Off-Line Type Thickness Measurement System

Introduction to ST Series

ST Series

K-MAC
Korea Materials & Analysis Corp.

Marketing Division

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K-MAC is

We will be your best partner providing total solutions with nano-measurement and analysis Technology.

Analysis & Measurement System based on Optical Technology

Basic Application Market	*NT+BT+IT Convergence Area*
Semiconductor / FPD	U - Healthcare
Nano / IT Materials	U – Monitoring Device (Safety, Pollution, Food)
Biotechnology	Mini Detector for Consumers
Education / Scientific Instrument	

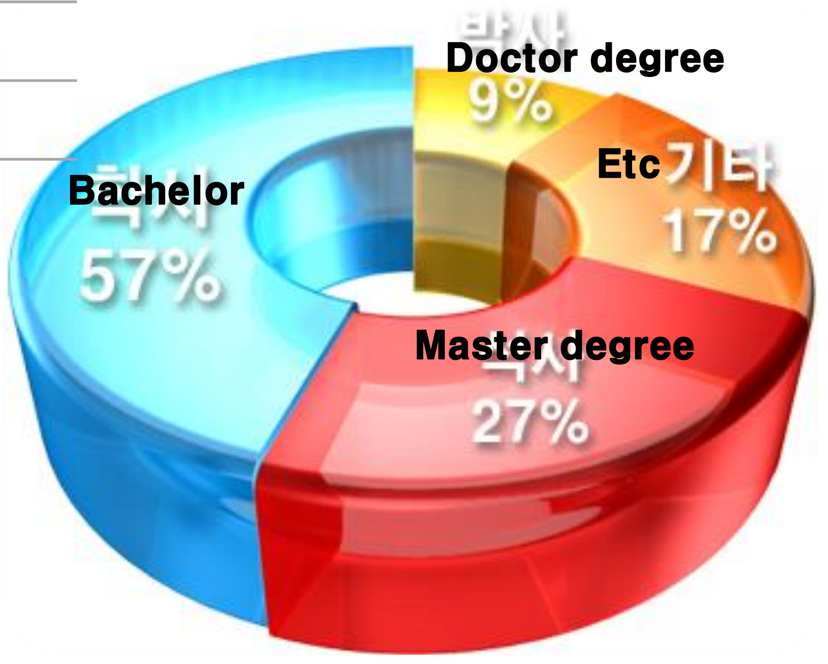
K-MAC comparative power : more 10 year experience of Thickness Measurement

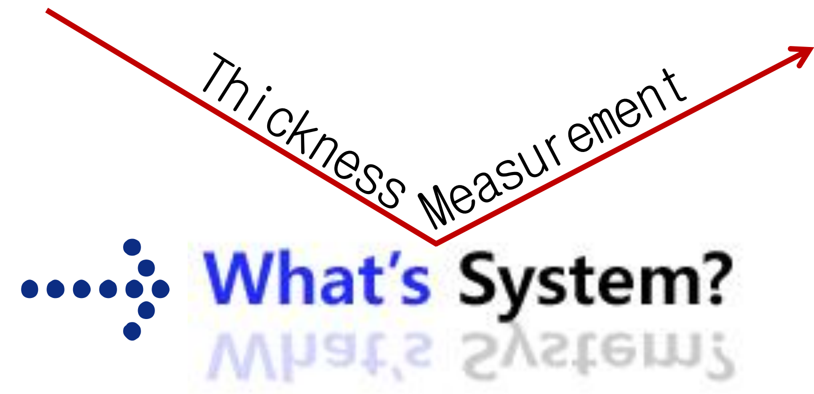
K-MAC is

Employee	285 staffs (KOR)

2017. 현재

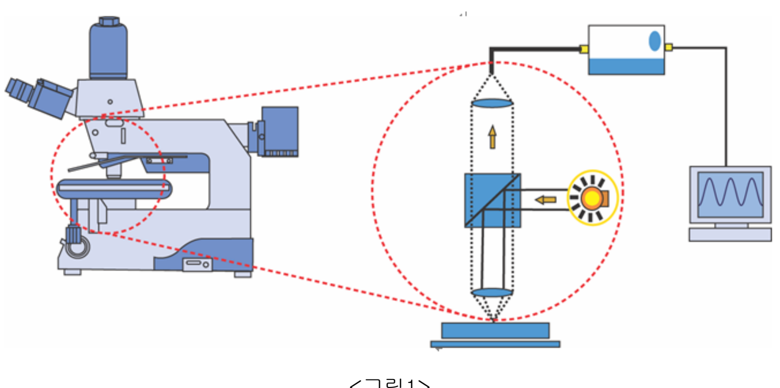
Production Eng. Center	177
R&D Center	84
K-MAC(Kunshan) R&D Corp.	25
Taiwan Branch	9



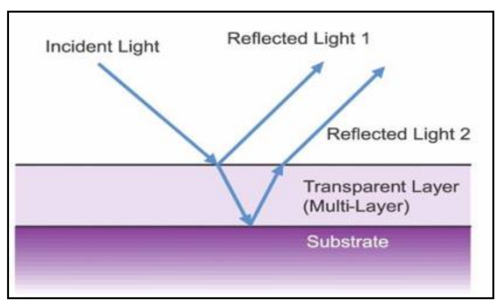

Thickness Measurement
What's System?

Principle of Thickness Measurement System

■Optical Reflectance (SR) Principle



<그림1>



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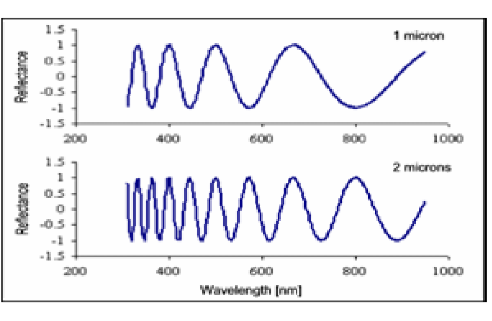


<그림3>

❖ **반사에 의한 비접촉식 두께측정원리:**

박막에 입사된 빛은 일부는 박막 표면에서 반사(1)되고, 일부는 박막으로 투과한 후 박막과 기판 경계면에서 반사(2)되어 두 반사광이 서로 간섭현상을 보여<그림2>, 파장에 따라 보강 및 상쇄간섭을 하게 된다<그림3>.

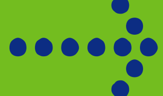
간섭하여 얻어진 반사도는 박막과 기판의 굴절률과 박막의 두께에 따른 함수(R{n,k,T})로 표현되며 수학적 모델을 이용하여 박막의 굴절률과 두께를 계산할 수 있다.

$$R = \frac{r12 + r23\exp(-j2\beta)}{1 + r12r23\exp(-j2\beta)}$$

where, $\beta = 2\pi(d/\lambda)\tilde{N}2$

$$r12 = (\tilde{N}2 - \tilde{N}1)/(\tilde{N}2 + \tilde{N}1)$$

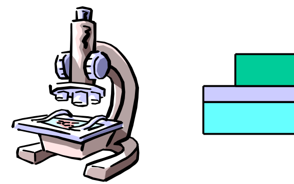
$$r23 = (\tilde{N}3 - \tilde{N}2)/(\tilde{N}3 + \tilde{N}2)$$



Comparison with other methods

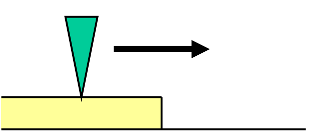
Comparison with other company

• Microscopy



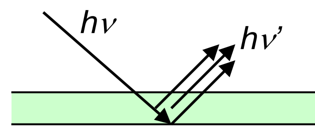
- Optical microscope, SEM, TEM
- Cross sectional image of sample with high magnification
- Destructive, special sample preparation, micro structure
- Any kinds of films, multi structure

• Surface Profiler

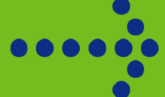


- Use a sharp tip
- Mechanical step difference according to surface profile
- Contact, Destructive, Sample preparation
- Any kinds of films

•X-ray Fluorescence



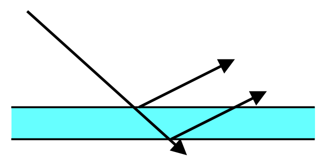
- Use an X-ray
- Characterized X-ray Fluorescence intensity of film composition
- Non contact, Non destructive
- Metal films



Comparison with other methods

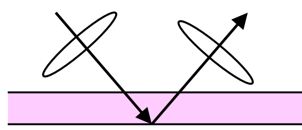
Comparison with other company

• Optical Reflectance



- Use Visible, Ultra Violet, Infrared lights
- Interference of lights reflected from surface and film interfaces
- Non contact, Non destructive, Able to focus on small spot
- Dielectrics, Transparent films

• Ellipsometer



- Use a polarized light
- Optical polarity rotation during transition into the film matrix
- Non contact, Non destructive
- Dielectrics, Transparent films

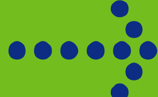
• Other Methods

- Phonon emission from crystal lattice: Metal films
- RS(Sheet Resistance) Measurement: Metal films
- C-V Plotter: Dielectric films
- FTIR: Epitaxial layer
- Photo acoustic Metrology: Metal and Transparent films

Comparison with other methods

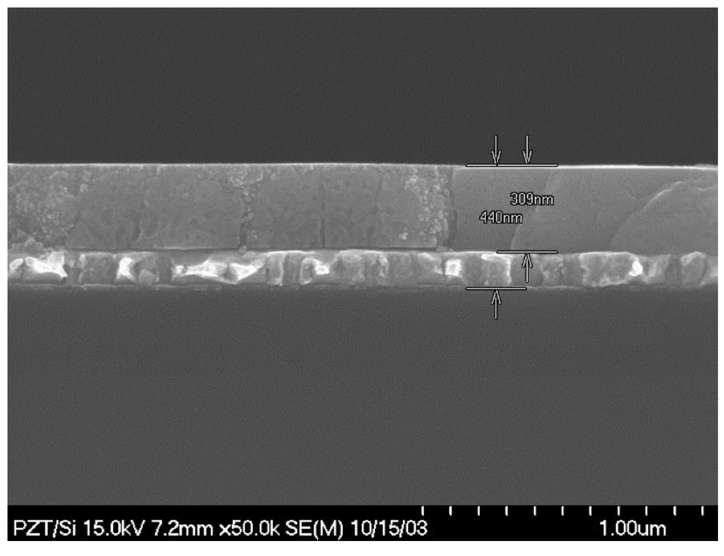
Comparison with other company

Property \ Method		Optical Reflectance (SR)	Ellipsometer (SE)	Surface Profiler
Non-Destructive		Yes	Yes	No
Micro Area		Yes	No	No
Pattern Wafer		Possible(4mm)	Impossible	Impossible
Thickness Range	Thick(㎛)	Possible	Periodic Ambiguity	Possible
	Thin(Å)	Possible	Possible	Possible
Measuring Speed		> 1 sec	> ~ min	> ~ min
Throughput		High	Low	Very low
Metal Film		No	No	Yes
N, K Measurement		Yes	Yes	No
Sample Preparation		Easy	Easy	Difficult
Convenience		Good	Bad	Bad
Price		Medium	High	Medium



Comparison with other methods

SEM vs K-MAC



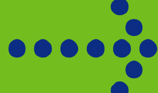
Fitted
Measured
% Reflectance
Wavelength [nm]

SEM image

PZT : 309nm, Pt : 131nm

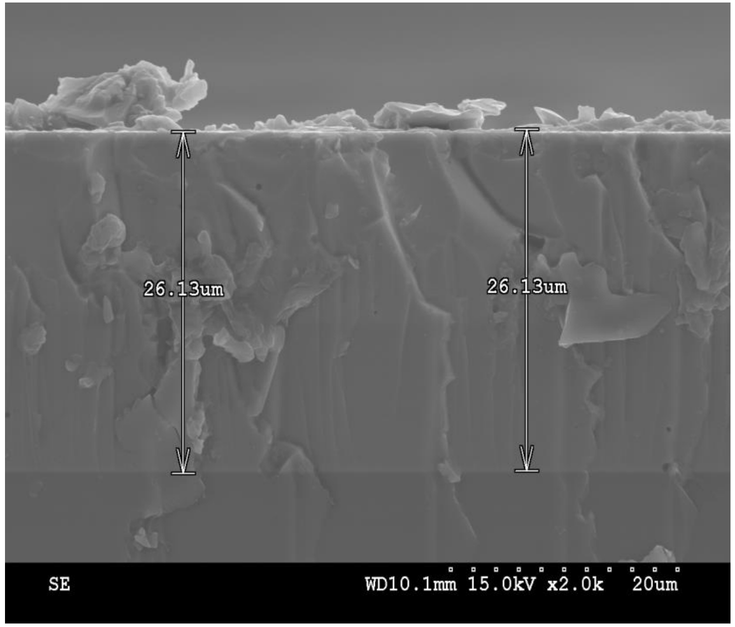
KMAC Result

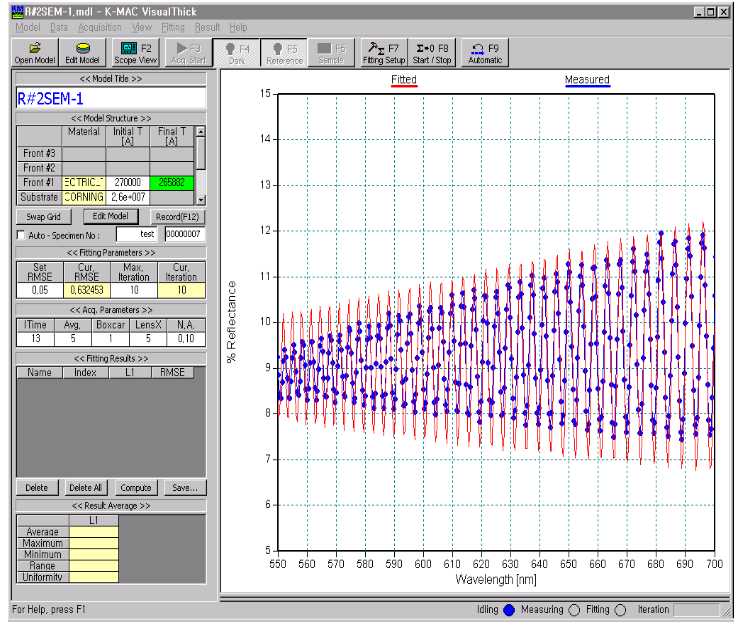
PZT : 3073.58Å, Pt : X



Comparison with other methods

SEM vs K-MAC



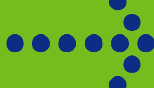


SEM image

MgO : 26.13um

KMAC Result

MgO : 26.588um

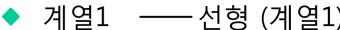


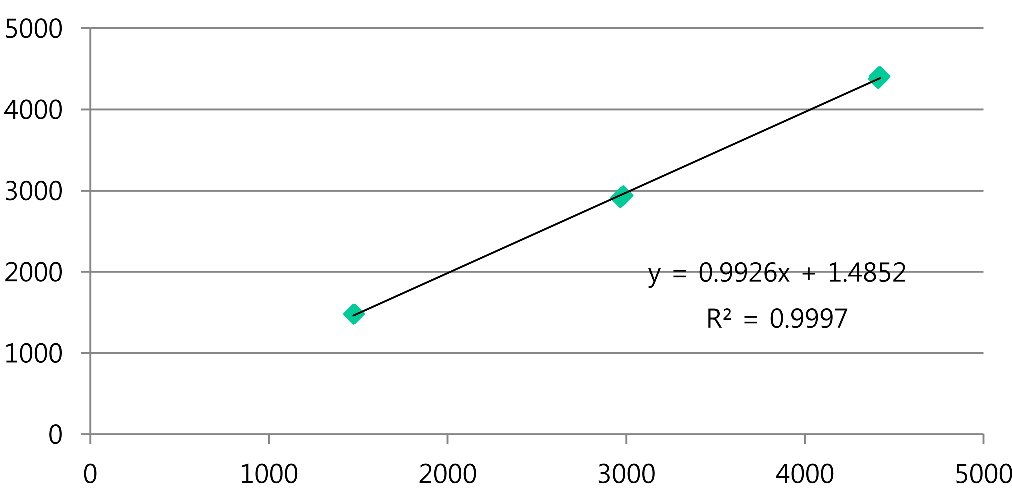
Comparison with other methods

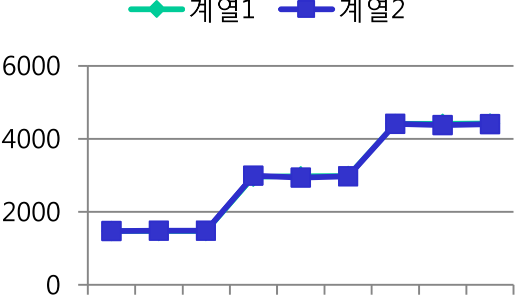
Comparison with other methods

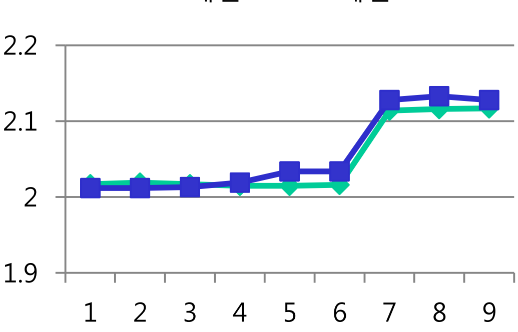
SiNx	SRM(KRISS)		SE(KRISS)		SR(KMAC)		Difference	
	THK	n	THK	n	THK	n	ΔTHK	Δn
1400	1473	2.018	1473	2.017	1473	2.012	0	0.005
			1473	2.019	1482	2.012	9	0.007
			1479	2.017	1482	2.013	3	0.004
3000	-	-	2966	2.015	2992	2.019	26	0.004
			2972	2.015	2941	2.034	31	0.019
			2982	2.016	2974	2.034	8	0.018
4400	4411	2.114	4413	2.114	4408	2.128	5	0.014
			4410	2.116	4376	2.133	34	0.017
			4420	2.117	4407	2.128	13	0.011

(unit: Å)



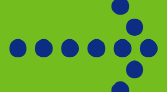






SE & SR correlation value

R^2=99.9% (THK)

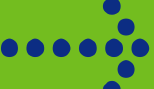


Comparison with other methods

Comparison with other methods

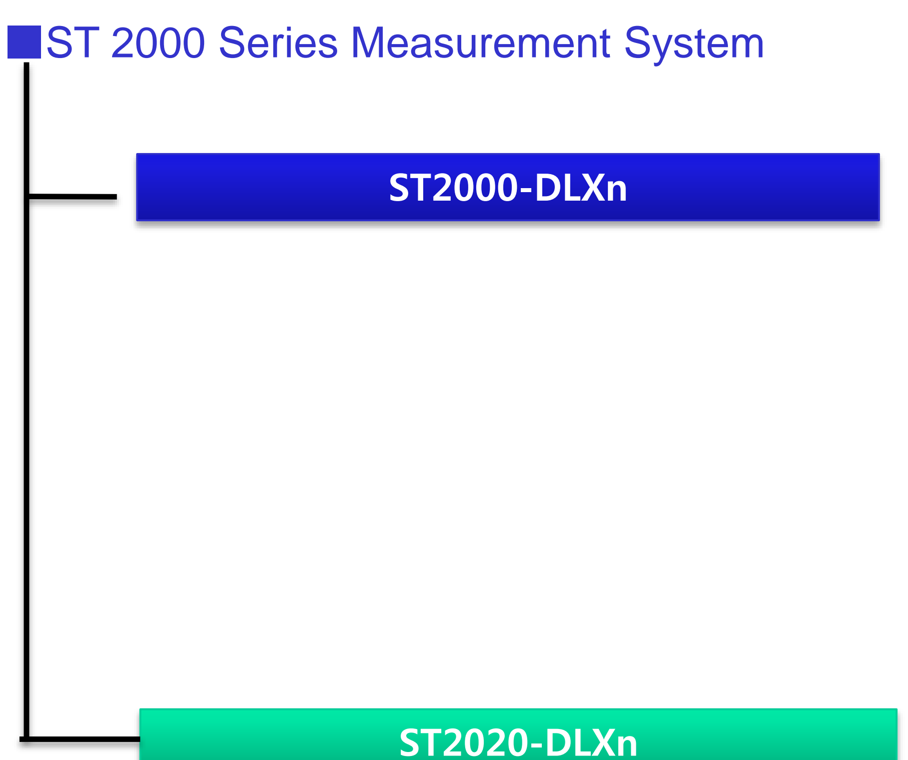
Item	Ellipsometry	Reflectometry	Comments
input	Δ, Ψ	R(%)	Polarization & Reflection
output	n,k,T	n,k,T	same
Reference	-	Si wafer	incident light
Theory	$E(z,t) = E_0 \sin(-\frac{2\pi}{\lambda}(z - vt) + \xi)$		Electromagnetic wave
Optical Data Analysis	$MSE = \frac{1}{N-M}\sum_{i=1}^{N}(\frac{y_i - y(\vec{x}_i, \vec{a})}{\sigma_i})$		Regression analysis methods

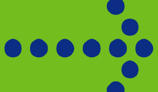
1. SE(Spectroscopic Ellipsometry) & SR(Spectroscopic Reflectometry)의 RI 차이 $\Delta n < 0.05$ 정도의 차이를 갖고 있음.
2. SE는 delta(Δ) 와 psi(Ψ) 두 개의 측정데이터를 이용하여 n&k, THK를 분석하므로 SR보다는 다소 정확한 면이 있음.
3. SR은 시료의 절대 반사도(두께와 굴절률의 정보를 포함)를 측정하여 n&k, THK를 분석 함.
4. 일반적으로 SR의 사용이 SE보다 쉬운 것으로 알려져 있어 공정 모니터링용으로 많이 사용함.



Overview of Thickness Measurement System

ST 2000 Series Measurement System





Overview of Thickness Measurement System

■ST 2000 Series Lay-Out

ST2000-DLXn

540mm

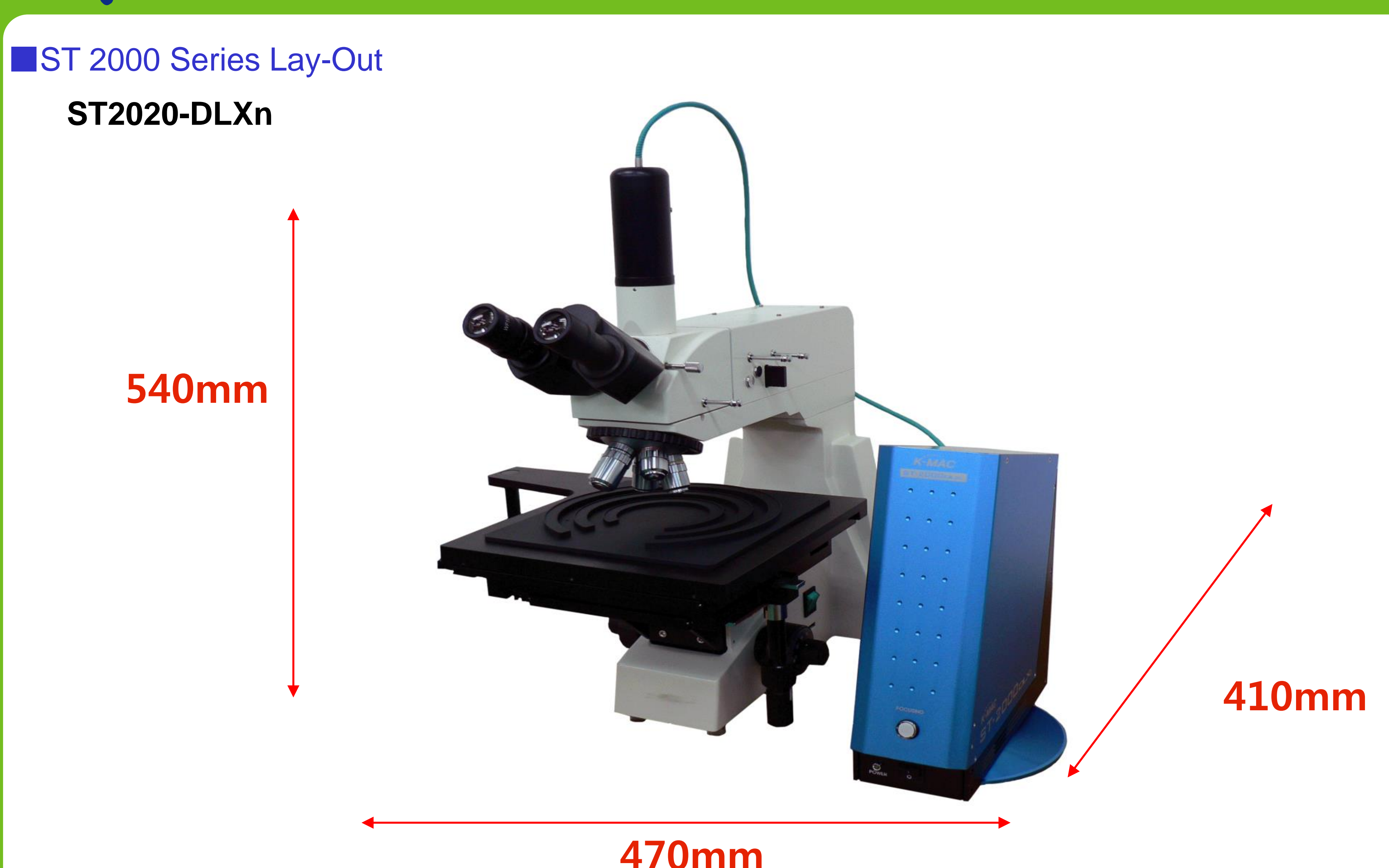
310mm

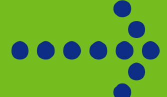
370mm

Overview of Thickness Measurement System

ST 2000 Series Lay-Out

ST2020-DLXn





Overview of Thickness Measurement System

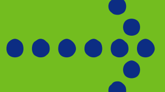
Specification (Model: ST2000-DLXn)

Wavelength Range	400nm~800nm
Thickness Measurement Range	200Å~35㎛
Lens Turret	M5x, M10x
Measuring Spot Size	40㎛, 20㎛
# of measurable layer	3
Size of sample stage	150mm x 120mm
X-Y-Z Mechanism	Roller guide type Travel Distance : 70mm x 50mm
Manual Focusing Module	Coaxial coarse & fine focusing controls

Overview of Thickness Measurement System

Specification (Model: ST2020-DLXn)

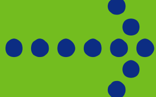
Wavelength Range	400nm~800nm
Thickness Measurement Range	200Å~35㎛
Lens Turret	M5x, M10x
Measuring Spot Size	40㎛, 20㎛
# of measurable layer	3
Size of sample stage	200mm x 200mm
X-Y-Z Mechanism	Roller guide type Travel Distance : 200mm x 200mm
Manual Focusing Module	Coaxial coarse & fine focusing controls



Overview of Thickness Measurement System

Option Parts (ST2000 Series)

Calibration Sample	SRM (Standard Reference Sample) Material Structure: SiO_2 on Si 1000Å, 2000Å, 5000Å, 10000Å
Optical Lens	M50x (Spot size: 4 ㎛)
CCD Camera	High Performance Digital Processing Picolo Capture Board Image: 1/2″ Interline Transfer CCD
Transmittance Function	Usable Wavelength: 420nm~730nm Repeatability: ±0.5% at 550nm Measuring Point: 1 point (Position: Center of Stage)



Overview of Thickness Measurement System

■ST 4000-DLX Lay-Out

ST4000-DLX

850mm

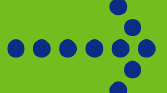
680mm

700mm

Overview of Thickness Measurement System

Specification (Model: ST4000-DLX)

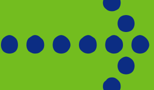
Wavelength Range	400nm~800nm
Thickness Measurement Range	200Å~35㎛
Lens Turret	M5x, M10x
Measuring Spot Size	40㎛, 20㎛
# of measurable layer	3
Size of sample stage	200mm x 200mm
X-Y-Z Mechanism	Roller guide type Travel Distance : 200mm x 200mm
Manual Focusing Module	Coaxial coarse & fine focusing controls



Overview of Thickness Measurement System

Option Parts (ST4000)

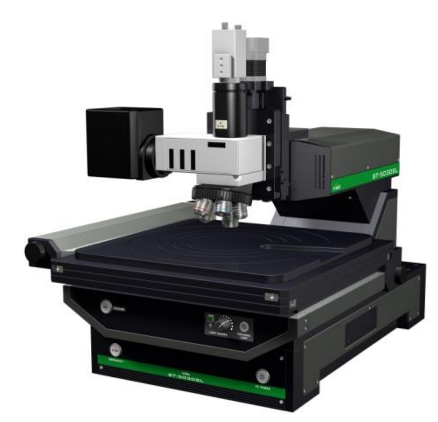
Calibration Sample	SRM (Standard Reference Sample) Material Structure: SiO_2 on Si 1000Å, 2000Å, 5000Å, 10000Å
Optical Lens	M50x (Spot size: 4 ㎛)
CCD Camera	Number of pixels: 640x480 pixels Pixel Size: 8.4x9.8um
Sample Stage	300mm x 300mm
Transmittance	Transmittance measurement range : 420nm ~ 780nm Repeatability (Precision) : ± 0.5% at 420nm ~ 500nm : ± 0.3% at 500nm ~ 730nm



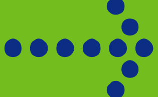
Overview of Thickness Measurement System

ST 5000 Series Measurement System

ST5030-SL



ST5000



Overview of Thickness Measurement System

■ST5030-SL Lay-Out

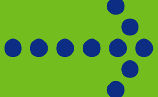
ST5030SL

Weight : 100Kg

650mm

500mm

750mm



Overview of Thickness Measurement System

■ST5000 Lay-Out

ST5000

Weight : 200Kg

1300mm

860mm

1200mm

Overview of Thickness Measurement System

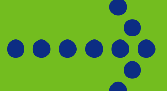
Specification (Model: ST5030-SL)

Wavelength Range	400nm~800nm
Thickness Measurement Range	Auto-mode (100Å~35㎛), Manual-mode (~50㎛)
Lens Turret	M5x, M10x, M20x
Measuring Spot Size	40㎛, 20㎛, 10㎛
# of measurable layer	3
Size of sample stage	200mm x 200mm
X-Y-axis Repeatability	± 5㎛
Z-axis Repeatability	± 4㎛
Motion Performance	X-Y motion Travel range : 200mm x 200mm Max. velocity : 50mm/s Z motion Travel range : 50mm Max. velocity : 50mm/s

Overview of Thickness Measurement System

Specification (Model: ST5000)

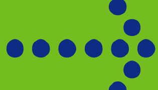
Wavelength Range	400nm~900nm
Thickness Measurement Range	100Å~50㎛
Lens Turret	M5x, M10x, M20x, M50x
Measuring Spot Size	40㎛, 20㎛, 10㎛, 4㎛
# of measurable layer	3
Size of sample stage	300mm x 300mm
X-Y-axis Repeatability	± 2.5㎛
Z-axis Repeatability	± 2㎛
Motion Performance	X-Y motion Travel range : 300mm x 300mm Max. velocity : 50mm/s Z motion Travel range : 50mm Max. velocity : 50mm/s



Overview of Thickness Measurement System

Option Parts (ST5000 Series)

Calibration Sample	SRM (Standard Reference Sample) Material Structure: SiO_2 on Si 1000Å, 2000Å, 5000Å, 10000Å
Optical Lens	M50x (Spot size: 4 ㎛)
Sample Stage	370mm x 470mm(About ST-5000)
Anti-Vibration Table (Only ST5030-SL)	Anti-vibration System with mechanical pneumatically controller
Auto Revolver	Auto changing Lens
Wafer Aligner	Automatically Wafer align



Overview of Thickness Measurement System

■ K-MAC Main programs (ST2000 & ST4000 Series)

K-MAC VThick

Recipe Name: default.rec | Open | Save | Save As

Lamp Timer: 0022:04:43

Shutter Speed: Auto | Save Image | Detect Spot

Fitting Graph | Save Refl... | Load Refl...

Status: RMSE: 1.12, Layer 1: Incoherent, Layer 2: 9955.52

Computed | Measured

Reflectance [%]

Wavelength [nm]

Spectrum | NK

Dark | Reference | Sample | Curr.Spectrum

Intensity [counts]

Wavelength [nm]

Current Thickness [A]

1 : SI	2 : SIO2
Incoherent	9955.52

N [632.8nm]	1.45705	K [632.8nm]	0

Original Result | Compare Result

Automatic number | Name: MeasID | Start No. 0001 | Save...

No.	Name	RMSE	X	Y	Z	L 1	L 2

Move | Delete | Delete All

Statistics	L 1	L 2
Average		
Max		
Min		
Range		
Uniformity		

Auto Ref / Dark | Auto-Meas. | Auto-All | Sample [F5] | Fitting [F6] | Record | One Step [F7] | Repeat(x10) [F8] | Stop Auto

Main | Measure | Setup | Area | Log-In | Exit

Examples of Thickness Measurement Results

K-MAC Main programs (ST5000 Series)

VThick [Auto]

K-MAC | VThick

Recipe Name: default.rec | Open | Save | Save As

Lamp Timer: 0022:06:56

Shutter Speed: Auto | Save Image | Detect Spot

Fitting Graph | Save Refl... | Load Refl...

Status:

Computed | Measured

Reflectance [%] / Wavelength [nm]

Spectrum | NK

Dark | Reference | Sample | Curr.Spectrum

Intensity [counts] / Wavelength [nm]

Wafer Size: 300 mm | 200 mm | Layer: 2

Contour | Color | Shade | Mesh

Meas. Area

Area	X	Y	Z
1	0.0000	0.0000	7.7740
2	0.0000	2.0000	7.7740
3	2.0000	2.0000	7.7740
4	2.0000	0.0000	7.7740

Add | Delete | Delete All | Up | Down | Move | Set Pos. | Generate

Reference / Dark Position

	X	Y	Z
Ref.	-149.0965	53.0005	20.7803
Dark	-149.0965	80.0000	0.0000

Move Ref. | Meas Ref. | Move Dark | Meas Dark

Move: Center Pos. | Unload Pos.

Joystick Control: Speed | Fast | Med | Slow | +Y | -X | XY | +X | -Y | Up | Z | Dn

X = 9999.9999, Y = 9999.9999, Z = 9999.9999

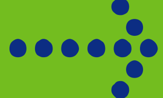
Stage Control [mm]

X	Y	Z
Get X	Get Y	Get Z
0.0000	0.0000	0.0000
Move X	Move Y	Move Z

Auto Focusing

Auto Ref / Dark | Auto-Meas. | Auto-All | Sample [F5] | Fitting [F6] | Record | One Step [F7] | Repeat(x10) [F8] | Stop Auto

Main | Measure | Setup | Area | Log-In | Exit

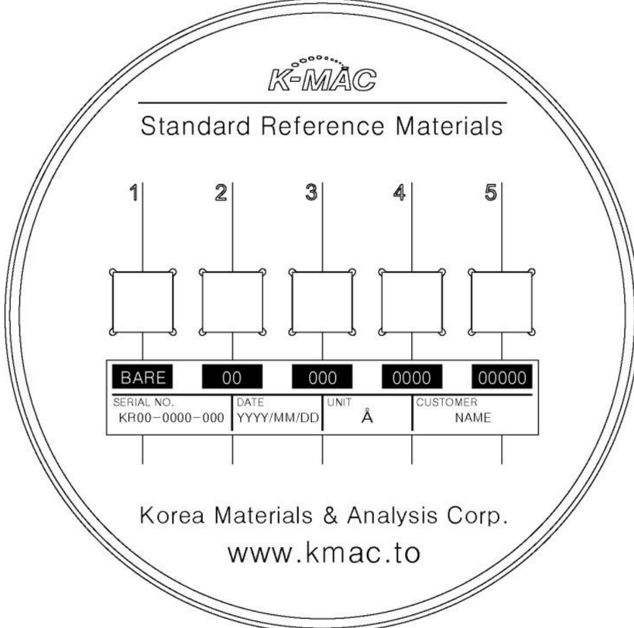


Verification of System (장비 신뢰성 검증 방법)

Using Standard Reference Materials

*Prepare NIST Certificate sample or similar certificate sample (as K-MAC SRM)

*Prepare Stable Sample Structure



[K-MAC Certificate Sample Image]

[Measurement Results]

SiO2-NIST SRM (971Å, 1995Å)   unit: Å

Times	SiO2-NIST SRM (971Å)	SiO2-NIST SRM (1995Å)
1	973.4	1992.9
2	973.1	1993.1
3	973.3	1993.4
4	973.5	1992.9
5	973.2	1993.1
6	973.3	1992.7
7	973.5	1992.8
8	973.6	1992.4
9	973.4	1992.5
10	973.5	1993.0
11	973.2	1992.7
12	973.7	1992.1
13	973.5	1992.5
14	973.2	1992.5
15	973.5	1992.6
16	973.4	1992.5
17	973.5	1991.9
18	973.4	1992.3
19	973.5	1992.3
20	973.4	1992.5
21	973.5	1992.2
22	973.5	1992.7
23	973.8	1992.2
24	973.8	1992.2
25	973.5	1992.1
26	973.6	1992.1
27	973.5	1991.9
28	974.0	1992.3
29	973.6	1992.3
30	973.5	1992.1
Average	973.5	1992.5
Max	974.0	1993.4
Min	973.1	1991.9
Range(Max-Min)	0.9	1.5
STD	0.19	0.38
Accuracy	2.5	-2.5

◆ Accuracy = Average measurement thickness – NIST SRM thickness

Conclusion

Why ST5000 Series?

- Non-Contact
- No Destruction
- Real-sample monitoring
- Easy Operation
- More 10 year experience
- Lots of major customers

→ K-MAC's ST5000 series

Questions ?

ST5000 Series

ST5030-SL