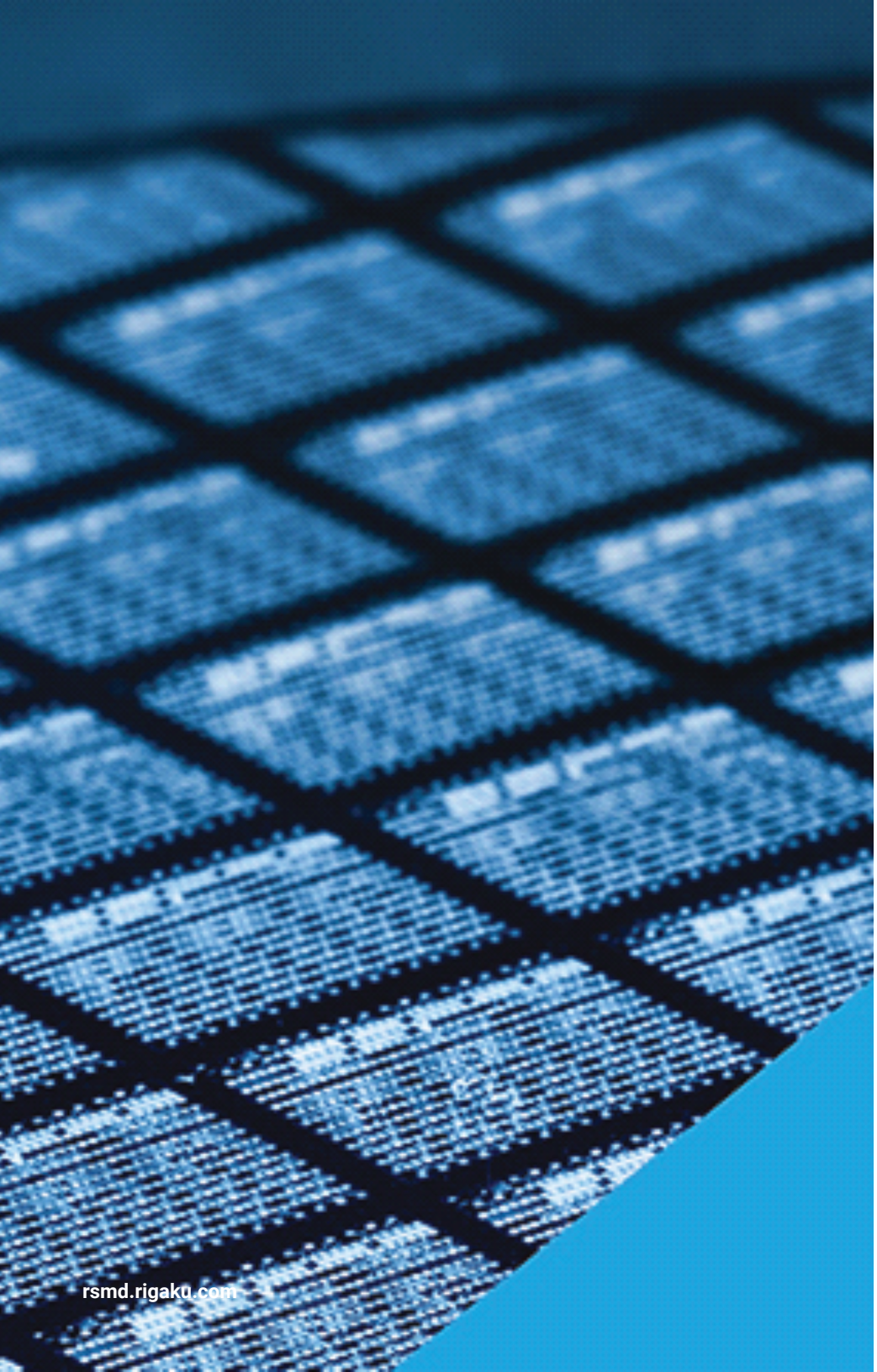
AZX 400

SEQUENTIAL WD-XRF SPECTROMETER

CUTTING-EDGE METROLOGY

IDEAL METROLOGY TOOL FOR MATERIALS FROM ISOLATION FILMS TO NEXT-GENERATION MEMORY HIGH-END XRF FOR B ANALYSIS AND SUB nm ULTRA-THIN FILMS



AZX 400 SEQUENTIAL WAVELENGTH DISPERSIVE X-RAY FLUORESCENCE

AZX 400 WD-XRF spectrometer was designed to handle very large and/or heavy samples. Accepting samples up to 400 mm in diameter, 50 mm thick, and 30 kg mass, this system is ideal for analyzing sputtering targets and magnetic disks, multilayer film metrology, or elemental analysis of large samples.

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- AZX 400 with Wafer Loader Addresses a Wide Range of Analysis Requirements, from R&D to Quality Control.
- AZX 400—Flagship model of wavelength-dispersive XRF spectrometer.
- Combined with the wafer loader, the AZX 400 enables efficient analysis.

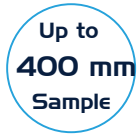
All-in-one unit performs analyses for various applications, including research, development, and quality control in response to accelerating development speeds and diverse analysis needs.

400 mm X-RAY METROLOGY SYSTEM

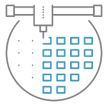
All-in-one unit performs analyses for various applications, including research, development, and quality control in response to accelerating development speeds and diverse analysis needs.

AZX 400
SYSTEM PARAMETERS

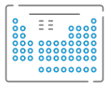
Technique	Sequential wavelength dispersive X-ray fluorescence
Benefit	Flexibility to measure a variety of sample types, including 50 - 300 mm wafers, coupons, and sputtering targets (up to 30 kg)
Technology	Analytical flexibility to measure elements from Be to U, well-suited for process R&D and low-volume, high product mix environment score
Core attributes	4 kW sealed X-ray tube, Sequential type goniometer, Primary beam filter; Measurement spot sizes 30, 20, 10, 1, and 0.5 mm (diameter)
Core options	Wafer Loader, SQX (Scan Quant. X) software, CCD Camera
Data processing system	External PC, MS Windows® OS Software: film thickness/concentration simultaneous analysis software, Fundamental Parameter software for thin film analyses
Core dimensions	1376 (W) x 1710 (H) x 890 (D) mm
Mass	Approx. 800 kg (core unit)



Large sample analysis, Up to 400 mm (diameter), Up to 50 mm (thickness), and Up to 30 kg (mass)



Analytical flexibility and Mapping capability



Analytical flexibility to measure elements from 5B-92U

SQX Scan Quant. X standardless analysis software

Wide range of elements and sample types and enhanced productivity wafer auto-loader

AZX 400
SYSTEM PARAMETERS

Power requirements	3Ø, 200 VAC 50/60 Hz, 50 A
X-ray tube	Rh target, maximum rating: 4 kW
X-ray high voltage generator	High-frequency inverter system; Maximum rating: 4 kW, 60 kV-150 mA; Stability: ± 0.005% (with 10% input variability)
Maximum sample size	400 (dia.) x 50 (H) mm (30 kg or less)
Analysis element applicable	4 Be to 92 U
Sample rotation	5 rpm
Primary beam filter	Standard: Al (2 types), Cu, Zr ; Optional: Ti, Sn
Diaphragm	Automatic seven positions exchanger ; 30, 20, 10, 1, and 0.5 mm (diameter); With attenuator (X-ray intensity: 1/10): 30, 20 mm (diameter)
Primary soller slit	Automatic three positions changer mechanism standard and high resolution, ultra-coarse (optional)
Secondary soller slit	For SC and F-PC
Goniometer	θ-2θ independent drive system
Measurement range	SC: 5°to 118°, F-PC: 13°to 148°
Max. scan speed	1400°/min (2theta)
Angle reproducibility	Within ± 0.0005
Continuous scan	0.1°to 240°/min
Crystal exchanger	Automatic 10-crystal exchanger

Analyzing crystal	Standard：LiF(200)、Ge、PET、RX25; Optional: LiF(220)、RX4、RX9、RX35、RX40、RX45、RX61、RX75
Detector	For heavy elements: SC; for light elements: F-PC; with an automatic center wire cleaning mechanism
Vacuum exhaust system	Vacuum pump, 1 set
Vacuum control	APC (Auto Pressure Control), with three levels
Temperature stabilizer	36.5 °C± 0.1 °C

XRF WITH CUSTOMIZED SAMPLE ADAPTER SYSTEM

Versatility to adapt to your specific sample types and analysis needs, this WD-XRF spectrometer is adaptable to various sample sizes and shapes using optional (made-to-order) adapter inserts. With a variable measurement spot (30 mm to 0.5 mm diameter, with 5-step automatic selection) and mapping capability with multi-point measurements to check for sample uniformity, this uniquely flexible instrument can dramatically streamline your quality control processes.

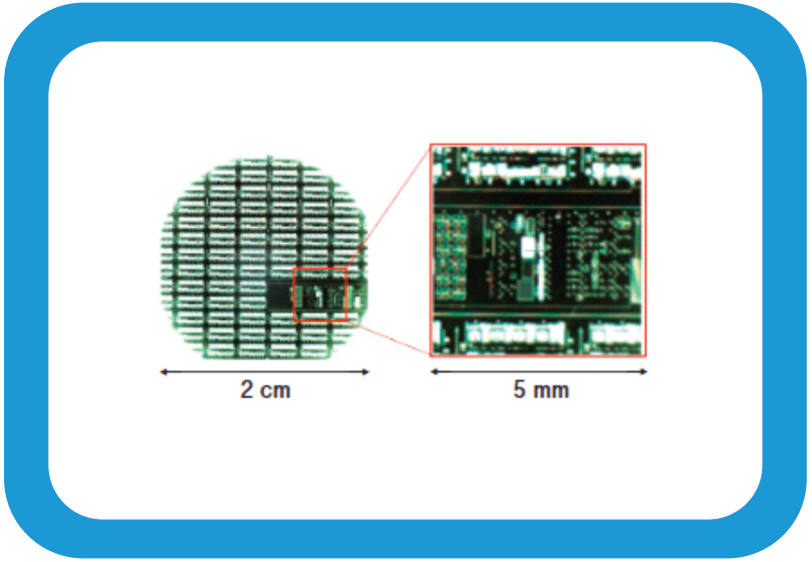
XRF WITH THE AVAILABLE CAMERA AND SPECIAL LIGHTING

The optional real-time camera allows the analysis area to be viewed within the software. The operator has complete certainty as to what is being measured.

CCD Camera: A sample camera with special lighting allows the analysis point to be viewed on the screen. The optional CCD camera allows pinpoint measurements of defects and/or patterns and enables analyses at 0.1 mm pitch.

TRADITIONAL WD-XRF ANALYTICAL CAPABILITIES

All analytical capabilities of a traditional instrument are retained in this "large sample" variant. Analyze beryllium (Be) through uranium (U) with high-resolution, high-precision WD-XRF spectroscopy, from solids to liquids and powders to thin films. Analyze wide composition ranges (ppm to tens of percent) and thicknesses (sub Å to mm). Optionally available is diffraction peak interference rejection for optimal results for single-crystal substrates. Rigaku AZX 400 wavelength dispersive X-ray fluorescence (WD-XRF) spectrometer complies with industry standards SEMI and CE.

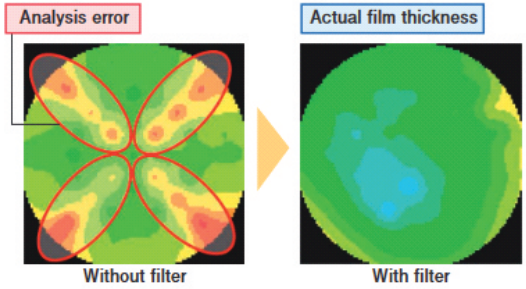


SAMPLE ADAPTERS

Various sample types can be analyzed simply by changing the adapter. The multi-adapter allows coupons or target materials (see the adapter at the top left or bottom left in the image).

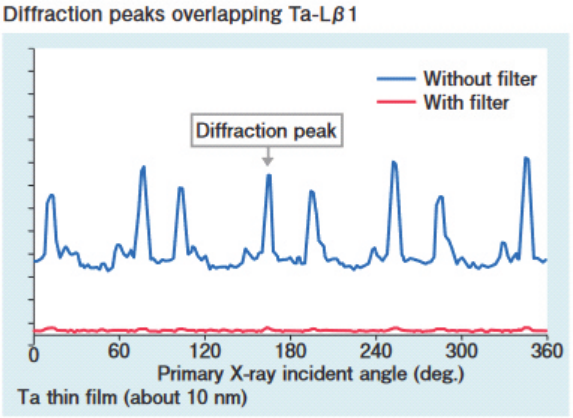
WAFER LOADER

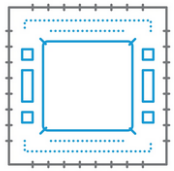
The 300 mm FOUP or open cassette down to 100 mm are available for the wafer loader. This system enables automatic analyses and reduces users' handling time dramatically.



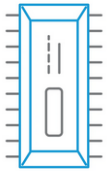
DIFFRACTION ELIMINATION

Diffraction interference rejection provides accurate results for single-crystal substrates. In analyses of single-crystal wafers, diffraction peaks often affect the target spectrum and cause errors.
AZX 400 eliminates undesirable diffraction peaks using filters for accurate results.
Six types of filters enable the analyses of all elements.

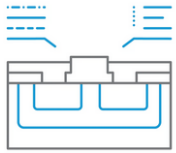




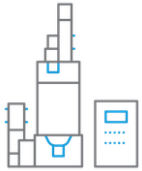
MEMORY



MEMS



POWER DEVICES



ADVANCED PACKAGING

INSULATION FLMMS

Sputtering target composition	
Isolation films	SiO2, BPSG, PSG, AsSG, Si_3N_4, SiOF, SiON,(...)
High-k and ferro-dielectric films	PZT, BST, SBT, Ta_2O_5, HfSiOx

METAL FILMS

Metal films	Al-Cu-Si, W, TiW, Co, TiN, TaN, Ta-Al, Ir, Pt, Ru, Au, Ni,(...)
Electrode films	doped poly-Si (dopant: B, N, O, P, As), amorphous-Si, WSix, Pt, (...)
Ferroelectric thin films	FRAM, MRAM, GMR, TMR; PCM, GST, GeTe

OTHER SEMICONDUCTOR MANUFACTURING APPLICATIONS

Solder bump composition	SnAg, SnAgCuNi
MEMS	thickness and composition of ZnO, AlN, PZT
SAW device process	thickness and composition of AlN, ZnO, ZnS, SiO2 (piezo film); Al, AlCu, AlSc, AlTi (electrode film)
Other doped films	(As, P), trapped inert gas (Ne, Ar, Kr, etc.), C (DLC)

Be - U

Rigaku systems can easily measure Ultra-Light elements such as B, C, N, O. Mg, and Al with high-resolution capability.

Measurable Element

Up to 20 stacked layers effectively analyzed.

The FP method can consider absorption by other layers and analyzes complex compounds or multi-layered samples.

Analyzable Structure

Sub-angstrom (Å) to micron level (µm)

High-power X-ray tubes (4 kW) to select multiple spectra for most elements, applying a wide range of thicknesses.

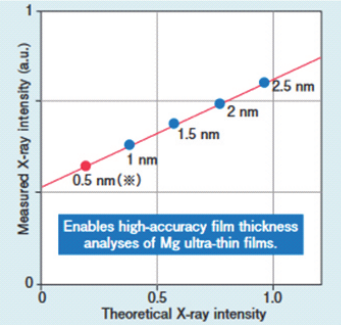
Analyzable Thickness

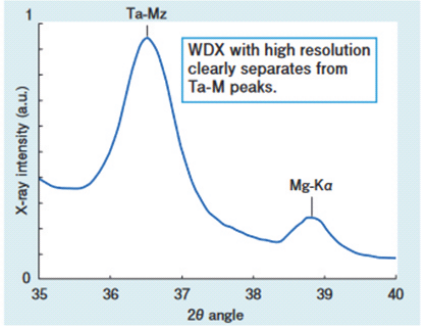
MgO ULTRA-THIN FILM ANALYSIS

MgO film thickness analysis can be performed accurately in units of 0.1 nm.
Since the L.L.D. will be smaller than 0.01 nm, it is possible to analyze ultra-thin films of less than 1 nm.
Theoretical analysis value of MgO ultra-thin film (0.5 nm)

Film Thickness (nm)	0.5
Range (nm)	0.014
Std. Dev. (nm)	0.007
R.S.D. (%)	1.43

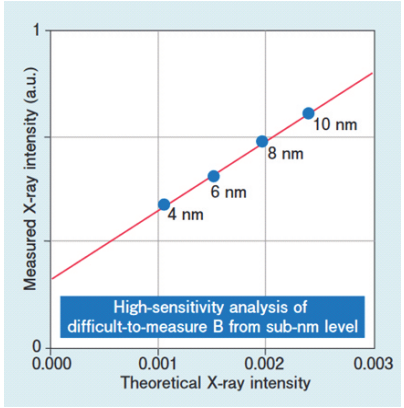
- High-sensitivity analysis enables accurate measurement of differences as small as 0.1 nm.
- Figures are calculated values. Based on theoretical X-ray Intensity. (Measurement time: 60 sec)
- Measurements for thicknesses ranging from 1 to 2.5 nm were obtained at Rigaku Lab.
- The value indicated for 0.5 nm is a simulated intensity.
- Ta is used for the cap layer and/or barrier layer.

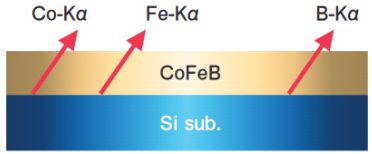




THICKNESS/COMPOSITION SIMULTANEOUS ANALYSIS OF CoFeB MAGNETIC LAYER

Widely used in magnetic thin films for universal memory devices and magnetic heads, B can be challenging to analyze. AZX 400 with Fundamental Parameters (FP) method allows it to analyze film thickness and material composition simultaneously.





Results of 10-times repeatability analysis of CoFeB layer

Measurement	Film Thickness	Material composition		
		Co	Fe	B
Target Value	5	30	50	20
Unit	nm	at%	at%	at%
Average	5.01	29.99	49.94	20.07
Range	0.07	0.49	0.65	0.31
Std. Dev.	0.020	0.14	0.18	0.09
R.S.D.(%)	0.41	0.47	0.37	0.45

MULTI-LAYER ANALYSIS OF STT-MRAM

AZX 400 can analyze up to 10 layers of different components. In the case of STT-MRAM, it analyzes not just a single MgO or CoFeB layer, but the thicknesses of all layers.

Results of 10-times repeatability analysis of STT-MRAM film stack

- Two or more layers of the same type are analyzed as one layer.
- Allows CoFeB film thickness analysis in the case of multi-layered film

Layer	Ru	CoFeB	MgO	PtMn	Ta	Cu
Target Thickness (nm)	8	5	1.5	12	20	40
Measurement time (sec)	20	10	60	30	10	10
Average (nm)	7.99	5.01	1.51	12.00	20.05	39.98
Range (nm)	0.09	0.06	0.02	0.15	0.25	0.33
Std.Dev. (nm)	0.030	0.025	0.008	0.057	0.098	0.11
R.S.D. (%)	0.37	0.49	0.54	0.48	0.49	0.28

EXAMPLE OF STT-MRAM LAYER STRUCTURE

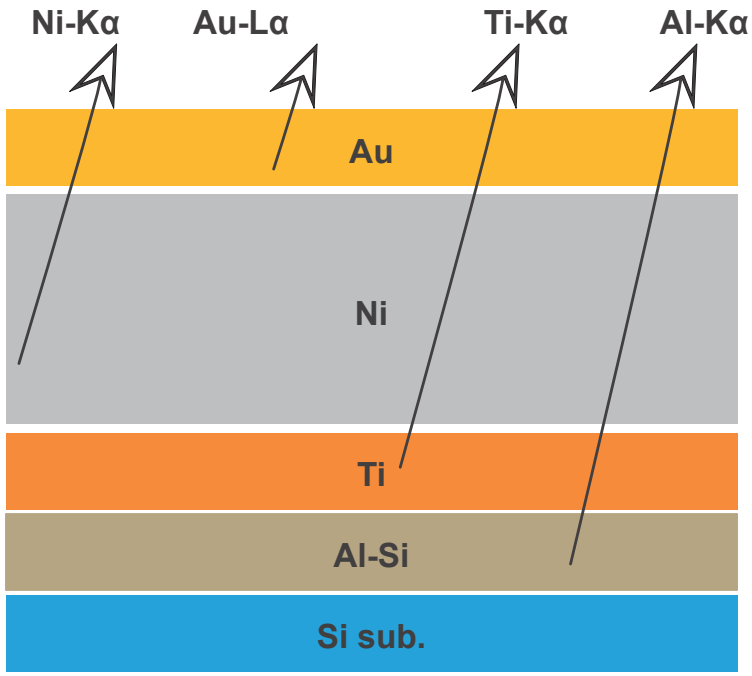
Au/Ni/Ti/Al-Si BACKSIDE ELECTRODE ANALYSIS

Since the FP method enables analyses using one calibration curve for each element, analyses can be performed even with a small number of standard samples. (When the Au or Ni film is thick, measurements of Al may not be possible due to X-ray absorption. In those cases, analyses require two separate processes: one for AuNiTi and the other for Al.)

Results of 10-times repeatability analysis of Au/Ni/Ti/Al-Si

- Si concentration is set as a fixed value.
- Measurement with 30 mm diameter

Layer	Au	Ni	Ti	Al-Si
Target Thickness (nm)	50	700	200	200
Average (nm)	50.06	700.24	198.61	199.90
Range (nm)	0.35	1.92	1.80	3.41
Std.Dev. (nm)	0.12	0.55	0.59	0.95
R.S.D. (%)	0.25	0.08	0.30	0.47



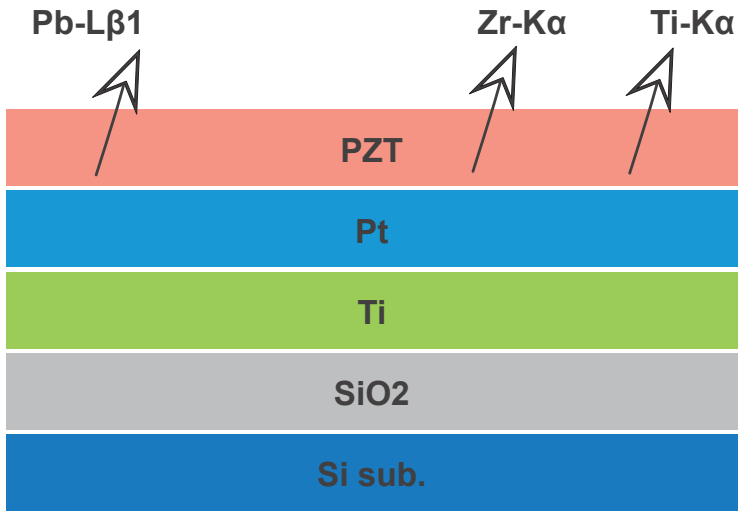
THICKNESS/COMPOSITION SIMULTANEOUS ANALYSIS OF PZT (PbZrTi)

AZX 400 can perform simultaneous analysis of the film thickness and material composition of PZT, an important material for MEMS and memory devices. In the case of Ir or Pt film stacks, spectra overlap in a complex manner. Under these circumstances, high-resolution WDX permits effective analyses.

Results of 10-times repeatability analysis of PZT film

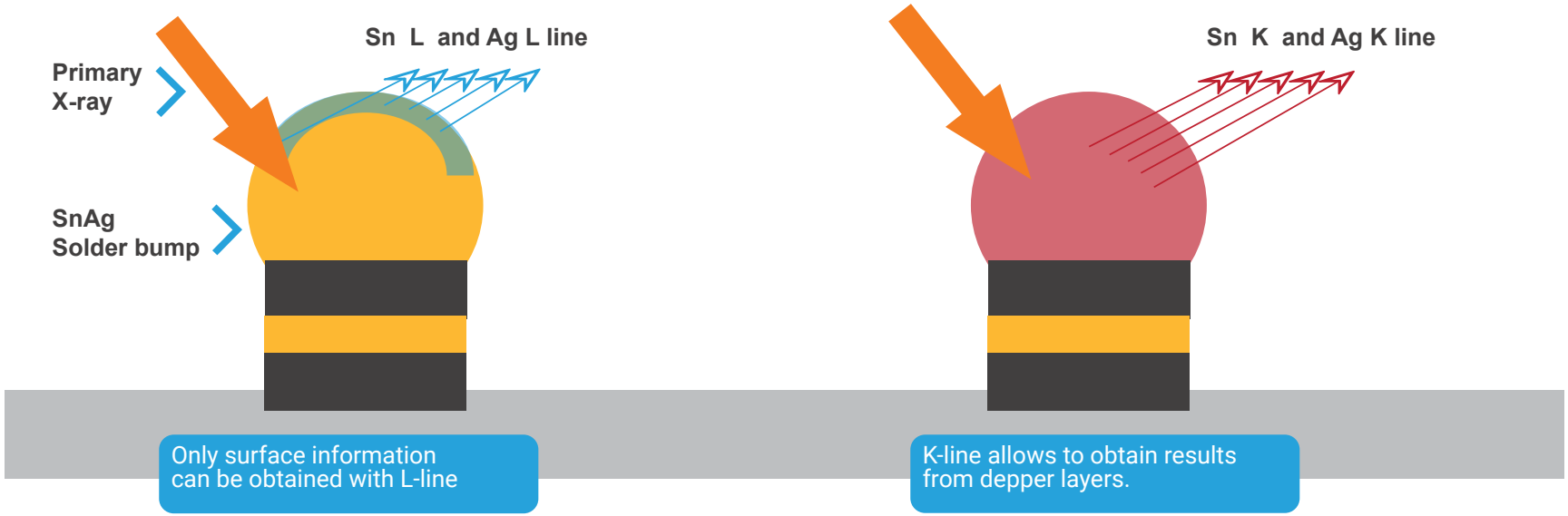
- Measurement 10 mm diameter
- Material compositions are converted to oxidative values.

Measurement	Film	Material composition		
	Thickness	PbO	ZrO2	TiO2
Target Value	3,000	50	25	25
Unit	nm	at%	at%	at%
Average	3,001.9	50.0	25.0	25.0
Range	20.1	0.2	0.2	0.2
Std. Dev.	6.59	0.067	0.066	0.061
R.S.D.(%)	0.22	0.13	0.26	0.24



ANALYSIS OF Ag CONCENTRATION IN SOLDER BUMPS

A solder bump ranges from 10 µm to 100 µm in size. Ag-Kα and Sn-Kα should be used to obtain information from a deeper part. If a standard sample is unavailable, the FP method enables using Ag and Sn pure metals as standard samples.



	Concentration (mass%)	
Element	Sn	Ag
Average	98.34	1.66
Range	0.02	0.02
Std. Dev.	0.0070	0.0070
R.S.D. (%)	0.01	0.42

SOFTWARE QUANTITATIVE APPLICATION SETTING FLOW FOR THIN FILM

The software supports easy calibration curve setup, even for first-time users.

STANDARDLESS ANALYSIS USING SENSITIVITY LIBRARY

If standard samples are hardly available, standard analysis can be performed using the optional SQX software. This function is available for thickness analyses for thin films and material composition analyses for bulk samples.

AZX 400 STANDARDLESS ANALYSIS ACCURACY.

Analysis element	Standarless analysis value	The standard value of thin film standard sample
Cu	52.90	54.36
Ni	47.73	49.55
Pt	20.75	21.31
Au	23.80	23.99

The error rate is about 5% for single-layer analyses of the thickness. It is efficient to analyze the estimated value, especially when a standard sample is unavailable. If necessary, the correction function can be used to manage. Analysis values.

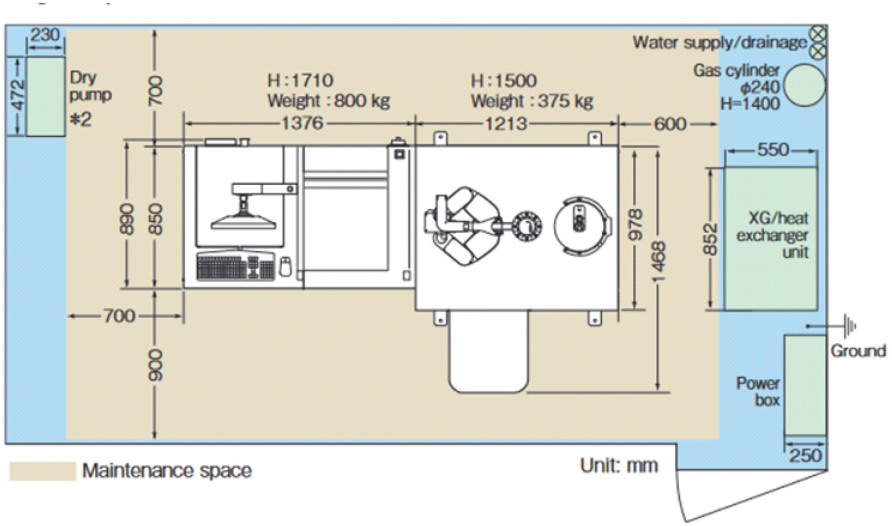
- 1 Analysis element in single-layer film on polymer
- 2 Thin film standard samples for XRF available from

MICROMATTER

The amount of adhering material is converted into a film thickness value using the density values stored in AZ X Software. Errors in standard values are within ± 5%

SQX ANALYSIS OF STAINLESS STEEL (JSS651-11)

Component	Quantitative value	Standard Value
Si	0.42	0.42
P	0.031	0.035
Cr	19.11	18.47
Mn	1.91	1.70
Co	0.18	0.17
NI	10.45	10.11
Cu	0.40	0.39
Mo	0.18	0.16



INSTALLATION REQUIREMENTS

The customer is responsible for connecting utilities to the equipment.

Power Supply	3-phase 200 VAC, 50A
Ground	Independent grounding with resistance 30 Ω or less
Cooling water	**Temperature:** 5 to 30°C **Pressure:** 0.29 to 0.49 MPa **Flow rate:**10 L/min **Quality:** Equivalent to tap water quality **Drain:** Open drainage **Connector (IN/OUT):** Joint for 26 (dia.) x 19 (dia.) blade hose **Compression fitting** (Abe Machinery B121926)
High Purity	Nitrogen (UPN) **Temperature:** 30°C or lower **Pressure:** 0.52 to 0.7 MPa **Flow rate:** 200 L/min **Connector (IN/OUT):** 1/4" Swagelok joint
Adsorption	Pressure: − 80 kPa Flow rate: 60 L/min
Vacuum	Connector (IN/OUT): 1/4" Swagelok joint
Room Temp.	15 to 28°C, fluctuation range: within ± 2°C
Humidity	75%RH or lower
Vacuum	Lower than human sensitive level
P-10 Gas	A mixed gas of 90% argon and 10% methane **Pressure:** 0.15 MPa

REQUIRED AREA

- If process modules are installed in a clean room, utility equipment should be in a separate maintenance area.
- Standard models manufactured by Rigaku Corporation

Compound Semiconductor Metrology Solutions

The World of Semiconductor

Metrology tools from lab to fab

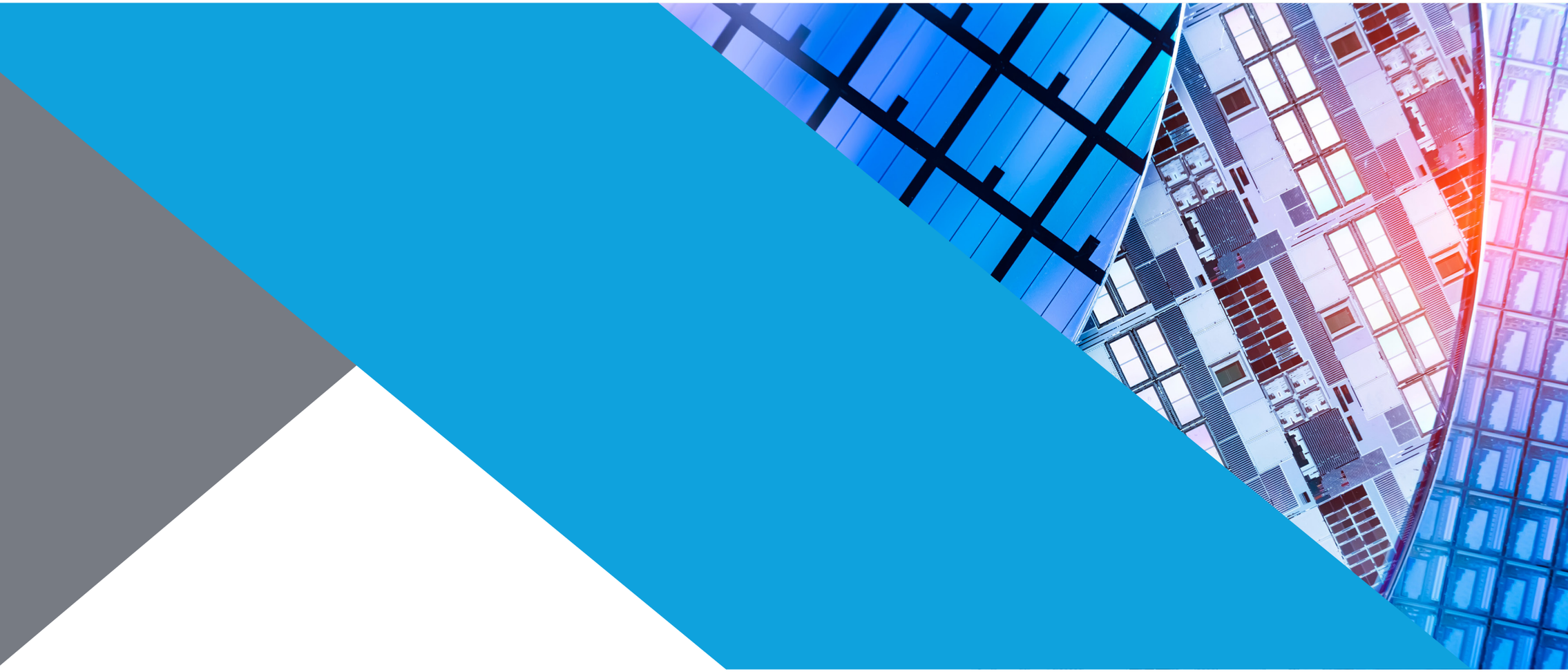
Rigaku Technology Center Silicon Valley
530 Mercury Drive
Sunnyvale, CA 94085, USA
rtc.sv@rigaku.com
+1-281-362-2300

XwinSys, a Rigaku Company
Ramat Gabriel Industrial Zone,
6 HaMehkar St., P.O. Box 371,
Migdal HaEmek, 2306990, Israel
info@xwinsys.com
+972-4-9951051

Rigaku Corporation
3-9-12, Matsubara-cho
Akishima-shi, Tokyo
196-8666, Japan
info-gsm@rigaku.co.jp
+81 3-3479-0618

Rigaku Americas
9009 New Trails Drive
The Woodlands, TX
77381-5209, USA
info@rigaku.com
+1-281-362-2300

Rigaku Europe SE
Hugenottenallee 167
63263 Neu-Isenburg,
Germany
semieurope@rigaku.com
+49 6102 77999 51



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