ANALYTICAL TECHNIQUE	TYPICAL APPLICATIONS	SIGNAL DETECTED	DETECTION LIMITS	IMAGING/ MAPPING	LATERAL RESOLUTION/ PROBE SIZE
Accelerator Techniques					
Rutherford Backscattering Spectrometry, Nuclear Reaction Analysis, Hydrogen Forward Scattering, Channeling	Thin film composition/thickness, quantitative dose measurement, quantitation without standards, hydrogen in thin films, defects and lattice locations	B - U (RBS) B, N, O, C (NRA) ^{1}H, ^{2}H (HFS)	RBS 0.001 – 10at% (Z dependent) NRA > 1 x 10^{15} at/cm^{2} HFS 0.1at%	No	≥1mm
AFM					
Atomic Force Microscopy	Roughness, 3D imaging of surfaces, critical dimensions, mapping of: electrical, material, and magnetic properties	n/a	n/a	Yes	1.5-5nm
APT					
Atom Probe Tomography	Elemental distribution and quantification in 3D nm-scale, including thin films, particles, interfaces, dopant mapping and quantification	H - U	~10ppm	Yes	0.5nm in lateral and 0.3nm in depth
Auger					
Auger Electron Spectroscopy	Surface, particle, defect analysis, and large and small area depth profiling	Li - U	0.1 – 1at% submonolayer	Yes	≥10nm
DHEM					
Differential Hall Effect Metrology	Depth profile of active dopants, carrier concentration, mobility and sheet resistance measurements of electrically isolated semiconductor layer	n/a	Carrier concentration is from 10^{14} – 10^{16} cm^{-3} and is sample dependent	No	> 8mm x 8mm
EBIC					
Electron Beam Induced Current	Junction location, electrically active crystal defects, depletion layer widths, minority carrier diffusion length	n/a	n/a	Yes	50nm – 1µm
EBSD					
Electron Backscatter Diffraction	Grain size, grain orientation, grain misalignment, % crystallinity	n/a	n/a	Yes	1nm imaging; ~80nm minimum grain size
Ellipsometry					
Spectroscopic Ellipsometry	Film thickness, n and k measurement	n/a	n/a	Yes	200µm or 2mm

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ETV-ICP-OES					
Electrothermal Vaporization ICP-OES	Direct single or multi-element determinations in solids, liquids and slurries	Li – U except atmospherics	pg/g	No	n/a
FIB/SEM Imaging					
Dual Beam and Single Beam	In-situ cross section preparation and imaging	n/a	n/a	Yes	1nm
FTIR					
Fourier Transform Infrared Spectroscopy	Identification of polymers and organics; contamination identification, particle analysis	Molecular functional groups	0.1 – 1wt%	No	≥15µm
GC-MS					
Gas Chromatography-Mass Spectrometry	Identification and quantification of volatile organic compounds in mixtures, outgassing, residual solvents, liquid or gas injection	Molecular ions up to m/z ~500	400ng (full scan) 10ng (outgassing)	n/a	n/a
GDMS					
Glow Discharge Mass Spectrometry	Bulk analysis: trace and ultra-trace elemental survey analysis, depth profiling	Li - U	10ppt wt - 100%	No	5 – 15mm
GPC					
Gel Permeation Chromatography	Molecular weight distributions and determinations, failure analysis and quality assurance and control	M_w, M_n, M_z, M_p, PDI	Sample dependent	n/a	n/a
IC					
Ion Chromatography	Identification and quantification of ions, organic acids and other polar compounds, typically in aqueous solution	Ions, organic acids, other polar compounds	1 ppm – 100%	n/a	n/a
ICP-OES					
Inductively Coupled Plasma Optical Emission Spectroscopy	Bulk composition analysis	Li - U	1ppm wt - 100%	n/a	n/a
IGA					
Instrumental Gas Analysis (Combustion and fusion gas analysis)	Bulk analysis of H, C, N, O and S, fractional gas analysis	H, C, N, O, S	0.1ppm - 50%	n/a	n/a
LA-ICPMS and ICPMS					
(Laser Ablation) Inductively Coupled Plasma Mass Spectrometry	Bulk composition, trace and ultra-trace elemental analysis, impurity distribution mapping	Li - U	10ppb wt - 100%	Yes	5µm

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LC-MS					
Liquid Chromatography Mass Spectrometry	Identification of analytes in complex matrices	Organics only	Molecular ions 50 - 4000 m/z 1 ppm – 100%	n/a	n/a
LIBS					
Laser Induced Breakdown Spectroscopy	Rapid elemental mapping, single or multiple element measurement laterally or by depth	All	Typically 5 ppmw to 10 ppmw	Yes	10 – 200µm
NI					
Nanoindentation	Assessment of highly localized mechanical properties, property mapping, wear, friction, scratch, fatigue, DMA, use-case simulation	n/a	n/a	Yes	10 – 30nm
NMR					
Nuclear Magnetic Resonance Spectroscopy	Chemical structure identification and composition analysis, raw materials fingerprinting	H, C, F, P	100 ppm – 100% H, F, P	n/a	n/a
OP					
Optical Profilometry	Non-contact 3-dimensional imaging of surface topography	n/a	n/a	Yes	435nm
Raman					
Raman Spectroscopy	Identification of organics and inorganics; particle identification, stress measurement, carbon phase identification	Chemical and molecular information	1wt%	Yes	1µm
RTX					
Real Time X-ray Analysis	Real-time 2D and CT/3D inspection, non-destructive	n/a	n/a	Yes	0.1µm
SEM (with EDS)					
Scanning Electron Microscopy Energy Dispersive X-ray Spectroscopy	Imaging, elemental identification	B - U	0.1 %	Yes	1nm imaging 0.5µm EDS
SEM-CL					
Scanning Electron Microscopy Cathodoluminescence	Characterization of composition, optical, and electronic properties of various materials at small length scales	n/a	n/a	Yes	30 – 250nm

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SIMS					
Secondary Ion Mass Spectrometry	Dopant and impurity depth profiling, surface, bulk and microanalysis, insulating films, ultra low energy/ultra shallow depth profiling	H - U	10^{12} – 10^{16} at/cm^3	Yes	≥20µm (Depth profiling) 1 - 5µm (Imaging mode)
STEM (with EDS and EELS)					
Scanning Transmission Electron Microscopy Energy Dispersive X-ray Spectroscopy Electron Energy Loss Spectroscopy	Imaging, Z-contrast, elemental mapping elemental identification, EELS line scans, lattice imaging, Bright Field and Dark Field imaging	B - U	1%	Yes	0.25nm
TEM (with EDS and EELS)					
Transmission Electron Microscopy Energy Dispersive X-ray Spectroscopy Electron Energy Loss Spectroscopy	Imaging, elemental identification, crystallographic information, lattice imaging	B - U	0.5%	Yes	0.19nm
TGA/DTA/DSC					
Thermogravimetric Analysis Differential Thermal Analysis Differential Scanning Calorimetry	Thermal stability and composition of organic/ inorganic composite materials; glass transition, crystallization, melting, clustering, curing, chemisorption, and etc.	n/a	0.01 – 200°C/min; 20 - 1100°C; ±0.1mg–±200mg; ±2.5µV–±2500µV	n/a	n/a
TOF-SIMS					
Time-of-Flight Secondary Ion Mass Spectrometry	Surface microanalysis of organic and inorganic materials, chemical mapping	H - U Molecular species	10^{7} – 10^{10} at/cm^2 submonolayer	Yes	≥0.20µm
TXRF					
Total Reflection X-ray Fluorescence Spectroscopy	Surface contamination measurement on semiconductor wafers, non-destructive	Na - U	10^{9} – 10^{12} at/cm^2	Yes	~10mm
XPS/ESCA					
X-ray Photoelectron Spectroscopy/ Electron Spectroscopy for Chemical Analysis	Surface analysis of organic and inorganic materials, depth profiling	Li - U Chemical bonding	0.01 – 1at% submonolayer	Yes	10µm – 2mm
XRD					
X-ray Diffraction	Identification of crystal phases, crystal orientation and crystal quality, % crystallinity	H - U	1at%	No	15µm
XRR					
X-ray Reflectivity	Determination of film density, roughness and thickness	n/a	n/a	Yes	5mm
XRF					
X-ray Fluorescence	Composition and impurities in films and bulk materials, wafer mapping	Be - U	10ppm	Yes	75µm