Application Note RSMD008

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Semiconductor Metrology Application: Metrology for MRAM Layer Thickness, Density & Roughness

XTRAIA MF-3000 EDXRF can measure metal layers, except for the MgO layer. The measurement time is faster than WDXRF and suitable for wafer mapping.

A small X-ray beam spot and small edge exclusion make the XTRAIA MF-3000 suitable for deposition process control.

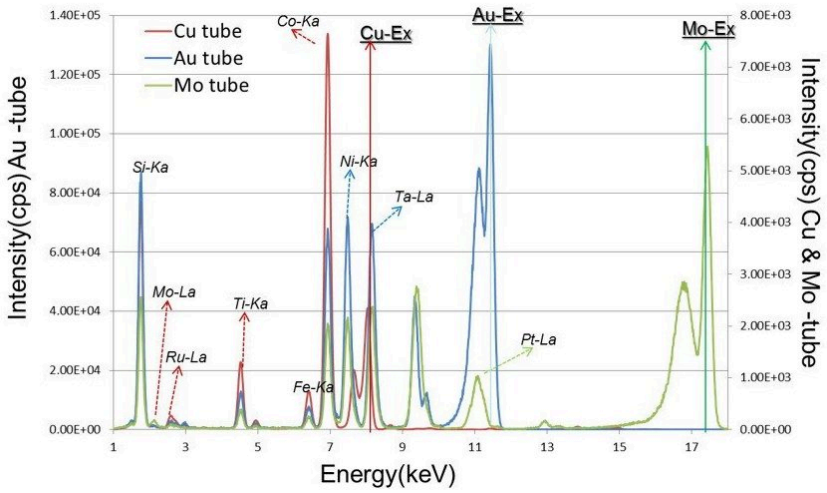


Figure 1: MRAM process layer EDXRF spectrum and X-ray excitation. Measurement target layer: CoFeB, Cu, Ta, Ti, Pt, Co, W, NiFe, Mo, IrMn, etc.

Measuring performance

Layer	**Ru / CoFeB**	**Ta**	**Pt**
X-ray	Cu-tube	Au-tube	Mo-tube
Incident angle	5° /20°	20°	5°
Measuring time	10 sec	30 sec	10 sec

	Thickness			
Layer	**Ru**	**Pt**	**T**	***CoFeB**
Unit	Angstrom			
Average	199.42	207.10	208.58	202.14

Maximum	200.60	208.03	209.09	203.09
Minimum	198.85	206.38	207.36	200.72
Range	1.75	1.65	1.73	2.37
Std. Dev.	0.57	0.55	0.68	0.65
R.S.D. (%)	0.28	0.27	0.33	0.32

*CoFeB: Fixed composition

MRAM QC structure

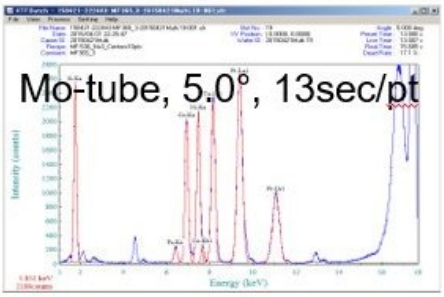
- Measurement with multiple X-ray tubes
- XRF measurement can determine PtMn and CoFeB layer when each composition is fixed

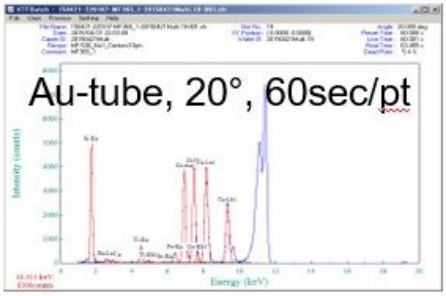
MRAM metal layer measurement for QC

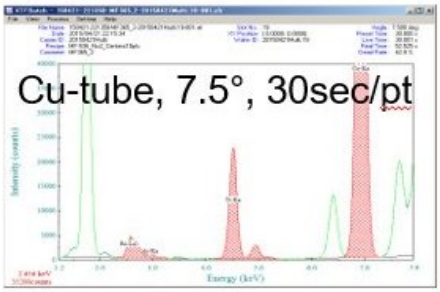
Layer#	Layer	Elements
L6	Pt	Pt
L5	Ru	Ru
L4	Ti	Ti
Le	NiFe	Ni
L2	CoFeB	Co
L1	Ta	Ta
Si-Sub		

Quality check measuring (Multilayer)

Layer#	Layer	Elements	Tube
L6	Pt	Pt	Mo
L5	Ru	Ru	Cu
L4	Ti	Ti	Cu
Le	NiFe	Ni	Au
L2	CoFeB	Co	Cu
L1	Ta	Ta	Au
Si-Sub			

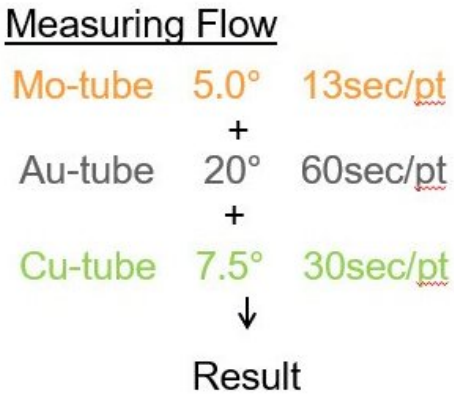




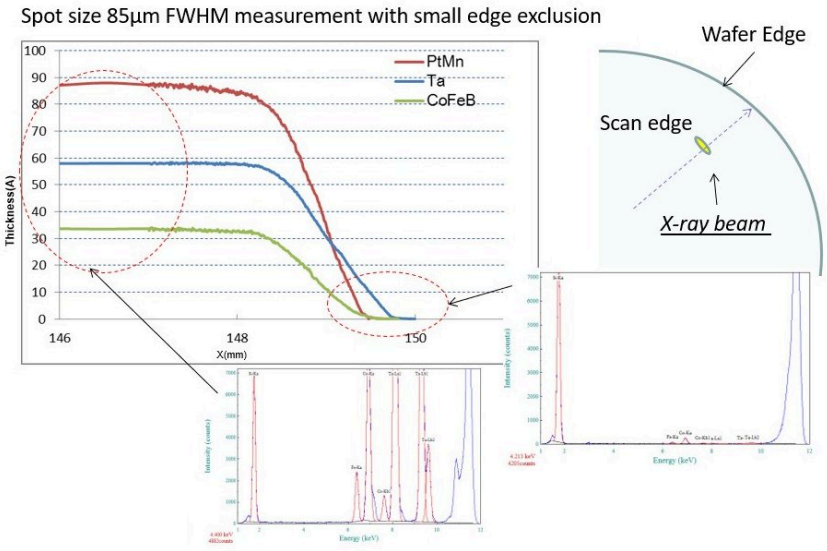


Layer	Pt	Ru	Ti	NiFe	CoFeB	Ta
Element	**Pt**	**Ru**	**Ti**	**Ni**	**Co**	**Ta**
Unit	(Å)					
1	202.99	201.13	200.29	200.29	199.80	200.00
2	200.80	200.90	199.52	201.46	199.82	200.53
3	200.00	202.21	200.35	197.37	200.00	199.07
4	199.27	203.73	200.25	200.58	199.90	200.40
5	200.31	200.21	200.16	200.28	200.19	200.30
6	199.93	201.24	200.28	199.27	199.81	200.27
7	201.73	202.43	199.89	197.23	200.05	200.67
8	199.67	200.85	201.05	202.77	199.97	198.80
9	200.86	200.96	200.81	201.46	199.93	199.73
10	202.06	201.75	200.28	199.12	199.76	200.13
Average	200.76	201.54	200.29	199.98	199.93	199.99

Std. Dev.	1.18	1.02	0.43	1.78	0.13	0.62
R.S.D. (%)	0.59	0.51	0.21	0.89	0.06	0.31

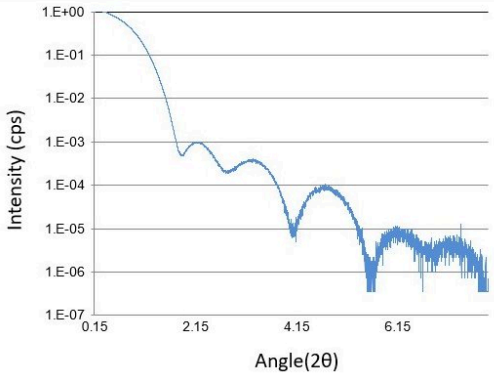


Measurement with small edge exclusion



XRR analysis of CoFeB layer

- No reference sample required
- Thickness, density and roughness analysis from the XRR fringes



Layer	CoFeB
Thickness （Å）	68.5
Density (g/cm^3)	5.768
Roughness （Å）	0.9

Related products

XTRAIA MF-3000

XRR, EDXRF, and XRD metrology tool for composition and t hickness (EDXRF), thickness, density, and roughness (XRR) for unpatterned and patterned films for up to 300 mm wafer s