



CENTRE FOR HYDROGEN ENERGY TECHNOLOGIES

**provided services
and
available facilities**



Facilities overview

Material synthesis:

- [Magnetron sputtering physical vapor deposition \(PVD\)](#)
- [Electron beam PVD](#)
- [Planetary Ball Milling \(BM\)](#)

Bulk analysis:

- [X-ray Diffraction \(XRD\)](#)
- [Glow Discharge Spectroscopy \(GDS\)](#)
- [Nitrogen, Oxygen and Hydrogen quantity analysis](#)
- [Impedance spectroscopy \(ionic-electronic conductivity\) analysis](#)

Surface analysis:

- [X-ray Photoelectron Spectroscopy \(XPS\)](#)
- [Auger Electron Spectroscopy \(AES\)](#)
- [Scanning Electron Microscopy \(SEM\)](#)
- [Energy Dispersive Spectroscopy \(EDS\)](#)
- [Atomic Force Microscopy \(AFM\)](#)
- [Contact stylus profilometry](#)
- [Nanoindenter microhardness testing](#)

Other :

- [Sievert type volumetric gas sorption/desorption analysis](#)
- [Optical spectroscopy and microscopy](#)
- [Other auxiliary laboratory equipment](#)

* **Remark:** you can press links to go directly to the related slides with main parameters of selected equipment



Magnetron sputtering system (PVD)

Main applications:

- Thin and thick film deposition
- Plasma treatment for surface activation/modification or other needs

Key features:

- 1500 L/s cryopump, base pressure $< 8 \times 10^{-8}$ mbar
- Three 400 W 3" magnetrons equipped with DC, pulsed-DC and RF power sources
- 2 MFC gas inlet channels
- 1-200 a.m.u. residual gas analysis (RGA)
- Heating up to 300 °C

Equipment:



Model: PVD-75

Manufacturer: Kurt. J. Lesker



Electron beam deposition system (PVD)

Main applications:

- Thin and thick film deposition
- Plasma treatment for surface activation/modification or other needs

Key features:

- 1500 l/s cryopump, base pressure $<8 \times 10^{-8}$ mbar
- 5 kW Electron Beam power source
- In-situ film thickness monitoring and control
- 2 MFC gas inlet channels, 1-200 a.m.u. RGA
- Substrates up to 4" diameter
- Heating up to 600 °C,
- RF and Ion Gun cleaning/treatment

Equipment:



Model: PVD-75

Manufacturer: Kurt. J. Lesker



Planetary Ball Milling (BM)

Main applications:

- Milling of materials to nm/ μ m size powders
- Cold welding and reactive nanomaterial synthesis

Key features:

- Grinding speed up to 650 rpm
- Sample quantity 1-200 ml
- Grinding in inert and reactive gas atmospheres up to 150 bars pressure
- Grinding of wet suspensions
- Continuous in-situ monitoring and recording of gas pressure and temperature

Equipment:



Model: Pulverisette 6
Manufacturer: Fritsch



X-ray Photoelectron Spectroscopy (XPS)

Main applications:

- Examining the elemental and chemical state information of a wide range of inorganic and organic solid materials, films, powders etc.

Key features:

- Monochromated Al radiation
- Energy resolution on Ag - FWHM < 0.50 eV (Ag 3d_{5/2}), on PET - FWHM < 0.85 (O=C*-O)
- Large and micro-area XPS, AR-XPS, UPS
- Dual beam charge neutralization
- Chemical and secondary electron imaging with a raster scanned 10 μm diameter beam

Equipment:



Model: PHI 5000
Versaprobe
Manufacturer: Physical Electronics, Inc.



Auger Electron Spectroscopy (AES)

Main applications:

- Correlate surface and bulk composition with electrical properties, growth mechanisms.
- Corrosion mechanisms and fracture analysis.
- Semiconductor, thin film composition, defect and impurity identification and quantification

Key features:

- Auger electron excitation: Schottky FE
- Cylindrical mirror analyzer (CMA) with energy resolution for AES: 0.5% to 0.1% $\Delta E/E$
- Elemental Auger mapping to 500,000 X magnification (resolution <8 nm)
- Ion gun for charge neutralisation

Equipment:



Model: PHI 700 Xi
Manufacturer: Physical Electronics, Inc.



Scanning electron microscopy (SEM) + EDS

Main applications:

- Investigation of various inorganic and some of the organic samples (magnification up to 300000)
- Composition analysis and elemental mapping with Energy Dispersive Spectrometer (EDS)

Key features:

- SE resolution of 3nm at 30 kV, 10nm at 3kV, BSE resolution of 4 nm at 30 kV
- Low vacuum mode (6-270 Pa) allows to measure dielectrics without any pretreatment
- Sample diameter up to 200 mm, height - 80 mm
- 3D imaging and quantitative analysis
- EDS elemental composition analysis

Equipment:



Model: S-3400N
Manufacturer: Hitachi



Atomic force microscopy + contact profilometry

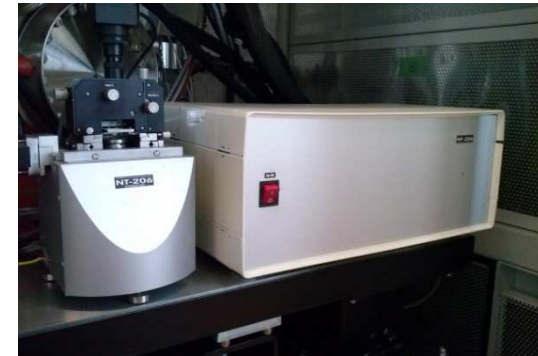
Main applications:

- Qualitative and quantitative surface topography analysis
- Film thickness measurements

Key features:

- AFM: Maximum range of heights: 2-4 μm ;
lateral resolution (plane XY): 1-5 nm,
vertical resolution (direction Z): 0.1-0.5 nm;
scanning matrix: up to 1024x1024 points.
- Profiler: Maximum sample thickness: 30 mm,
maximum range of heights: 400 μm ;
vertical resolution: 1Å at 10 μm , 15Å at 100 μm ;
stylus Force: 0.05-10mg (programmable).

Equipment:



AFM model: NT-206
Manufacturer: Microtestmachines



Profiler model: XP-200
Manufacturer: Ambios



Nanoindenter microhardness testing

Main applications:

- System for measuring the material strength of micro regions, such as semiconductors, LSI, ceramics, hard disks, vapor deposited films, thin coating layers, plastics and rubbers

Key features:

- Triangular pyramid indenter
- Test force range: 0.1 - 2000 mN, test force accuracy: no more than 1% of displayed force
- Instrument measures dynamic indentation depth, not the indentation after the test.
- Measurement of very thin films and surface (treatment) layers: measuring range 0-10 μm , minimum measuring increment 0.001 μm
- Supplies the data to calculate elastic modulus

Equipment:



Model: Dynamic Ultra-Hardness Tester
DUH-211S
Manufacturer: Shimadzu



X-ray Diffraction (XRD)

Main applications:

- Crystal structure analysis
- In-situ heating/cooling and phase change analysis

Key features:

- Configurations: Theta/2Theta, Theta/Theta
- Smallest step size (Theta/2Theta): 0.0001° , reproducibility (Theta/2Theta): $\pm 0.0001^\circ$;
- Motorized divergence and antiscatter slits, fixed slits, 60 mm Göbel mirror and 0.12° long soller slit for parallel beam operation
- MRI heating/cooling chamber: temperature range: -190 – 1400°C , pressure: 10^{-11} – 2 bar
- 3 detectors: Scintillator, Li-drifted Silicon, PSD

Equipment:



Diffractometer

Model: D8
Manufacturer: Bruker

Heating chamber

Model: TC-wide range
Manufacturer: Mri



Glow Discharge Optical Emission Spectroscopy

Main applications:

- Bulk elemental analysis of metals, alloys, etc.
- Qualitative and quantitative depth profiling of conductive and dielectric film/layer systems
- Detecting changes in chemical composition of sample surface compared to subsurface

Key features:

- Usable wavelength range: 119 – 800 nm;
- Paschen Runge polychromator of 0.75 m focal length, resolution < 25 pm in all spectral range
- Selectable anode diameter: 2.5 and 4 mm
- DC source, operational up to 1500V, 250 mA; RF source, fully programmable up to 150 W
- 27 installed PMT channels and 200-800nm CCD

Equipment:



Model: GDA-750
Manufacturer: Spectruma



Nitrogen, Oxygen and Hydrogen quantity analysis

Main applications:

- Determination of the O/N/H contained in ferrous and non-ferrous metals, ceramics, electronic materials and other inorganic materials using the inert gas fusion method.

Key features:

- Measurement range (at 1 g sample): oxygen: 0-5%, nitrogen: 0-3%, hydrogen: 0-0.25% (up to 100% wt is possible with less sample).
- Sensitivity (minimum reading):
Oxygen/Nitrogen/Hydrogen: 0.001 ppm
- Cycle Time (includes purge/outgas/analysis) not more than 100 s for oxygen, 120 s for nitrogen, 110 s for hydrogen

Equipment:



Model: EMGA – 830AC

Manufacturer: HORIBA



DC, AC, Impedance spectroscopy

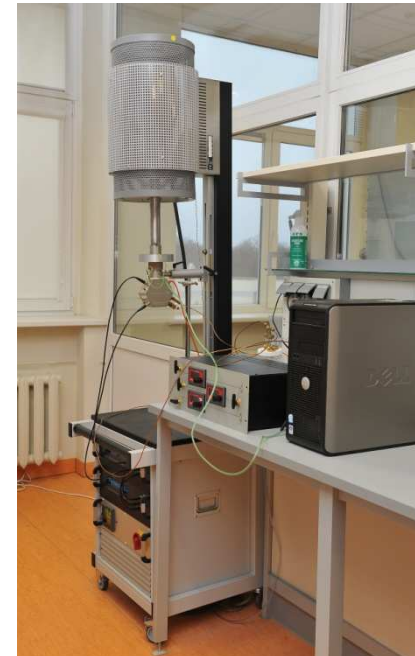
Main applications:

- Measurements of electrical properties, transport parameters (eg. ions), kinetics of materials, solid/as interfaces and electrodes under controlled atmospheres at high temperatures

Key features:

- AC amplitude 0-3 V_{rms}, voltage range 1 μ V to 3 V_{rms}, frequency range 10 μ Hz to 32 MHz, impedance range 10 Mohm to 100 Mohm
- Potentiostat/galvanostat: maximum applied polarisation 14.5V/2A, frequency 10 μ Hz-1MHz
- Atmosphere: oxidising or reducing, wet or dry, from small overpressure to vacuum low, Temperature: >1400°C (short term <1600°C)

Equipment:



Model: ProboStat
Manufacturer: Norwegian Electro Ceramics AS



Sievert type volumetric gas sorption/desorption

Main applications:

- Fully automated Sievert instrument for measuring gas sorption properties (thermodynamics, kinetics, cycling) of materials, especially for hydrogen storage

Key features:

- Main measurements: PCT Isotherms; Sorption Kinetics; PCT and Kinetics Cycling; Temperature Programmed Desorption;
- pressure steps can be controlled sub-atmospherically (1 mbar) up to 200 bar
- Temperature from LN₂ up to 350°C
- Microdoser for µg sample amounts

Equipment:



Model: PCTPro 2000
Manufacturer: HyEnergy (Setaram)



Optical spectroscopy and microscopy

Main applications:

- Optical investigation of samples up to 1000x magnification
- Spectroscopic analysis in UV-Vis/NIR

Key features:

- Microscope: Bright field CFI LU Plan Flour EPI objectives (10x, 20x, 50x, 100x); Nikon DS-Fi1 Digital 5-Megapixel CCD camera that captures 2560x1920 pixels.
- Spectrophotometer: double-beam with single monochromator, linearity up to 4 absorbance, range 190-900nm, variable bandpass to 0.1nm

Equipment:



Microscope model: Eclipse LV150
Manufacturer: Nikon



Spectrophotometer: V-650
Manufacturer: Jasco



Other auxiliary laboratory equipment

Auxiliary facilities:

- High temperature (up to 1700 °C) furnace
- High precision Analytical Balance
- Ultrasonic Baths
- Fumes
- Glovebox
- 4 probe resistivity measurements

