

X-ray Fluorescence Spectrometer for Thin Film Evaluation

# AZX400



# Flexible, Precision Hardware Features

## Features of WDX System

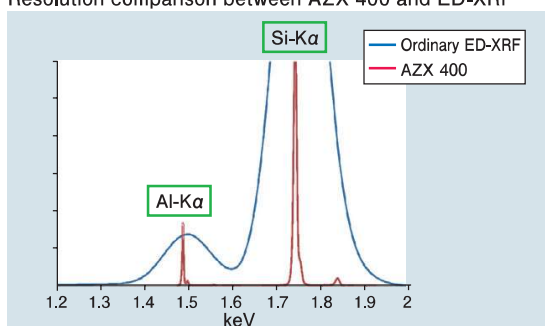
Feature comparison between AZX 400 and ED-XRF

	AZX 400 (WD-XRF)	Ordinary ED-XRF
Analysis target	Be to U	Mg to U
Resolution (FWHM)*	26 eV	>150 eV
Analyzable thickness	0.01 nm or greater	Several-10 nm and more

\* In the case of Mn-K $\alpha$

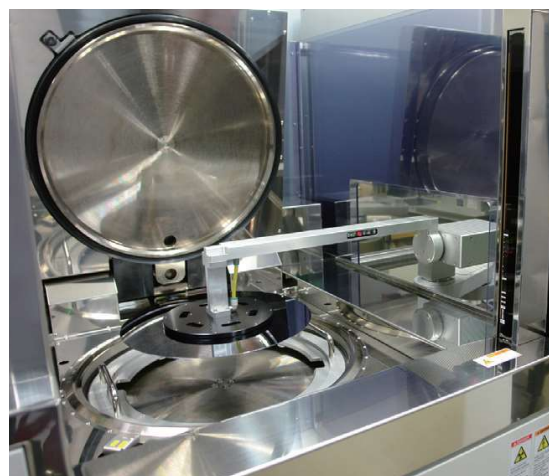
WDX with high resolution is suitable for Al ultra-thin films by separating the Al and Si peaks.

Resolution comparison between AZX 400 and ED-XRF



## Wafer Loader

A 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.



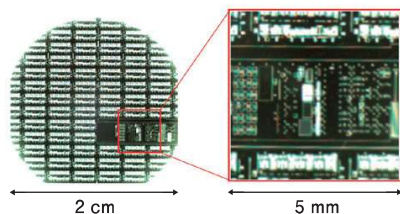
## Various Sample Adapters

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



## CCD Camera

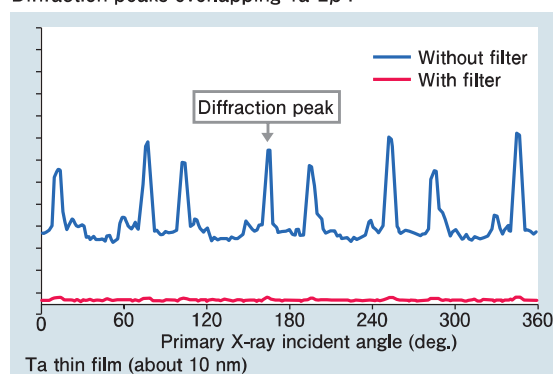
The optional CCD camera allows pinpoint measurements of defects and/or patterns and enables analyses at 0.1 mm pitch.



## Diffraction Elimination

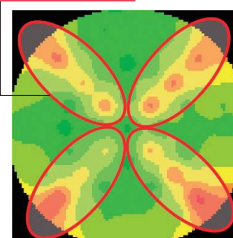
In analyses of single-crystal wafers, diffraction peaks often affect the target spectrum and cause errors. AZX 400 eliminates undesirable diffraction peaks using filters for accurate results. Six types of filters enable the analyses of all elements.

Diffraction peaks overlapping Ta-L $\beta$ 1

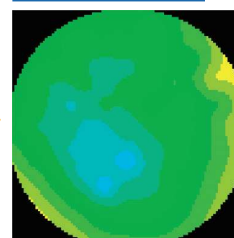


Analysis error

Actual film thickness



Without filter



With filter

# Useful Software Features

## Quantitative Application Setting Flow for Thin Film

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

AZX 400 software setting screen

## Standardless Analysis Using Sensitivity Library

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

AZX 400 standardless analysis accuracy

Analysis element *1	AZX 400 standardless analysis value (nm)	Standard value of thin film standard sample *2 (nm)
Cu	52.90	54.36
Ni	47.73	49.55
Pt	20.75	21.31
Au	23.80	23.99

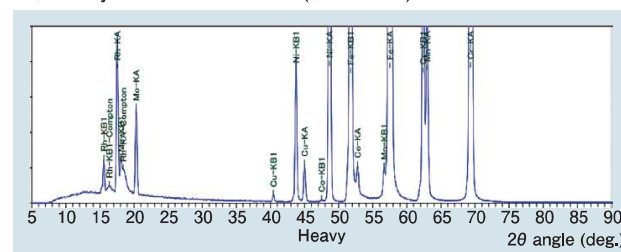
The error rate is about 5% for single-layer analyses of the thickness. It is efficient to analyze estimated value especially when a standard sample is not available. If necessary, the correction function can be used to manage analysis values.

\* 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 AZX software. Errors in standard values are within  $\pm 5\%$ .

SQX analysis of stainless steel (JSS651-11)



Unit: mass%					
Component	Quantitative value	Standard value	Component	Quantitative value	Standard value
Si	0.42	0.42	Co	0.18	0.17
P	0.031	0.035	Ni	10.45	10.11
Cr	19.11	18.47	Cu	0.40	0.39
Mn	1.91	1.70	Mo	0.18	0.16

# A Flexible Technique for a Wide Variety of Applic

## MgO Ultra-thin Film Analysis

MgO film thickness analysis can be performed accurately in units of 0.1 nm.

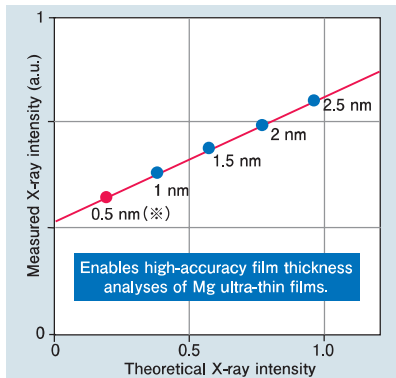
Since the L.L.D. will be smaller than 0.01 nm, it is possible to analyze ultra-thin films of less than 1 nm.

Theoretical analysis value of MgO ultra-thin film (0.5 nm)

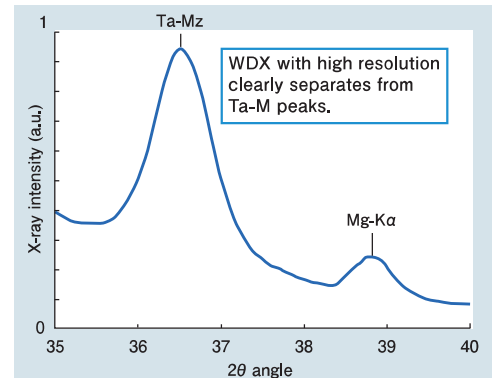
Film thickness (nm)	0.5
Range (nm)	0.014
Std. Dev. (nm)	0.007
R.S.D. (%)	1.43

\* Figures are calculated values based on theoretical X-ray intensity. (Measurement time: 60 sec)

High-sensitivity analysis enables accurate measurement of differences as small as 0.1 nm.



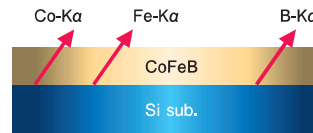
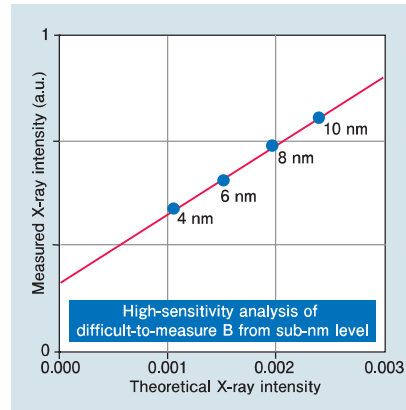
\* Measurements for thicknesses ranging from 1 to 2.5 nm were obtained at Rigaku Lab. The value indicated for 0.5 nm is a simulated intensity.



\* Ta is used for 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 difficult to analyze. AZX 400 with Fundamental Parameters (FP) method makes it possible to simultaneously analyze both film thickness and material composition.



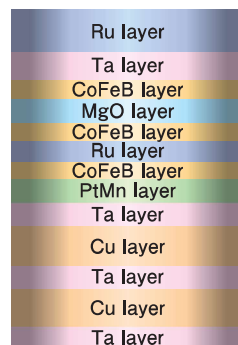
Results of 10-times repeatability analysis of CoFeB layer

	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

## Multilayer 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, as shown below.

Example of STT-MRAM layer structure



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

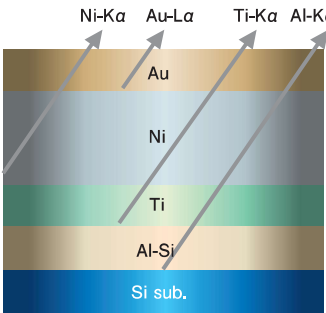
Layer	Ru	CoFeB	MgO	PtMn	Ta	Cu
Target thickness (nm)	8	5	1.5	12	20	40
Measurement time (sec)	20	10	60	30	10	10
Average (nm)	7.99	5.01	1.51	12.00	20.05	39.98
Range (nm)	0.09	0.06	0.02	0.15	0.25	0.33
Std. Dev. (nm)	0.030	0.025	0.008	0.057	0.098	0.11
R.S.D.(%)	0.37	0.49	0.54	0.48	0.49	0.28

\* 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.

### 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 requires two separated processes: one for AuNiTi and the other for Al.)



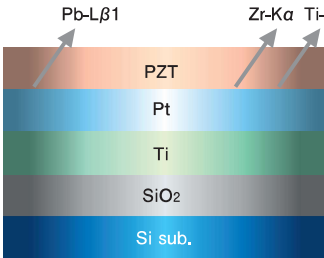
Results of 10-times repeatability analysis of Au/Ni/Ti/Al-Si

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

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

### Thickness/Composition Simultaneous Analysis of PZT (PbZrTi) Film

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 film stacks of Ir or Pt, spectra overlap in a complex manner. Under these circumstances, high-resolution WDX permits effective analyses.



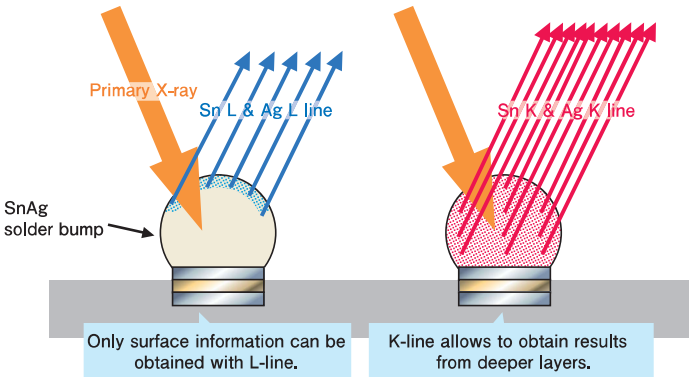
Results of 10-times repeatability analysis of PZT film

	Film thickness	Material composition		
		PbO	ZrO <sub>2</sub>	TiO <sub>2</sub>
Target value	3,000	50	25	25
Unit	nm	at%	at%	at%
Average	3001.9	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

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

### 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 not available, the FP method enables use of Ag and Sn pure metals as standard samples.



Results of 10-times repeatability analysis of solder bump metal

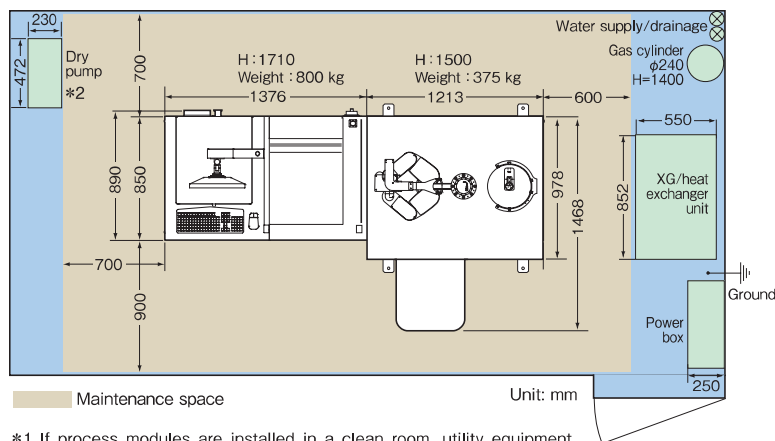
Element	Concentration	
	Sn	Ag
Unit	mass%	mass%
Average	98.34	1.66
Range	0.02	0.02
Std. Dev.	0.0070	0.0070
R.S.D.(%)	0.01	0.42

\* Measurement with 30 mm diameter

## Specifications

X-ray tube	Rh target, maximum rating: 4 kW	Measurement range	SC: 5° to 118°, F-PC: 13° to 148°
X-ray high voltage generator	High-frequency inverter system Maximum rating: 4 kW, 60 kV-150 mA Stability: $\pm 0.005\%$ (with 10% input variability)	Max. scan speed	1400°/min (2theta)
Maximum sample size	400 (dia.) x 50 (H) mm (30 kg or less)	Angle reproducibility	Within $\pm 0.0005^\circ$
Analysis element applicable	4Be to $^{92}\text{U}$	Continuous scan	0.1° to 240°/min
Sample rotation	5 rpm	Crystal exchanger	Automatic 10-crystal exchanger
Primary beam filter	Standard: Al (2 types), Cu, Zr Optional: Ti, Sn	Analyzing crystal	Standard : LiF(200), Ge, PET, RX25 Optional : LiF(220), RX4, RX9, RX35, RX40, RX45, RX61, RX75
Diaphragm	Automatic 7 positions exchanger 30, 20, 10, 1, and 0.5 mm (diameter) With attenuator (X-ray intensity: 1/10): 30, 20 mm (diameter)	Detector	For heavy elements: SC; for light elements: F-PC; with automatic center wire cleaning mechanism
Primary soller slit	Automatic 3 positions changer mechanism standard and high resolution, ultra coarse (optional)	Vacuum exhaust system	Vacuum pump, 1 set
Secondary soller slit	For SC and F-PC	Vacuum control	APC (Auto Pressure Control), with 3 levels
Goniometer	$\theta - 2\theta$ independent drive system	Temperature stabilizer	36.5 °C $\pm$ 0.1 °C
		Data processing system	Windows PC, printer Software: film thickness/concentration simultaneous analysis software, Fundamental Parameter software for thin film analyses

## Layout plan and dimensions \*1



\*1 If process modules are installed in a clean room, utility equipment should be in a separated maintenance area.

\*2 Standard model manufactured by Rigaku Corporation

## Installation requirements \*

Power supply	3-phase 200 VAC, 50A
Ground	Independent grounding with resistance 30 $\Omega$ 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 vacuum	Pressure: $-80$ kPa    Flow rate: 60 L/min Connector (IN/OUT): 1/4" Swagelok joint
Room temperature	15 to 28°C, fluctuation range: within $\pm 2^\circ\text{C}$
Humidity	75%RH or lower
Vibration	Lower than human sensitive level
P-10 gas	Mixed gas of 90% argon and 10% methane Pressure: 0.15 MPa

\*The customer is responsible for connecting utilities to the equipment.

Compliance with safety standards



SEMI S2/S8

Compliance with communication standards

GEM300

SECS/GEM

ISO 9001/ISO 14001 certified

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