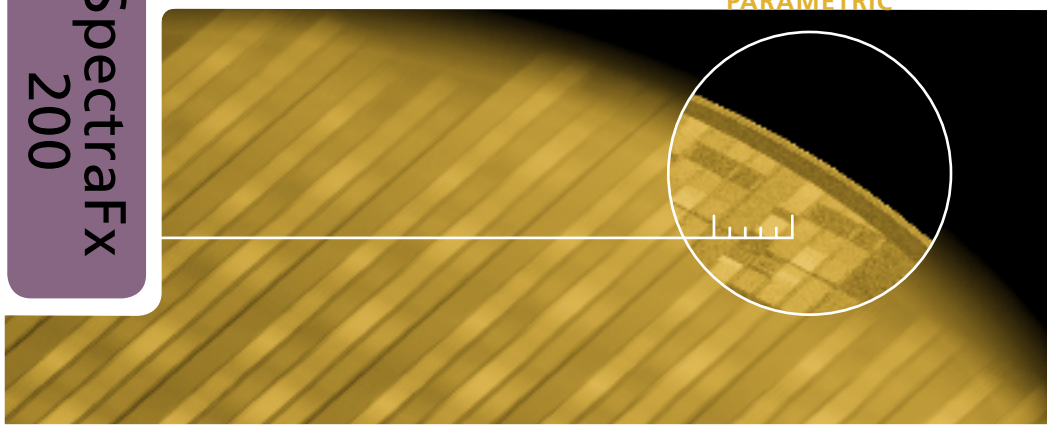
Advanced Thin Film Measurement System

SpectraFx 200

KLA-Tencor



SPECIFICATIONS

MEASUREMENT CAPABILITIES[1]

Single Layer Thickness (t)

Thermal Oxide:	0 Å to 40 µm
Oxynitride:	0 Å to 30 µm
Nitride:	0 Å to 25 µm
BPSG:	0 Å to 40 µm
Photoresist:	0 Å to 40 µm
Polyimide:	0 Å to 40 µm
Poly[5] on Oxide:	50 Å to 2 µm Poly on 40 Å to 4,000 Å Oxide
Poly[5] on Nitride:	50 Å to 2 µm Poly on 40 Å to 4,000 Å Nitride
Amorphous Silicon[5]:	50 Å to 2 µm Amorphous on 40 Å to 4,000 Å Oxide or Nitride
Oxide on Poly[2]:	50 Å to 1 µm Oxide on > 500 Å Poly
Nitride on Poly[2]:	50 Å to 1 µm Nitride on > 500 Å Poly
TiN[3]:	80 Å to 500 Å
Oxide on Aluminum[4]:	< 1,000 Å to 25 µm
Oxide on Tungsten[4]:	< 1,000 Å to 25 µm

Single layer refractive index (n,k)

Thermal Oxide:	> 100 Å
Oxynitride:	> 100 Å
Nitride:	> 100 Å
BPSG:	> 100 Å
Poly[2] on Oxide:	> 100 Å
Amorphous Silicon:	> 100 Å
TiN:	> 200 Å

Simultaneous Multilayer and Simultaneous MultiVariable (SML/SMV)

Up to eight unknowns in up to a 16-layer stack[5]

NO	Nitride	t, n	NPO	Nitride	t, n
	Oxide	t, n		Polysilicon	t, n, k
				Oxide	t
PO	Polysilicon	t, n, k	OTiN	Oxide	t, n
	Oxide	t, n		TiN	t, n, k
PN	Poly	t, n, k			
	Nitride	t, n	ONO	Oxide	t, n
				Nitride	t, n
AO	Amorphous Silicon	t, n, k		Oxide	t, n
	Oxide	t, n	NOPO	Nitride	t, n
				Oxide	t, n
OPO	Oxide	t, n		Polysilicon	t, n, k
	Polysilicon	t, n, k		Oxide	t, n
	Oxide	t			
Resist/ BARC	Resist	t, n, k			
	BARC	t, n, k			

SiON (single layer or multi-layer)

Single layer:	SiON	t, n, k
Dual layer:	$SiON_4$	t, n, k
	$SiON_5$	t, n, k

SiOF/SiON/TiN/Ti/AlCu

	SiOF	t, n
	SiON	t
	TiN	t
$TiSi_2$	$TiSi_2$	t, n, k
$CuSi_2$	$CuSi_2$	t, n, k

Additional films

Anti-reflective coating

Silicon on insulator

Films on silicides

Low k dielectrics

Single Layer Thickness (with AccuFilm and SWE[6])

Thermal Oxide:	0 Å to 2000 Å
Nitride:	0 Å to 1500 Å

Reflectivity range

220 nm to 780 nm

190 nm to 780 nm (optional)

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PERFORMANCE SPECIFICATIONS

SE-SE matching[10]

Thickness only	0.6% or 0.6Å
t & RI 250<500 Å	1.0% for t 0.003 n, k @ 633 nm on Nitide, SiON 0.003 n, k @ 193 nm on Nitride, SiON
t & RI>500 Å	1.0% for t 0.003 n, k @ 633 nm on Oxide, Nitide, SiON 0.003 n, k @ 193 nm on Oxide, Nitride, SiON

SWE-SWE matching[7]

Oxide thickness only:

15 – 100 Å	t	≤ 0.20 Å
100 – 200 Å	t	≤ 0.47 Å
200 – 350 Å	t	≤ 1.29 Å
350 – 500 Å	t	≤ 1.88 Å

Absolute accuracy[8]

Thickness:	±1.5 Å of NIST certified range for oxide <125 Å
	±1 Å of NIST certified range for oxide 125 Å to 300 Å
	±0.3% of NIST certified range for oxide 300 Å to 1.0 µm
	±1.0% for films 300 Å to 1um Using VLSI Standard
Index[9] @ 633 nm:	±0.007 for 350 Å to 1.0 µm oxide ±0.01 for 250 Å to 1.0 µm nitride

Precision (3 sigma) SE[10]

Single parameter measurements

Oxide and Nitride thickness:

20 – 100 Å	t	≤ 0.10 Å
100 – 300 Å	t	≤ 0.30 Å
300 – 2000 Å	t	≤ 0.50 Å
2000Å – 1.0 µm	t	≤ 0.025%

Two parameter measurements

Oxide and Nitride thickness and refractive index:

t & RI 250<500 Å	1.5 Å for t 0.0015 n, k @ 633 nm 0.0015 n, k @ 193 nm

SiON thickness and refractive index:

t & RI>500 Å	> of 1.5 Å or 0.1% for t 0.0015 n, k @ 633 nm 0.0015 n, k @ 193 nm

Precision (3 sigma) SWE[10]

Oxide thickness only:

15 – 100 Å	t	< 0.05 Å
100 – 200 Å	t	< 0.15 Å
200 – 350 Å	t	< 0.25 Å
350 – 500 Å	t	< 0.63 Å

Precision (3 sigma) DBS (Reflectometer)

Single parameter measurements

Oxide and Nitride thickness:

500 – 2000 Å	t	≤ 0.75 Å
2000 Å – 1.0 µm	t	≤ 0.05 %

Reflectivity[11]:

193 nm (optional)	0.011
248 nm	0.005
365 nm	0.001
433 nm	0.001

Stability (3 sigma of means) SE[12]

Single parameter measurements

Oxide and Nitride thickness:

20 – 100 Å	t	≤ 0.25 Å
100 – 300 Å	t	≤ 0.40 Å
300 – 2000 Å	t	≤ 1.5 Å
2000 Å – 1.0 µm	t	≤ 0.075 %

Two parameter measurements

Oxide and Nitride thickness and refractive index:

t & RI 250<500 Å	2 Å for t 0.0015, 0.002 n, k @ 633 nm 0.0015, 0.002 n, k @ 193 nm

SiON thickness and refractive index:

t & RI>500 Å	> of 2 Å or 0.15% for t 0.0015, 0.002 n, k @ 633 nm 0.0015, 0.002 n, k @ 193 nm

Short Term and Long Term Stability (3 sigma of means) AccuFilm[13-14]

Oxide thickness only:

0 – 100 Å	t	< 0.15 Å (short term)
0 – 100 Å	t	< 0.24 Å (long term)

Short Term Stability (3 sigma of means) SWE[13-14]

Oxide thickness only:

15 – 100 Å	t	< 0.15 Å
100 – 200 Å	t	< 0.24 Å
200 – 350 Å	t	< 0.66 Å
350 – 500 Å	t	< 0.94 Å

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Stability (3 sigma of means) DBS (Reflectometer)[12]

Single parameter measurements

Oxide and Nitride thickness:

500 – 2000 Å	t	≤ 2.5 Å
2000 Å – 1.0 µm	t	≤ 0.25%

300 MM STRESS/BOW MEASUREMENTS

Stability[15]

Global Spec – Standard 1D, Enhanced 1D and 2D

For 300mm wafer, 5mm edge exclusion.
1D spec is based on 51 pt polar map.
2D spec is based on 49 pt polar map.

DiffBow Stability: Max of 0.3um or 2% of Mean (1-sigma)

Local Spec (2D only)

For 300mm wafer, 5mm Edge Exclusion, 121pt polar map

DiffCurvature Stability: Max of 0.1 km-1 or 2% of Mean (1-sigma)

Matching[16]

Global Spec – Standard 1D, Enhanced 1D and 2D

For 300mm wafer, 5mm edge exclusion.
1D spec is based on 51 pt polar map.
2D spec is based on 49 polar map.

Matching spec for system-system with each measurement type.
No spec for 1D to 2D measurements.

DiffBow Matching: Max of 0.5um or 2% of Mean
(Max Abs Mean Error)

Equivalent to DiffCurvature Matching:
Max of 0.0475 km^{-1} or 2% of Mean (Max Abs Mean Error)

Local Spec (2D only)

For 300mm wafer, 5mm Edge Exclusion
Based on 121 pt polar map for 2D monitor
Based on 145 pt grid for 2D pattern (20mm rect. Die, 1 pt per die)

DiffCurvature Matching: Max of 0.1500 km-1 or 4% of Mean
(Max Abs Mean Error)

Throughput[17]

1D (Standard and Enhanced, non-pattern)

51 pt line scan, no MWA: 30 WPH

51 pt line scan, w/ MWA: 25 WPH

1D Pattern Line Scan

Based on 20mm rectangular die, 4 pts per die

56 pt line scan: 22 WPH

2D Monitor Wafer (polar map)

49 pt, no MWA: 30 WPH

49 pt, w/ MWA: 25 WPH

121 pt, no MWA: 15 WPH

121 pt, w/ MWA: 14 WPH

2D Pattern Wafer (die grid map):

Based on 20mm rectangular die, 1 pt per die

145 pt grid: 12 WPH

TEST & ANALYSIS CAPABILITIES

Mapping

Die, contour, and 3D

Throughput[18]

		200 MM			300 MM	
		Dual Open	Single SMIF	Dual SMIF	Dual FIMS GEN 4	Single Open
SE	Monitor wfrs/hr auto focus 4X	92	80	80	86	80
	Pattern wfrs/hr auto focus 4X	66	60	60	64	60
DBS	Monitor wfrs/hr pre-programmed focus 1X	120	100	100	115	110
	Monitor wfrs/hr auto focus 15X	95	90	90	109	95
	Pattern wfrs/hr pre-programmed focus 1X	98	80	80	91	90
	Pattern wfrs/hr auto focus 15X	67	60	60	73	65
SWE	Monitor wfrs AccuFilm	—	—	62	65	62
	Pattern wfrs AccuFilm	—	—	46	50	46
	Monitor wfrs w/focus	110	96	96	99	92
	Pattern wfrs w/focus	80	72	72	77	70

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Scanning

Quick tests: user definable

SUMMIT-XP® software

- Windows XP® graphical user interface
- Cassette queueing
- Average, difference, ratio maps
- Process control charts
- Statistical calculations
- Database management
- ASCII data and recipe upload to a floppy disk
- Correlation curves
- Pattern recognition transportability
- Auto model select pattern recognition
- Multiple films (9) and sites per die
- Integrated spectral analysis
- Goodness of fit, normalized goodness of fit
- Tabular, Bruggeman, Cauchy, Harmonic oscillators and polynomial optical constants
- Graded index
- Integrated wafer navigator
- Sequential recipe cassettes
- One-button cassettes: user-defined, per user
- Security password protection: user defined
- Etch-to-clear algorithm
- Etch-to-thin-film
- HSMS Ethernet

Pattern Recognition

- PatMax (Standard)

Optional

- GEM SEMI E30-98
- SECSII SEMI E5-93
- Off-Line Spectral Analysis software (OLSA)
- Barcode reader
- HPPM/HPPC
- Recipe generator
- Remote access capability
- Light tower
- HSMS E37-95
- Carrier ID (300 mm)
- E23 (300 mm)
- E84 (300 mm)
- E87 (300 mm)

HARDWARE COMPONENTS

Measurement unit

Stage resolution:	xy 0.1 µm $z_{4x,\ 15x}$ 0.005 µm z_{1x} 0.1 µm
Spot placement[19]:	±1.5 µm
Wafer sizes[20]:	100-200 mm or 200-300 mm
Illumination sources:	Broadband Xenon Arc Lamp Deuterium Lamp (optional) HeNe Laser (SWE)
Objectives:	Automatic, 3-position turret: 1X, 4X (visible light only), 15X Additional 2x optics for pattern recognition
DBS™ spot:	40, 10, 2.7 µm (1x, 4x, 15x objective, respectively)
SE spot:	Measure within a 50 µm well
SWE spot:	Measure within a 40 µm well
AccuFilm spot:	Clean spot 80 mm, measure within a 40 mm well
Max field of view[21]:	1.125 mm x 1.5 mm (nominal)
Filters:	Wavelength cut-off (400 nm/495 nm) and color filters
Focus:	Automatic focus on measurement site

Controller

Computer:	Pentium 4 computer 80 GB hard drive, USB
Data transfer:	3.5 in. floppy disk, DVD
Monitor:	17 in. high resolution color

Auto wafer handler

Cassettes:

Open system:	300 mm SEMI standard kinematic mount/200 mm SEMI standard H-bar
FOUP system:	SEMI standard FOUP compatibility with integrated mini-environment and 200 mm insert
SMIF pod:	Single and dual position: SEMI standard H-Bar. Integrated Asyst Technologies indexer available in 8 inch to 6 inch configuration; cassette mapping is standard.
Wafer handling:	Backside vacuum pickup: random access
Wafer pre-alignment:	Optical non-contact; centered and notch or flat aligned
Diagnostics:	Resident diagnostic software
Handler safety shield:	Optional

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Light tower:	Optional
Wafer placement xy (GEN 4):	± 70 µm
Wafer placement Theta (GEN 4):	± 0.06 degrees

INSTALLATION REQUIREMENTS[22]

Physical characteristics

300 mm single open cassette

Height[23]:	72.8 in. (184.9 cm)
Width:	50.3 in. (127.8 cm)
Depth (keyboard open):	58.9 in. (149.6 cm)
Weight:	1535 lbs (698 kg)

300 mm dual FIMS(GEN 4)

Height[23]:	76.4 in. (194.1 cm)
Width:	79.8 in. (202.7 cm)
Depth (keyboard open):	63.2 in. (160.6 cm)
Weight:	3240 lbs (1470 kg)

200 mm dual open

Height[23]:	72.8 in. (184.9 cm)
Width:	65.4 in. (166.2 cm)
Depth (keyboard open):	58.9 in. (149.6 cm)
Weight:	1705 lbs (775 kg)

200 mm single SMIF[24]

Height[23]:	72.8 in. (184.9 cm)
Width:	56.8 in. (141.5 cm)
Depth (keyboard open):	58.9 in. (149.6 cm)
Weight:	1835 lbs (834 kg)

200 mm dual SMIF[24]

Height[23]:	72.8 in. (184.9 cm)
Width:	56.8 in. (141.5 cm)
Depth (keyboard open):	58.9 in. (149.6 cm)
Weight:	2970 lbs (1347 kg)

Mounting options

Standard ballroom

Optional bulkhead (dual FIMS only)

Package options

Epoxy paint

Facilities power

Electrical power:	200/208/220/230/240 VAC (±5%) @ 15 Amps, 50/60 Hz single phase
Power demand:	3 kVA maximum, 1.7 kVA continuous
Power connector:	A 10 ft, 3 conductor, 12 AWG, 600V rating power cord is supplied with the system. The cord is not terminated.
Power quality:	An internal power conditioner is provided to protect against power line disturbances. A dedicated power line is recommended.
Auxiliary power:	Printer options will require additional 110-125 VAC outlet.

Facilities air

Characteristics:	90-100 psi clean dry air @ 1 SCFM
Connection:	One fitting for 1/4 in. (6.35 mm) OD tubing, 1/4 in. (6.35 mm) Swagelock compression fitting preferred.

Facilities vacuum

Characteristics:	20-25 in. (625 mm) Hg minimum @ 1 SCFM for each of 2 lines (3 lines with the SWE option)
Connections:	Two fittings for 1/4 in. (6.35 mm) OD tubing, 1/4 in. (6.35 mm) Swagelock compression fitting preferred; third fitting required for SWE option.

System venting

Connection:	One 6 in. (200 mm) OD exhaust port
Air volume:	260 CFM
Standard config.:	Port at the lower back of the cabinet
Optional config.:	Port at the bottom of the cabinet

Cleanroom: Class 10 or cleaner

Temperature:	18°C – 25°C Stability ±2.0°C
Relative Humidity:	30% - 45% (non-condensing)
ESD Grounding:	A true earth ground facility with 14 AWG wire and terminating rings should be available at installation.
Vibration:	< 325 µg rms @ 10 Hz < 813 µg rms @ 25 Hz < 1300-3250 µg rms @ 40 – 100 Hz
Frontside PWP[24]:	3.5x10^{-4} PWP/cm^2 @ 0.2 µm particle size

Backside PWP:	Standard	Option
	Anodized Platen	LBC Platen (300mm only)
> 0.16µm	4000 adders	3000 adders
Backside metal contamination		
Fe, Cr, Ni, Zn	<1E10 at/cm2	<1E10 at/cm^2
Cu	<3E10 at/cm2	<1E10 at/cm^2
Al	<50E10 at/cm2	<1E10 at/cm^2

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1 Broadband UV Spectroscopic Ellipsometer and Spectrophotometer.

2 Assumes smooth, specular surface.

3 Thicker films can be measured but may depend on stoichiometry.

4 Surface roughness typically <20% of film thickness for thin films, thicker films greater.

5 Contact KLA-Tencor Sales for films and specific film ranges.

6 Single Wavelength Ellipsometer.

7 For single layer oxides and nitrides matching measurement: 9 sites in a 1 mm area at the center of a wafer (stable or cleaned from airborne molecular contamination). Calculate the mean (M) of the 9 readings, acquire 10 runs over 2 days on both tools, with the same wafer and with a minimum delay between runs on tool 1 and runs on tool 2. Calculate the mean of the 10 values of M for tool 1 and the mean of the 10 values of M for tool 2. Calculate the difference (>0 or <0) between these two means.

8 Measurement accuracy for SE and SWE measurement technology. Accuracy measurement is performed at 9 sites within a 2 mm diameter at the center of the wafer. The average is calculated and is used for comparison. SWE does not measure index.

9 Compared to monitor wafer results on a SOPRA ES4G after ES4G stability is accounted for. Specifications for use with VLSI standard.

10 For oxides and nitrides, defined as the 3 sigma standard deviation of a 30 site measurement at the center of a uniform wafer (focusing each time without moving the wafer on the stage) using appropriate SE or DBS subsystems and objective. Film measurements using KLA-Tencor qualification recipes n @ 633 nm; on other wavelengths contact the factory. RI precision measurement on single layer oxide using 1X objective.

11 Measured in Actual Reflectivity Units (ARU) on 1X objective - assumes normalized reflectivity to the incident intensity (an ARU of 1.0 indicates 100% of incident intensity is reflected).

12 For oxides and nitrides, defined as the 3 sigma of means of 30 site measurements at the center of a uniform wafer over 3 days, at least 10 wafer cycles total, using known stable wafers. Film measurements using KLA-Tencor qualification recipes.

13 Short term stability for oxide is defined as the 3 sigma of means of 30 site measurements at center of a uniform wafer over 3 days, at least 10 wafer cycles total, using known stable wafers and correction for wafer growth if needed. Film measurements using KLA-Tencor qualification recipes.

14 Long term stability measurement is defined as the 3 sigma of means of 30 site measurements at center of a uniform wafer over 30 days using known stable wafers and correction for wafer growth if needed. At this point KLA-Tencor does not have a long term stability specification.

15 Stability is defined as 1 sigma of the means of individual scans taken over 3 days, 5 times per day. For global stress, spec is for bow stability (1D: 51 pt line scan, 2D: 49 or 121 pt polar map). For local stress, spec is the local stress stability based on 121 pt 2D polar map). The spec is based on the assumption that stress of the wafer is not changing as a function of time, due to changes in film properties, temperature or other environmental conditions, and known-stable, mature wafers should be used for testing to spec.

16 Using "stress cal refine".

17 For standard 51 pt. scan using 15X DBS objective, average over 25 wafer cassette with dual FIMS handler. Monitor Wafer Alignment is an alignment that uses the edge of the wafer and the notch to consistently align the wafer.

18 5 site measurement standard KLA-Tencor qualification test measuring all 25 wafers run in a cassette on a single layer oxide on silicon using pre-programmed focus. Data is collected in the visible range only, therefore, the UV filter is not used. Throughput will vary depending on test setup and wafer size. Throughput is determinded with GEM/SECS off.

Throughput Calculations
Dual Wafer End Effector Handlers; 200 mm DO, SS & DS:
T1 – 1st load
T2 – exchange + measurement time
T3 – last unload
Formula = (3600–T1+T2–T3)/T2
Single Wafer End Effector Handlers; 300 mm DF & SO:
T1 – time from wafer 1 pick up from FOUP to placement in FOUP (does not include mapping)
T2 – time after 1st wafer is placed in FOUP
Formula = 3600/[(T1+(23*T2)+T3)/25]

19 Site by site alignment on a 300 mm wafer, placement within a 6 µm x 6 µm box.

20 200 mm wafers can be run on open 300 mm system with adapter plate and on FIMS 300 mm system with special optional insert for pods.

21 Using 1X objective.

22 For additional information, refer to facilities requirments specification.

23 Height with optional light tower is 79.3 in. (201.4 cm).

24 For SMIF and FIMS systems in a class 100 environment, particle spec remains the same.

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