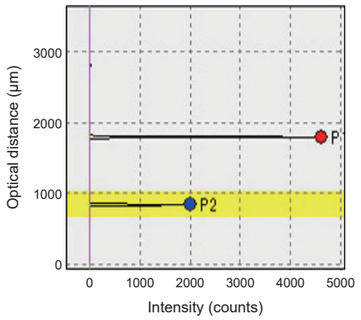
Features

- Infrared light measurement for non-transparent (white) samples
- High-speed measurement at 60 Hz
- Measurement of wafers with patterns or protective films
- Long working distance
- Mapping function (Option)
- External control available

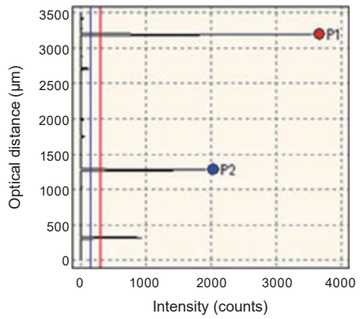
Measurement examples

Patterned and bonded wafers can be measured without contact.

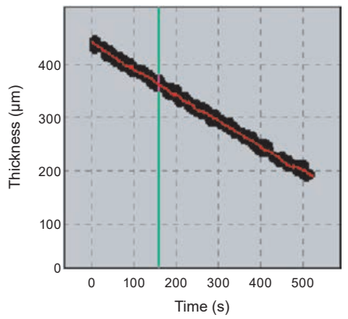
■ Patterned wafer measurement example



■ Bonded wafer measurement example



■ In-situ monitoring example (Thickness measurement data)



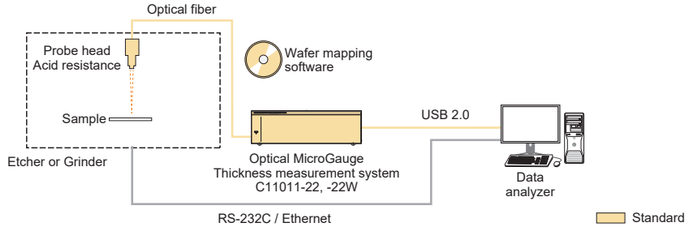
Specification

Product number		C11011-02	C11011-02W	C11011-22	C11011-22W
Measurement film thickness range	glass *1	25 µm to 2.2 mm	25 µm to 2.9 mm	25 µm to 2.2 mm	25 µm to 2.9 mm
	silicon *2	10 µm to 0.9 mm	10 µm to 1.2 mm	10 µm to 0.9 mm	10 µm to 1.2 mm
Measurement reproducibility	glass *3	250 nm			
	silicon *4	100 nm			
Measurement accuracy *5		±0.5 µm (≤500 µm), ±0.1 % (>500 µm)			
Light source		Infrared LD (1300 nm)			
Spot size		Approx. Φ60 µm			
Working distance *6		155 mm			
Number of measurable layers		Max. 1 layer		Max. 10 layers	
Analysis		Peak detection			
Shortest takt time		16.7 ms/point	22.2 ms/point	16.7 ms/point	22.2 ms/point
External communication interface		RS-232C, PIPE		RS-232C, Ethernet	
Interface		USB 2.0 (Main unit - Computer)			
Power supply voltage		AC100 V to AC240 V, 50 Hz/60 Hz			
Power consumption		Approx. 50 VA			
Light guide connector shape		FC			

*1: When converted with the refractive index of glass = 1.5.
*2: When converted with the refractive index of silicon = 3.67.
*3: Standard deviation (tolerance) when measuring glass film.
*4: Standard deviation (tolerance) when measuring silicon.
*5: When measuring silicon.
*6: Optional model with 1000 mm working distance is available.

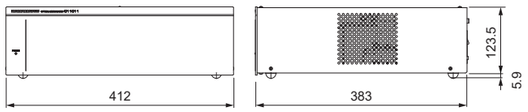
Configuration example

■ C11011-22, -22W Example of system configuration (in-line)



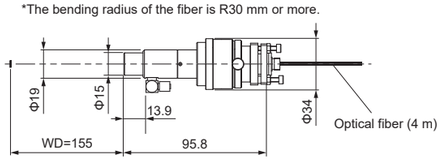
Dimensional outline (Unit: mm)

■ Optical MicroGauge Thickness measurement system C11011-02, -02W, -22, -22W (Approx. 8.5 kg)



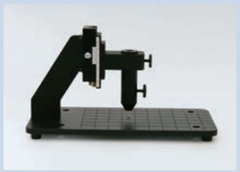
■ Prove head Acid resistance A8653-02

*The bending radius of the fiber is R30 mm or more.



For Optical NanoGauge Thickness measurement system

Sample stage for Optical NanoGauge
A10192-10



This stage accommodates samples up to Φ200 mm in diameter. Light condenser is not included. This is a pen type model designed to view samples more easily.

- WD: Approx. 10 mm
- Measurement spot diameter: Φ1 mm

Sample stage FC connector type for VIS
A10192-05

This stage accommodates samples up to Φ200 mm in diameter. It comes with a visible light condenser lens with corrected chromatic aberration.

- WD: approx. 35 mm
- Measurement spot diameter: Φ1.5 mm

Macro optics FC connector type for VIS
A10191-03

Visible light conductor lens for A10192-05.

- WD: Approx. 35 mm
- Measurement spot diameter: Φ1.5 mm

Film thickness measurement software for both surface U12708-01

Analysis software for both surface.

FC Receptacle A12187-02

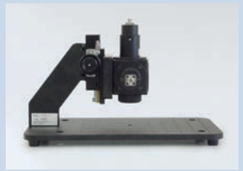
A tool for setting a fiber probe in a mount.

Lamp unit L12839-02

Lamp unit for C13027.

Micro optics A13097

Micro optics A13097-01, -02



Micro optics A13097-11, -12
(For off-line use)

The A13097 is a micro-optical system for in-line film thickness measurement, designed to measure samples that are difficult or impossible to measure by a wide field of view. When used in combination with an Optical NanoGauge Thickness measurement system, the spot diameter can be narrowed down to 100 µm in diameter to allow measuring interface roughness as well as samples with high scattering and very small areas on patterns, which up until now have been difficult to measure. The A13097 is quite stable even when there are variations in height, and so gives reliable measurements at diverse manufacturing sites. A sample stage type is also provided for off-line applications.

■ Specifications when C13027 and A13097 are combined

Product number	A13097-01, -11	A13097-02, -12
Measurement film thickness range (glass) *1*2	100 nm to 100 µm	10 nm to 50 µm
Measurement reproducibility (glass) *3	0.2 nm	
Measurement accuracy	±0.4 %	
Light source	Halogen light source	
Measurement wavelength range	700 nm to 1100 nm	400 nm to 800 nm
Spot size	Φ100 µm	
Working distance	32 mm	
Height fluctuation	±2 mm	
Maximum repetition frequency	200 Hz	
Measurement time	3 ms/point	
Light guide connector shape	FC	

*1: When converted with the refractive index of glass = 1.5.
*2: When combined with C15151, the measurable film thickness value changes.
*3: Standard deviation (tolerance) when measuring 400 nm thick glass film.

For Optical MicroGauge Thickness measurement system

Probe head Acid resistance A8653-02

This probe head is surface-treated to make it acid-resistant and is recommended for use while mounted in wet etching equipment.

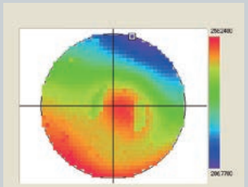
Horizontal setting optics A9925-01

This optical system is designed to be connected to the probe head.
It is useful when installing the probe head in narrow locations with little working distance.

For Both Optical NanoGauge Thickness measurement system and Optical MicroGauge Thickness measurement system

Mapping stage C8126 series

This is a mapping system that measures wafer and film thickness distribution when combined with models from Optical Gauge series. It can be used to confirm in-plane homogeneity of etching and grinding features and for quality control.



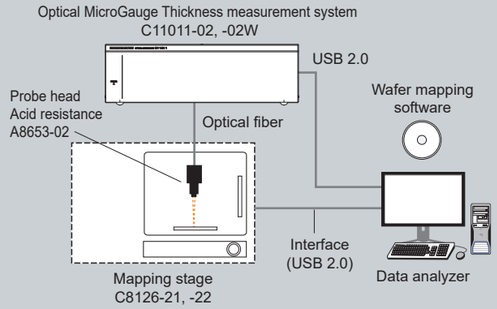
Features

- Thickness distribution measurement
- Mapping thickness distribution of pattern-formed wafer
- Mapping thickness distribution of pattern-formed wafer with protective film

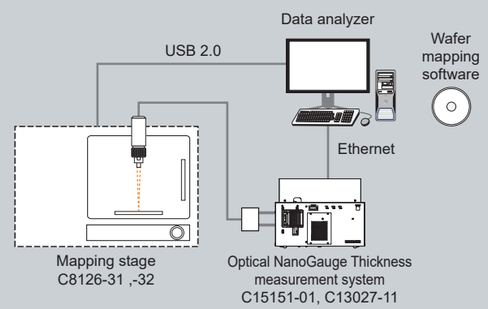
Product number	Measurable range		Compatible with NanoGauge / MicroGauge
	Wafer (inch)	Film *1	
Mapping stage Φ200 mm C8126-21	4 to 8	< 140 mm × 140 mm	C11011-02 C11011-02W
Mapping stage Φ300 mm C8126-22	4 to 12	< 200 mm × 200 mm	
Mapping stage Φ200 mm C8126-31	4 to 8	< 140 mm × 140 mm	C13027-11
Mapping stage Φ300 mm C8126-32	4 to 12	< 200 mm × 200 mm	

*1: Please contact us for the specifications of the stage unit for film measurement and information on the compatibility of 16-inch wafers.

■ C8126-21, -22 Example of system configuration (For C11011 series)



■ C8126-31, -32 Example of system configuration (For C15151-01 and C13027)



Product number	C8126-21, -31	C8126-22, -32
Stage movement resolution	0.1 mm	
Stage movement repeatability	±0.01 mm	
Power requirement *1	AC100 V to AC117 V, AC220 V to AC240 V, 50 Hz/60 Hz	
Power consumption	60 VA (at 100 V), 80 VA (at 200 V)	
Dimensional outline / Weight	820 mm (W) × 595 mm (H) × 600 mm (D) / Approx. 67 kg	940 mm (W) × 595 mm (H) × 750 mm (D) / Approx. 82 kg

*1: Either 100 V system or 200 V system can be selected.

• Please contact us for more details of the specification.

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