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Analytical Methods

Secondary Ion Mass Spectrometry (SIMS)

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Technical Parameters

Magnetic Sector SIMS System:
CAMECA IMS WF

Primary Beam: O and Cs Ion Sources
Signal Detected: Secondary Ions

Elements Detected: H – U
Lateral Resolution: 10 μm
Depth Resolution: 1 – 3 nm
Detection Limits: 10^{13} - 10^{16} at/cm^3

B / HE:	$5 \cdot 10^{13}$ at/cm^3
B / LE:	$2 \cdot 10^{15}$ at/cm^3
As / HE (HMR):	$5 \cdot 10^{13}$ at/cm^3
As / LE (HMR):	$2 \cdot 10^{16}$ at/cm^3
P / HE (HMR):	$2 \cdot 10^{14}$ at/cm^3
P / ME (HMR):	$1 \cdot 10^{15}$ at/cm^3
P / LE (HMR):	$5 \cdot 10^{16}$ at/cm^3

HE – High Energy; LE - Low Energy
HMR – High Mass Resolution

Application areas

- Dopant and impurity depth profiling
- Composition and impurity measurements of thin films
- High-precision matching of process tools, such as ion implanters and CVD etc.

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Time-of-Flight Secondary Ion Mass Spectrometry (TOF-SIMS)

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Technical Parameters

Time-of-flight mass spectrometer:
ION-TOF 5

Primary Beam:

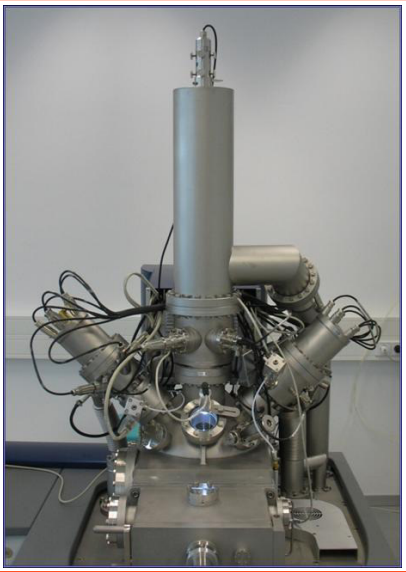
Analysis Gun:
Liquid Metal Ion Gun (LMIG)

Bi_1, Bi_3 und Bi_3^{++} Ions/Clusters

Sputter Gun: O und Cs

Signal Detected: Secondary Ions

Elements Detected: H – U
Lateral Resolution: 90 nm (Imaging)
Depth Resolution: 1 – 3 nm (Profiling)
Detection Limits: 10^9 - 10^{10} at/cm^2 (sub-monolayer)



Application areas

- Surface microanalysis of organic and inorganic materials
- Ion imaging of surfaces
- Dopant and impurity depth profiling
- Composition and impurity measurements of thin films

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Focused Ion Beam (FIB)

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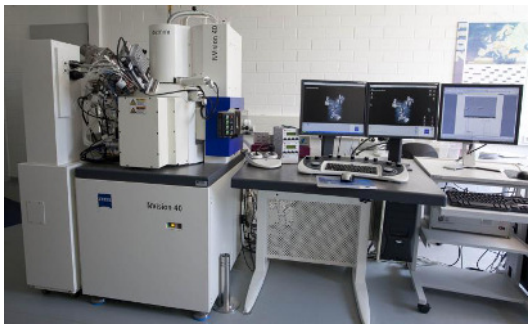
Technical Parameters

FIB-SEM System:
NVision 40
Primary beam:
SEM (Gemini Zeiss): e^- 1 - 30 kV
FIB (Seiko Zeta): Ga^+-Ions 5 - 30 kV
Lateral resolution: REM: 1.1 nm @ 20 kV
2.5 nm @ 1 kV
FIB: 4.0 nm @ 0.1 pA
Signal Detected:
Secondary electrons
(SE, In lens, EsB, STEM Detectors)

EDX-System:
SDD-Detector Bruker Xflash 4010

Elements Detected:	B – U
Lateral Resolution (EDX):	≥ 1 µm
Depth resolution (EDX):	0.5 – 3 µm
Energy resolution (EDX):	125 eV
Detection Limits (EDX):	0.1 – 1 at%



Application areas

- High resolution cross-section images of small sample features
- SEM Imaging
- TEM sample preparation
- „on-chip“ circuit modification (FIB Cuts, W, C and SiO_2 deposition)
- In-situ STEM Imaging
- Chemical Microanalysis by EDX (point analysis, line scans, mapping)

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Scanning Electron Microscopy (SEM)

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Technical Parameters

SEM System:
Hitachi S-4500
EDX Detector Noran System Six

Primary Beam: Electrons 5 - 25 kV
Signal Detected:

- Secondary electrons
  (SE, BSE Detectors)
- X-rays (EDX)

Elements Detected: B-U (EDX)
Lateral Resolution: SEM: 2.0 nm @ 25 kV
2.5 nm @ 1 kV
EDX:≥ 3 μm
Depth Resolution: EDX 0.5 – 3 μm
Detection Limits: EDX: 0.1- 1 at%

Application areas

- High resolution SEM images
- Elemental analysis by EDX (point analysis, line scan and mapping

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Transmission Electron Microscopy (TEM)

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Technical Parameters

TEM System:
FEI Tecnai Osiris
Super-X windowless silicon drift detector
Primary Beam: Electrons 200 keV
Signal Detected:

- Transmitted electrons
- Scattered electrons
- X-rays

Elements Detected: B-U (EDX)
Lateral Resolution: TEM: 0.26 nm
STEM: 0.18 nm
EDX: 5 nm
Detection Limits: EDX: 0.1 - 1 at%
EELS: 1 at%
EELS Energy Resolution: 1.1 eV
Goniometer: α: -35°- 35°
β: -30°- 30°
STEM: BF, DF, HAADF Detectors

Application areas

- Cross-section and plan-view (S)TEM analysis
- Failure analysis of integrated circuits
- Determination of crystallographic phases
- Crystal defect characterization
- Ultra small area elemental analysis by EDX and EELS

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X-Ray Photoelectron Spectroscopy (XPS)

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Technical Parameters

Photoelectron Spectrometer:
PHI VersaProbe II

X-Ray Source: Aluminium anode (Al Kα, photon energy 1486,6 eV)
Ion Source: Ar^+ Ions (Energy 0.25-5 keV)
Primary Beam: mono chromatised AlKα - 1486,6 eV

Signal Detected: Photoelectrons
Elements Detected: Li – U Chemical bonding information
Lateral Resolution: 10 µm – 100 µm
Depth Resolution: 2 - 5 nm (Profiling Mode)
Detection Limit: 0.5 at%

Application areas

- Surface analysis of organic and inorganic materials
- Determining composition and chemical state information from surfaces
- Depth profiling for thin film composition
- Thin film oxide thickness measurements

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Auger Electron Spectroscopy (AES)

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Technical Parameters

Auger Electron Spectrometer:
Physical Electronics PHI 670 Nanoprobe

Ion source: Ar^+ Ions (Energy 1-5 keV)

Primary Beam: focused electron beam (1 - 25 keV) – Field emitter
Signal Detected: Auger electrons, Secondary electrons

Elements Detected: Li-U; Chemical bonding information

Lateral Resolution: 100 nm
Depth Resolution: 2 – 3 nm (Profiling mode)
Detection Limits: 0.1-1at% sub-monolayer

Application areas

- Surface analysis
- Particle analysis
- Small-area depth profiling
- Defect analysis
- Thin film composition analysis

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Hall Effect Measurement System

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Technical Parameters

Lakeshore 7600 System

Magnetic Field: 0-1.8 Tesla

Temperature: 15K -800 K

Software:

Quantitative **M**obility **S**pectrum **A**nalysis Software (**QMSA**) calculates the mobility and concentration of different charge carriers (holes and electrons)

Application areas

- Measurement of resistivity and Hall coefficient by Van-der-Pauw method (10 mΩ-10 MΩ)
- Temperature- and field-dependent determination of sheet carrier density and carrier mobility

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X-ray Diffraction (XRD)
X-ray Reflectivity (XRR)

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Technische Parameter

X-Ray Diffractometer
RIGAKU SmartLab (9 kW rotating anode,Cu) 18 kW Rotating Anode X-ray Generator with Dmax 1500 und Triple-Crystal Diffr.

SmartLab
Variable X-Ray optics, Bragg-Brentano and parallel beam with crystal collimator and analyzer (2Θ: 0 – 130°, Φ– and χ–Rotation□, "in-plane"-Option, 1100°C-Temperofen

Dmax1500
XRR from 0° to about 10° 2Θ
XRD im wide angle range up to 105° 2Θ

Triple-Crystal Diffractometer
Ge-400 2x Channel-cut collimator
Angle range ΔΘ : ± 3600 arcsec
Step width: 0.01 arcsec

Application areas

- XRR measurements of smooth layer systems determination of layer thickness, roughness, and density (thickness range: 1 – 500 nm)XRD
- XRD measurements for phase analysis, in-situ high-temperature studies
- HR-XRD measurements of single crystals with epitaxial layer structures (e.g. Si1-xGex) or implantation layers, determination of layer thickness, strain, and content of dopants
- Pole figure and in-plane measurements
- Rocking curve and reflectivity curve simulation and fitting program RCRefSimW 1.09

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Raman - Spectroscopy

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Technical Parameters

Raman-Spectrometer:
Renishaw inVia Raman Microscope

Measurement geometry:
Backscattering

Measurement range: 100 cm^{-1} - 3200 cm^{-1}

Excitation wavelenght:
UV: 325 nm
Visible: 457 nm, 488 nm, 514 nm, 633 nm
Polarisation: normal, orthogonal, circular

Lateral resolution: minimum spot size:
0.6 µm

Scanning and Mapping:
Minimum step: 0.1 µm
Scan range: 30 x 30 mm^2

Application areas

- Thin layer composition (Si, Ge, C)
- Characterisation of intrinsic stress
- Quality of Graphen thin layers
- Defect analysis

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