Physical and chemical characterization facilities of the CEA-LETI

Characterization	Tool	Information	Specifications	Limits
FIB *Focused Ion Beam*	HITACHI 2000	SEM Sample preparation	Ga source, W deposition	Small samples (few mm^2) Charge effect on insulators
	FEI DB STRATA 400	• SEM & TEM Sample prep. • Morphology • Devices reconfiguration • Tip and fiber configuration	Ga source, W & SiO_2 deposition, Dual Beam 30kV STEM	Small samples (few cm^2)
	FEI EXPIDA 1285	• Sampling on full wafer • Sample preparation for SEM and TEM	Ga source, W & TEOS deposition, X-EDS, Dual Beam 200 & 300 mm in line tool	Charge effect on insulators
TEM *Transmission Electron Microscopy*	AKASHI	Morphology	Atomic resolution	Destructive Specific sample preparation
	JEOL 2010 FEF	Morphology and chemical analysis	Atomic resolution, STEM X-EDS and EELS	
	FEI TECNAI G2 F20	Morphology and chemical analysis	Atomic resolution, STEM X-EDS	
	FEI TITAN	Morphology and chemical analysis	Atomic resolution, STEM Probe Cs corrector X-EDS and EELS Electron holography Electron tomography	

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SEM *Scanning Electron Microscopy*	HITACHI 4000 & 4100	Morphology	Standard resolution (1.5 nm)	Destructive Cross section Charge effect on insulators
	HITACHI 5500	Morphology and chemical analysis	High resolution, SEM & STEM (0.4nm & 0.5 nm)	
	HITACHI 5000	Morphology and chemical analysis	High resolution, SEM X-EDS	Destructive for cross section, charge effect on insulators
	HITACHI 4160 & 7800	Morphology analysis	Standard resolution	200 mm wafer, Charge effect on insulators
OVERLAY	DSM8	Double side overlay measure	+/-0.5 µm	Automatic measurement but manual wafer loading, 200, 150 & 100 mm wafers,
	NANOMASTER ALARM 1&2	Overlay & critical dimensions (CD) measurements	Overlay : 0 to 125nm (mean+3σ) CD : 5 µm to 30 µm	Optical measurements, 200 mm wafers
	IVS-165	Overlay & CD measurements	Overlay : 0 to 125nm (mean+3σ) CD : > 0.5 µm	Optical measurements, 200 mm wafers
CD-SEM *Critical Dimensions Measurements – Scanning Electron Microscopy*	HITACHI CG4000	CD measurements on lithography and etch steps	10 nm to 5 µm	200 & 300 mm wafers, Charge effect and high slope feature sensitive
	HITACHI 9300A	CD measurements on lithography and etch steps	30 nm to 5 µm	200 & 300 mm wafers, Charge effect and high slope feature sensitive
	APPLIED MATERIALS VERASEM	CD measurements on lithography and etch steps	30 nm to 5 µm	200 & 300 mm wafers, Charge effect and high slope feature sensitive

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Characterization	Tool	Information	Specifications	Limits
RAMAN *Raman spectrometry*	Jobin Yvon T 64000	• Chemical composition • Cristal properties • Strain	UV, Vis and NIR excitation	No signal on metals
	Renishaw RN1000	• Chemical composition • Cristal properties Strain	UV and Vis excitation	No signal on metals
FTIR *Fourier Transform InfraRed spectrometry*	Bruker IFS 55	Chemical bonding % R & T	ATR and MIR attachments for 200 mm wafers	Full wafer layers
	Bruker IFS 66 microscope	Chemical bonding % R & T	Spot size 10 µm	No mapping
Spectrophotometry	Varian Cary5	% R & T	Wavelength: 0.19-3.3 µm	Small samples (few cm^2)
Ellipsometry	Sopra EP12	Porosimetry	Wavelength: 0.4-0.8 µm, Wafer: 200-300 mm	Open porosity only
	Jobin-Yvon UVISEL-DUV	Morphology and dielectric function	Wavelength: 0.15-0.83 µm	Full wafer layers Small samples (few cm^2)
	Woolam M2000	Morphology and dielectric function	Wavelength: 0.19-1,7 µm, Wafer: 200-300 mm	Full wafer layers Small samples (few cm^2)
	KT Aleris ^{XP}	Morphology and dielectric function	Wavelength: 0.155-0,9 µm, Wafer: 200-300 mm	Blanket and product wafers

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Characterization	Tool	Information	Specifications	Limits
XRR *X-Ray Reflectometry*	Jordan Valley 5200	Morphology	Wafer: 200-300 mm	Full wafer layers
	Bruker D8 Fabline	Morphology	Wafer: 200-300 mm	Full wafer layers
XRD *X-Ray Diffraction*	Bruker D5000	Phase, texture	Standard resolution,	Full wafer layers
	Laue bench	Orientation	Reflection or transmission	Bulk crystal
	PANalytical X-Pert	Phase, texture, composition, strain	High angular resolution, Grazing incidence, Wafer : 200 mm-300mm	Full wafer layers
	PANalytical X-Pert Pro	Phase, texture, composition, strain	High angular resolution, Grazing incidence, in-plane diffraction; Wafer : 200 mm	Full wafer layers
	Hibrix	Phase, texture, composition, strain, XRF	High brilliance micro-source, High angular resolution, Grazing incidence; XRF, 1D or 2D detection, Wafer : 100 mm	Spatial resolution <50 µm
	ESRF µ-XRD	Orientation, strain	White/monochromatic beam, high spatial resolution (0.5 µm)	Time consuming accessibility, small samples (cm²)
XRF *X-Ray Fluorescence*	PANalytical - WDXRF	Thickness, composition	Fixed channels: B, O, F, Al, P, Cl, Ti, Cu Goniometer ($22 \leq Z \leq 92$)	Full wafer layers Samples (>10cm²) up to ∅ 200mm

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Characterization	Tool	Information	Specifications	Limits
SPM *Scanning Probe Microscopy*	VEECO Multimode	Surface morphology	Contact and Tapping modes, Scan range : 100x100 µm, Amplitude limit : 5.5 µm	Small samples (cm^2)
	VEECO 3100	Surface morphology, work function, dopant distribution, resistivity Oxide integrity	Contact and Tapping modes in air or under N_2 atmosphere, KFM, SRRM, SCM, TUNA modules, Scan range : 100x100 µm, Spatial resolution: > 10 nm	Samples up to ∅ 200 mm, Calibration and Tip life time
	Omicron VT AFM XA	Surface morphology, work function, dopant distribution, resistivity	Contact and Non-contact modes in UHV, Scan range : 8x8 µm, Spatial resolution: down to atomic scale, Variable temperature (50-500K) KFM, Resiscope & STM Prep chamber (baking, sputtering, cleavage, LEED/Auger) Coupling with XPS & PEEM (via a UHV transfer suitcase)	Small samples (cm^2)
In-line AFM *Atomic force microscopy*	VEECO Dimension 5000	Step height and roughness meas.	Roughness : > 0.1nm Step height : < 1.5µm	200 mm wafers, (possibility with 300 mm wafers on a reduced area)
	VEECO INSIGHT 3D AFM	Reference metrology tool for CD, side wall roughness	3D Metrology for nano lithography (LER, LWR, SWA)	300 mm wafers, measurements for high density lines (tip edge size)

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Characterization	Tool	Information	Specifications	Limits
Profilometer *Stylus and Optical*	KLA TENCOR HRP 340	Step height and roughness meas. Fully automatic.	20 nm to 100 µm	200 & 300 mm wafers, Contact measurement (stylus)
	TENCOR P10, P11 & P16	Step height and roughness meas.	20 nm to 300 µm	200 mm wafers, Contact measurement (stylus), manual wafer loading
	2 TENCOR P16+	Step height, roughness and stress measure. Automatic (pattern recognition)	< 1mm	200 mm wafers, Contact measurement (stylus), manual wafer loading
	VEECO WYKO NT9300	Step height and roughness meas. Automatic (pattern recognition)	0.1 nm to 10 mm	200 & 300 mm wafers, Optical profiling system: transparent materials
SIMS *Secondary Ion Mass Spectrometry*	CAMECA 5F	Element profiling	Cs and O primary ions, Depth resolution: 1nm, Mass resolution < 15000 m/dm	Destructive, Small samples, Charge effect on insulators, Spatial resolution limit: 100µm
	ION TOF TOFSIMS 5	Element profiling Surface contamination	Bi pulsed sources, Cs and O source for abrasion, Wafers: 100 mm, Depth resolution: 1 nm, Spatial resolution: > 50 nm, Mass resolution < 10000 m/dm	Destructive

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Characterization	Tool	Information	Specifications	Limits
Laser Atom Probe	CAMECA LAWATAP+	3D atomic scale elemental analysis	IR/vis/UV fs laser, 0.3 nm resolution, Mass resolution < 3000 m/dm	Destructive, Samples must be in form of needle with 50 nm tip radius, FIB sample prep
MEIS *Medium Energy Ion Scattering*	HVEE 400 kV	Element profiling Surface structure Damage and strain profiling	H, He ion sources, 2D (energy-angle) detection, Depth resolution : down to few Å angular resolution: ~ 0.1°	Small samples (cm^2), Full wafer layers, Spatial resolution: 0.5 mm^2
XPS-UPS *X-ray and Ultra-violet Photoelectron Spectroscopy*	SSI-S probe ESCA	Surface chemical bonds, Electronic properties	Angle resolved, Al-Kα and Mg-Kα sources, Sensitivity: 10^{13} at. cm^{-2}; 1 at %	Full wafer layers Small samples (cm^2) Charge effect on insulators
	OMICRON MXPS		Idem + He Lamp for UPS and ion gun for XPS depth profiling Preparation chamber	UHV, small samples (cm^2), Low throughput
PEEM *PhotoElectron Energy Microscopy*	OMICRON NanoESCA	Chemical bond imaging	X and UV lab sources Synchrotron rad. compatible Sub µm spatial resolution High energy resolution	Low surface topography (< 1nm)
AES *Auger Electron Spectroscopy*	PHI 700 Xi	Surface chemical analysis, Scanning Auger Microscopy (SAM) and depth profiling	Sensitivity: 0.1 to 1 at % for Z>2 Spatial resolution: 8 nm (SAM), Depth resolution: 2 nm, High energy resolution: 0.1 %	Charge effect on insulators, Small samples < 50 mm, Beam damage
4-point bending test	MTS	Adhesion	Controlled environment	Sample preparation Time consuming interpretation

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Characterization	Tool	Information	Specifications	Limits
TXRF *Total X-ray Reflection Fluorescence*	Rigaku Fab 300	Elemental Surface Contamination	From Na to U Spot size: ~1cm² Sensitivity: ~10^{10} at/cm² or few ng	Flat and smooth surface Samples with wafer like geometries
ICPMS *Inductively Coupled Plasma Mass Spectrometry*	Agilent HP 7500	Elemental chemical composition and contamination of fluids, surface, or bulk material	~ All Mendeleiev periodic table elements Sensitivity: few pg or ~10 pptw in aqueous sample	Aqueous liquid samples Sample preparation step Destructive
AAS *Atomic Absorption Spectrometry*	Varian AAS400		~ All Mendeleiev periodic table elements Sensitivity: few ng or ~0.1 ppbw in aqueous sample	Aqueous liquid samples Sample preparation step Destructive
GC/MS *Gas Chromatography/Mass Spectrometry*	Perkin Elmer AutosystemXL & TurboMass	Molecular chemical composition and contamination of fluids, surface, or bulk material	Organic molecules from C_4 to C_{25} Sensitivity: few ng or ~10^{11} at.C/cm² for surfaces or ~1µg/m3 in air	Gaseous samples Sample preparation step Destructive
IC *Ionic Chromatography*	Dionex DX320 & DX600	Ionic chemical composition and contamination of fluids, surface, or bulk material	Anions and cations Sensitivity: few ng or ~10^{11}ions/cm² or ~0.1ppbw in water	Aqueous liquid samples Sample preparation step Destructive

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Characterization	Tool	Information	Specifications	Limits
Automatic Micro cleaving System	SELA MC600i	Fully automatic cleaving process, SEM cross section preparation	High accuracy : 1σ< 0.3 µm, High mag.: X7500, 100 nm structure capability. High throughput: 9 min, full process, High edges quality,	Crystalline material and crystal orientation Thickness < 2 mm Sample size : 2 x 1 mm to 35 x 11 mm, target in the center, in Y axis.
Computer controlled polishing system	GATAN CENTAR Frontier	Cross section, thinning, shallow angle and parallel polishing. (SEM, TEM, SIMS, SRM)	90° View mode for incremental polished (x9000 on screen) Flatness accuracy (0.003°) Cross section accuracy : ±100nm TEM lamella thickness down to 20 µm or less.	Sample : up to 30x30x6 mm^3 To use non-crystallizing slurries only or lapping films and water Force : 140 g minimum
Ion Polishing system	GATAN PIPS	TEM preparation: Argon milling of thin lamella after polishing.	Beams angle adjustment: ± 10° Diameter center hole etched Etching rate: on Si ≈ 20 µm/h at 5 kV and lower, according to the voltage (3-6 kV).	Sample must be on a TEM grid and thickness < 30µm, Not usable on localized target No beam alignment, No sample cooling option, No end point detection
CSP *Cross Section Polishing*	JEOL SM-09010	SEM cross section etching or cleaning: Argon milling	2- 6 kV Cross section surface up to 1mm width, depth according to time etching. Etching rate: on Si ≈ 1.3 µm/min at 6 kV and lower, according to the voltage.	Sample : up to 11x10x2 mm^3 Not usable on small localized target (optical mag x100) Accuracy : ± 25µm