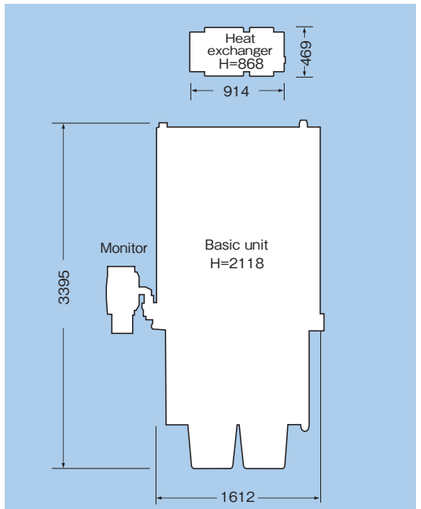
Specifications

Wafer size		200 mm
Load port		2 FOUP load ports
Dimensions	Main unit	1612 (W) × 3395 (D) × 2118 (H) mm　※Excluding load ports
	Heat exchanger	469 (W) × 914 (D) × 868 (H) mm
Utilities	Power supply	3-phase, 208 V, 20 A, avg. 2 kVA (Main unit)
		1-phase, 208 V, 8 A, avg. 0.5 kVA (Heat exchanger)
	CDA	0.5～0.7 MPa　20 L/min
	Vacuum	-80 kPa　20 L/min

Typical floor arrangement



Compliance with safety standards **SEMI S2/S8**

Compliance with communication standards **GEM300** **SECS/GEM**

ISO 9001/ISO 14001 approved

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CED442D/200200E

Rigaku
Leading With Innovation

XTRAIA MF-2000

In-line X-ray Metal Film Monitor

Setting the Standard for Semiconductor In-line Process X-ray Metrology Tools

World Leader in Analytical X-ray Metrology Tools and Solutions for the Semiconductor Industry

High-throughput Measurement of Product Wafers

From Ultrathin Films to Micron-order Films,
Applicable to a Wide Range of Thickness and Film Types

High-throughput Measurement of Product Wafers

- With pattern recognition, an area 100 µm or smaller on product wafers can be measured at any position.
- No monitor wafers are required for the thickness inspection process. Thickness, roughness, and composition are measured in atmosphere with no contact and with high throughput (15-20 WPH).

Micro-XRF: Both High Precision and High Throughput are Achieved

- A lineup of monochromatic, micro-spot X-ray beam modules (COLORS™) enables a choice of optimized X-ray sources.
- Thanks to grazing-incidence radiation realized by variable X-ray incidence angle, ultrathin films are measured with high precision and high throughput.

Micro-XRR: Wide Dynamic Range and High Throughput are Realized

- Equipped with an ultrafast detector with up to 10^8 dynamic range and with monochromatic, micro-spot X-ray sources.
- High-precision, high-throughput micro-XRR measurements are achieved.

Micro-XRD: Available for Crystallinity Analysis of Various Metal Films

- Using a 100 µm or smaller monochromatic, micro-spot X-ray beam, XRD measurement of small areas is possible.

Micro-XRF
Micro-XRR
Micro-XRD

XTRAIA MF-2000

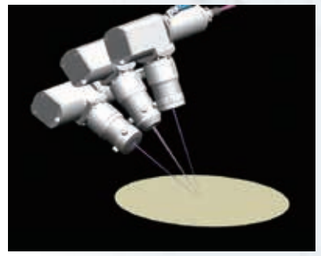
In-line X-ray Metal Film Monitor

Monochromatic, Micro-spot X-ray Beam Module, COLORS™

A high-brilliance monochromatic, micro-spot X-ray beam is realized by Rigaku's unique multilayer mirror technology. Select and exchange the X-ray beam best suited for XRR, XRF, and XRD applications of interest.

Right: COLORS Cu
Left: COLORS-i Mo

	FWHM (µm)	XRF	XRR	XRD
COLORS Cu	85	○	○	○
COLORS Au	85	○	–	–
COLORS Mo	85	○	–	–
COLORS Rh	85	○	–	–
COLORS-n Cu	50	○	–	–
COLORS-i Au	35	○	–	–
COLORS-i Mo	35	○	–	–



Applications

XTRAIA MF-2000 can handle a variety of FEOL and BEOL films ranging from single layer to multilayered stacks.

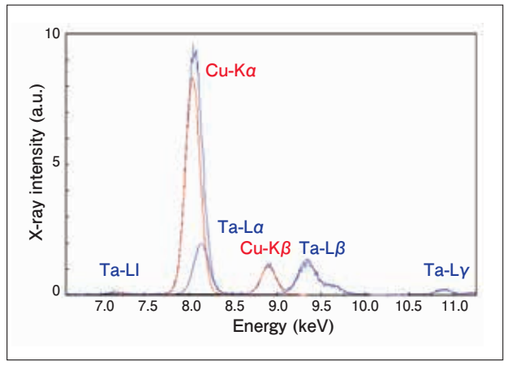
FEOL	SiGe, CoSix, NiSix, SOI, Al, SiON, Hi-k dielectric/metal gate ...
BEOL	Cu seed, Cu barrier, Cu plating, Ti/TiN, Ta/TaN, W ...
Others	MgO, CoFeB, Ru, Pt, PZT ...

New X-ray Metrology Tool Realizes High-precision Measurements

Micro-XRF Measurement of Thickness and Composition

Using a monochromatic, micro-spot X-ray beam module and a high-sensitivity, energy-dispersive silicon drift detector (SDD), high-throughput and high-precision thickness and composition measurements by X-ray fluorescence (XRF) are realized.

Micro-XRF measurement example: Cu/Ta/TaN

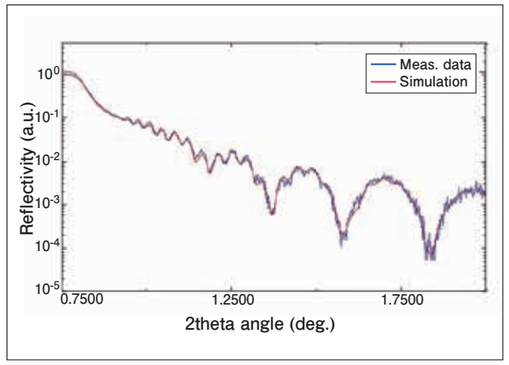


Micro-XRR Measurement of Thickness

Thanks to an ultrafast X-ray detector, high-throughput X-ray reflectivity (XRR) measurements are realized. It enables simultaneous measurement of a multilayer film over an 8-order dynamic range.

	Density (g/cm³)	Thickness (nm)	Roughness (nm)
Cu	8.60	153.83	1.51
Ta	15.85	16.43	0.00
TaN	14.02	9.81	8.70
SiO_2	2.20	300.00	0.00

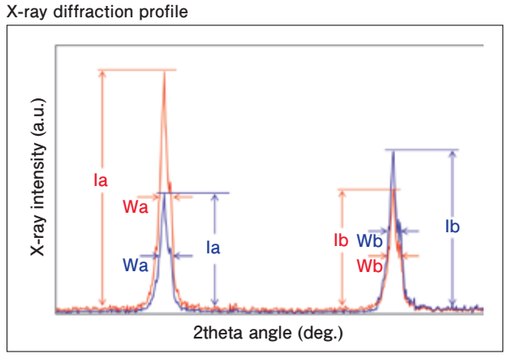
Micro-XRR measurement example: Cu/Ta/TaN



Evaluation of Crystallinity and Orientation by Micro-XRD

By X-ray diffraction (XRD), crystalline phase identification and crystal orientation can be evaluated from peak locations and intensities in the diffraction pattern.

X-ray diffraction profile

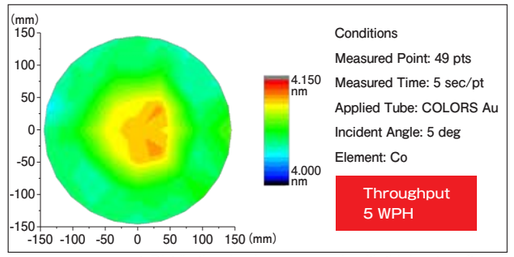


Applications

XRF Measurement of Thickness Variation in MRAM Process

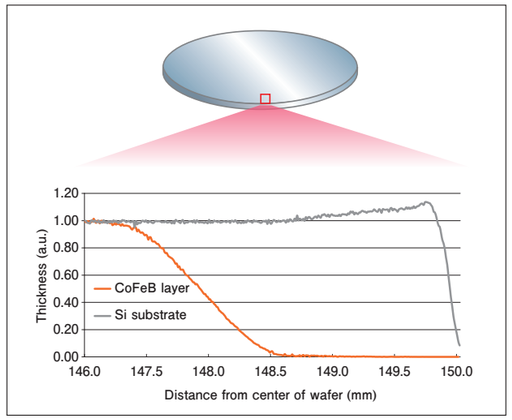
Low-incidence angle measurements enable high-speed analysis of very thin films like those found in MRAM devices.
Flexible recipe settings cover a variety of film stacks and applications.

WIW thickness variation of CoFeB



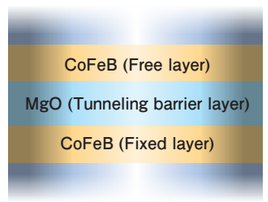
∗ Distribution drawings were made with third party software.

Wafer edge measurement example: CoFeB on Si

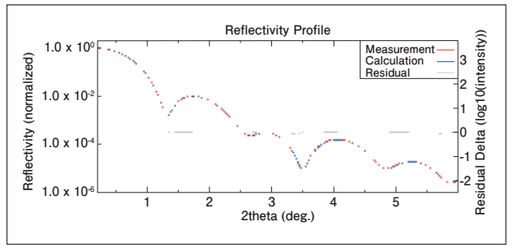


XRR Measurement of Physical Characteristics in MTJ Stack

XRR is applicable for multiple alternating stack structures for which XRF is unable to distinguish each layer of the same composition.



XRR measurement example: CoFeB/MgO/CoFeB

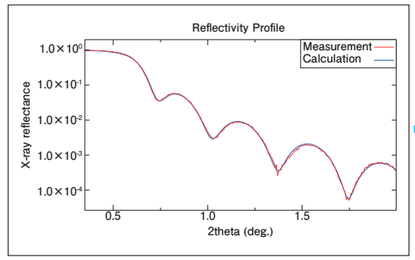


Layer name	Thickness (nm)	Density (g/cm³)	Roughness (nm)
$CoFeB_2$	2.89	8.28	0.3
MgO	1.195	3.78	0.5
$CoFeB_2$	3.44	8.15	0.4

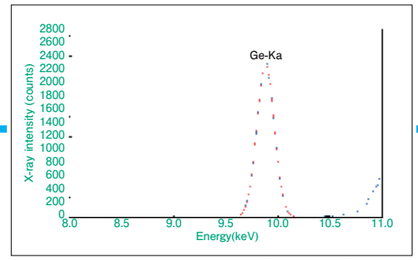
XRR/XRF Combo Measurement of SiGe Composition in Fin Gate

Combined XRR/XRF measurements enable simultaneous analysis of composition and thickness. The density and thickness of a SiGe layer on a Si wafer are obtained by XRR, then the amount of Ge is determined by XRF, and the SiGe composition is derived. This XRR/XRF measurement scheme is especially effective on thin films (<100 nm) that do not typically show significant peak shifts in HRXRD measurements.

Step.1 Thickness・Density measurement: XRR



Step.2 X-ray intensity measurement: XRF with FP∗ method



Thickness (nm)	Composition (%)	
SiGe	Si	Ge
35.0	57	43

∗ Fundamental Parameter

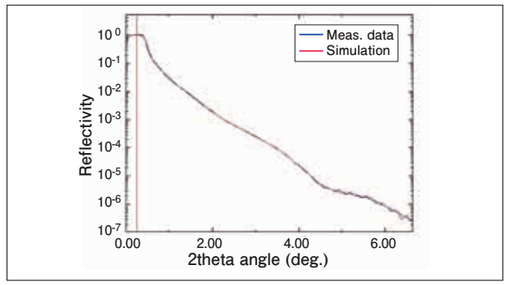
Applications

Thickness Measurement of Ultrathin Films Down to 1 nm

The XRR detector of the XTRAIA MF-2000 can measure even the direct beam from the X-ray source. It realizes low background that is essential to characterizing ultrathin films.

	Density (g/cm³)	Thickness (nm)	Roughness (nm)
HfSiO	8.80	1.40	0.36
SiO_2	3.09	2.51	0.60

Micro-XRR measurement example: 1.4 nm thick high-κ film (HfSiOx)

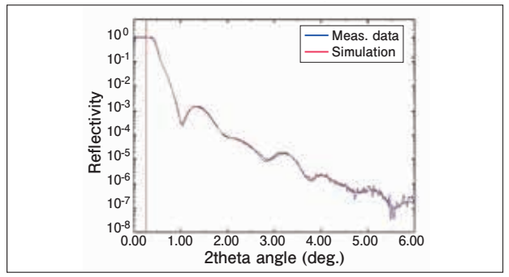


Multilayer Dielectric Film Measurement

The low background noise of the XTRAIA MF-2000 enables accurate measurement of spectra from under thin layers. It is a very powerful tool for multilayer measurement.

	Density (g/cm³)	Thickness (nm)	Roughness (nm)
SiO_2	2.29	5.47	0.44
Si_3N_4	3.02	4.09	0.65
SiO_2	2.23	4.10	0.50

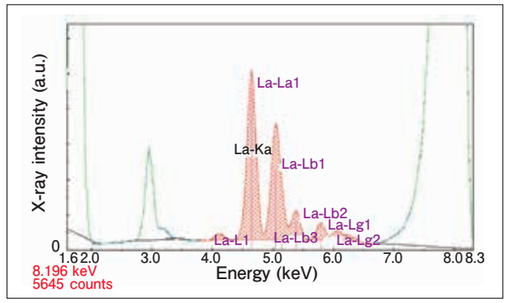
Micro-XRR measurement example: Multilayer dielectric film (ONO)



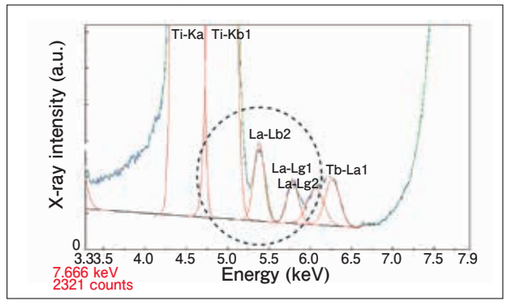
Ultrathin Lanthanum Film Measurement

Using a low incidence angle, monochromatic, micro-spot X-ray beam, fast XRF measurement of a monolayer film is enabled with low background. A multilayer of LaOx and TiN metal gate electrode films is also measured.

Very low incidence angle XRF measurement example: LaOx



Very low incidence angle XRF measurement example: LaOx/TiN

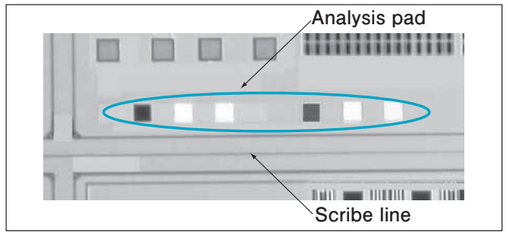


Equipped with the Latest Core Technology and Functions

Applicable to Microscopic Measurement Pads

Micro-XRF measurement enables evaluation of Cu thickness on small pads.

Example of a film thickness analysis pad on an LSI chip

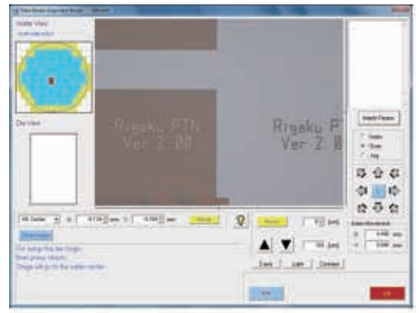


Ultrafast X-ray Detector D/teX-HS

High-precision, fast XRR measurements are realized thanks to an 8-order dynamic range.

Pattern Navigation

Product wafer measurement is possible with the high-performance pattern recognition function. It contributes to cost reduction by reducing monitor wafer requirements, and it contributes to higher yield.



User-friendly Interface

A new user interface enables faster setup of operational, engineering, and maintenance tasks.