Institute of Physics

Center for Science and Education
Silesian University of Technology

DIVISIONS, LABORATORIES and METHODS

Divisions:

- Division of Applied Physics
- Division of Radioisotopes
- Division of Solid State Physics

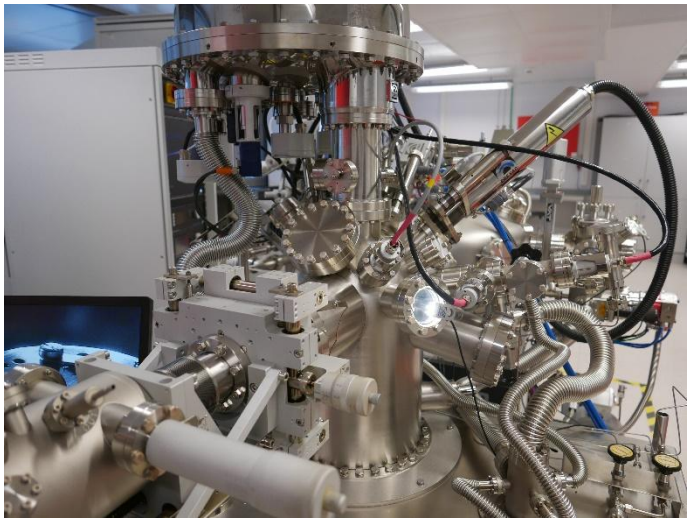
Division of Applied Physics

Electron Spectroscopies and Functional Materials Laboratory

ESpeFuM

Ultra high vacuum system for thin film deposition and testing of materials:

- fully controlled deposition of ultrathin organic layers (PVD),
- investigation of elemental composition, chemical state and electronic state of solid surface by X-ray and ultraviolet photoelectron spectroscopies (XPS, UPS), and photoemission yield spectroscopy (PYS),
- investigation of sensing mechanisms by thermal desorption spectroscopy (temperature programmed desorption - TDS or TPD),
- surface cleaning and depth profiling by the use of ion etching.

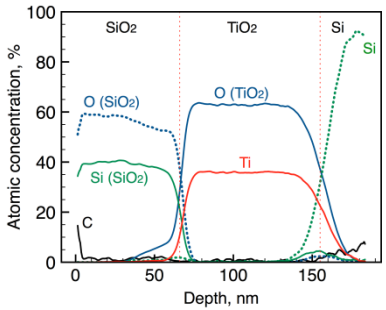


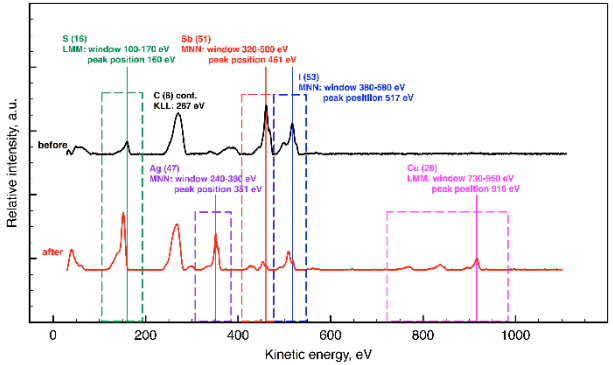
Electron Spectroscopies and Functional Materials Laboratory

ESpeFuM

PHI 670 Scanning Auger Nanoprobe System:

- mapping of elemental composition of solid surface,
- elemental analysis at selected spots on solid surface with high spatial resolution (<100 nm),
- in-depth chemical profiling in a selected area (< 1x1 mm^2),
- precise selection of the measured area (SEM preview).



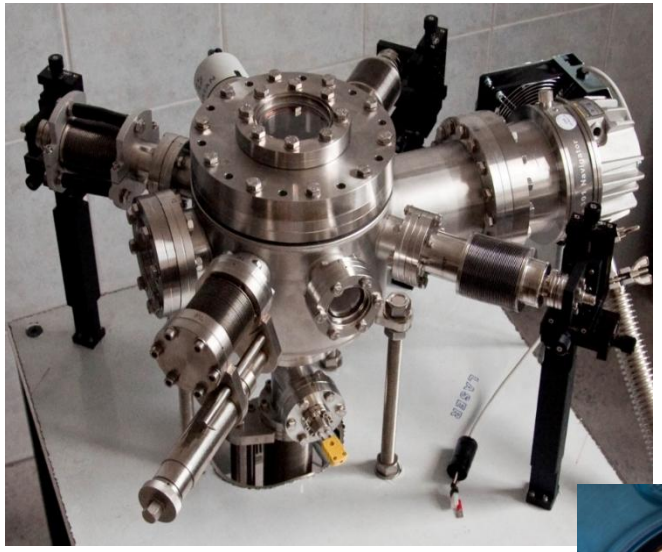


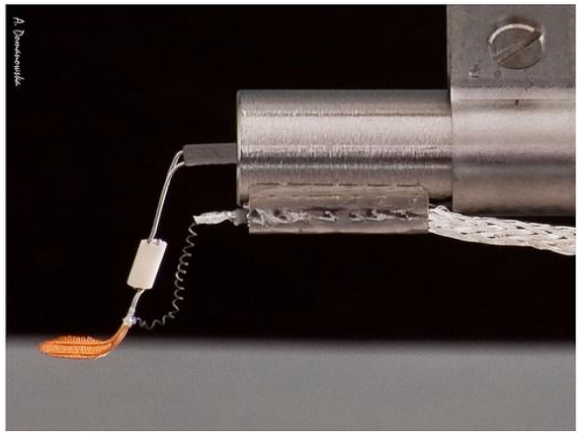
Electron Spectroscopies and Functional Materials Laboratory

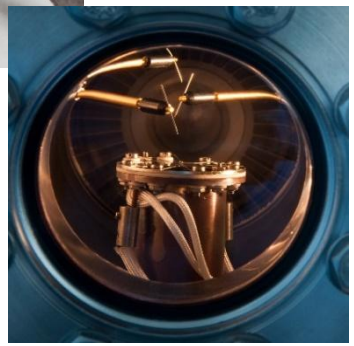
ESpeFuM

Vacuum system equipped with a Kelvin probe, micromanipulators, UV-VIS light sources and spectrophotometer for electric and photoelectric measurements:

- surface potential (KP),
- surface photovoltage (SPV)
- photoluminescence (PL),
- photocapacitance,
- photocurrent.







Electron Spectroscopies and Functional Materials Laboratory

ESpeFuM

Scanning microscope (XE-70, Park Inc.):

- contact and non-contact atomic force microscopy (AFM),
- electric force microscopy (EFM) and Kelvin probe force microscopy (KPFM)
- scanning thermal microscopy (SThM),
- temperature controlled sample table: RT – 600 °C.

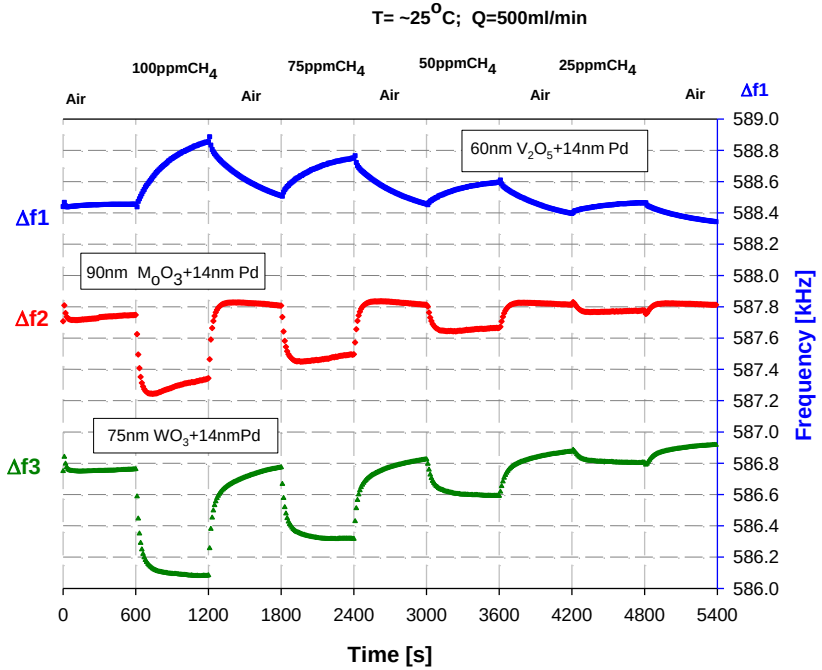
Laboratory of spintronics and optical spectroscopies

- magneto-optic Kerr effect measurements with diffracted option (DMOKE):
  - measurements of exotic magnetic states in low-dimensional structures
    and magnetic properties of textile materials,
- Brillouin spectroscopy:
  - investigation of elastic properties of layers, multilayered structures and samples of arbitrary shapes,
  - investigations of spin-waves in ferrimagnetic nanolayers,
- Clustered micromagnetic simulations:
  - analysis of low-dimensional magnetic structures by the use of finite elements method,
  - investigations of magnetization dynamics including switching between bit states.

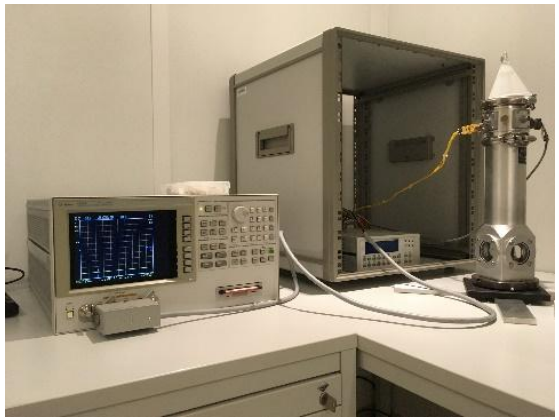
Laboratory of sensor structures

Laboratory equipped with OVG Owlstone dossing system:

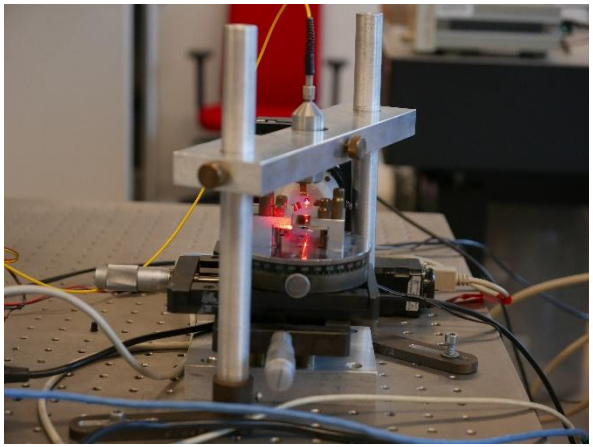
- analysis of sensing mechanisms in resistance and surface-acoustic-wave sensors for low pollutants concentration in air of controlled humidity,
- investigation of various sensor structures.



Other equipment



- Impedance analyzer (Agilent 4990A).
- Differential scanning calorimeter (DSC 3500 Sirius, Netzsch): 170 – 600 °C.
- Setup for photothermal radiometric and photodeflection measurements (PTR, PDS):
  - thermal diffusivity and effusivity measurements on plate-like and layered samples.



International programmes for scientific collaboration

- Visegrad Group (V4) -Japan Joint Research Program on Advanced Materials:
  Highly Safe GaN Metal-Oxide-Semiconductor Transistor Switch (SAFEMOST).
- Hubert Curien Programme for Scientific Research „POLONIUM”:
  Towards the metrology for local thermal conductivity measurement and imaging with sub-micron resolution.

UNIVERSITE DE REIMS CHAMPAGNE-ARDENNE

GRESPI
Groupe de Recherche En Sciences Pour l'Ingénieur

Division of Radioisotopes

Division of Radioisotopes

GADAM Centre of Excellence (Gliwice Absolute Dating Methods Centre)

- Radiocarbon Laboratory – Liquid scintillation counting (LSC) facility
- Radiocarbon Laboratory – Accelerator Mass Spectrometry (AMS) facility
- Radiocarbon Laboratory – Isotope Ratio Mass Spectrometry (IRMS) facility
- Laboratory of Luminescence Dating (LD)

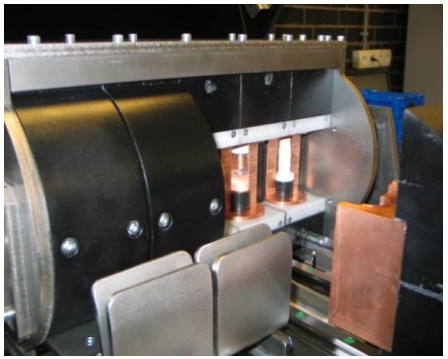
Liquid scintillation counting (LSC) facility

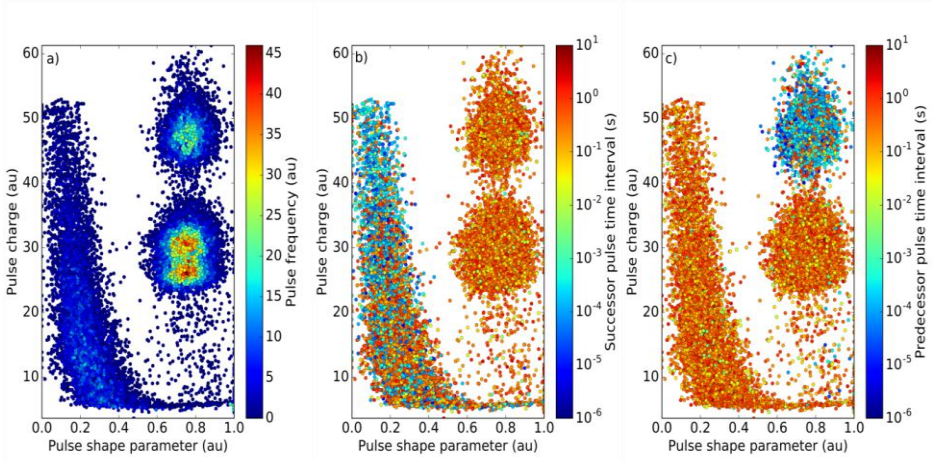
- chemical and physical facilities for pretreatment of samples dedicated to measure of the concentration of the ^{14}C isotope
- equipment to obtain CO_2 for the production of a liquid scintillator to measure the concentration of the ^{14}C isotope in liquid combustible organic compounds, especially in fuels (patent PL 219401)
- vacuum line for benzene production
- two automatic liquid scintillation beta radiation spectrometers Quantulus 1220 with the ultra low-level background
- Two small liquid scintillation beta radiation spectrometers with ^{222}Rn decay products excluded (patent PL 222910)
- MultiCell LSC spectrometer (see the next page)

Application: measurements of ^{14}C concentration in environmental samples and industrial products - bio-fuels, food.

MultiCell LSC spectrometer

- Pulse analyzer measures the pulse height, its shape, and the time between pulses
- Scintillation mismatch index allows for active background reduction
- $^{214}Bi/^{214}Po$ measurement with ultra low background of 2 pairs per 48 h for low level ^{222}Rn
- LSC spectrometer allows low level ^{14}C measurements for radiocarbon dating.





Accelerator Mass Spectrometry (AMS) facility

Preparation of geological, biological and archaeological samples (e.g. plant remains, charcoal, peat, bones, shells) for radiocarbon dating with use of accelerator mass spectrometry (AMS) technique.

Laboratory equipment:

- chemical and physical pre-treatment facilities
- vacuum lines for production and purification of CO_2
- automated combustion and graphitisation system (AGE-3) with elemental analyser

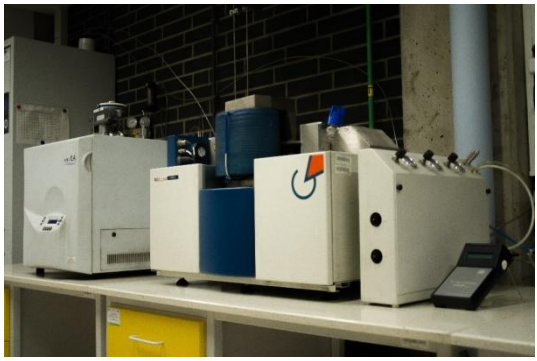
Accelerator Mass Spectrometry (AMS) facility

Selected projects:

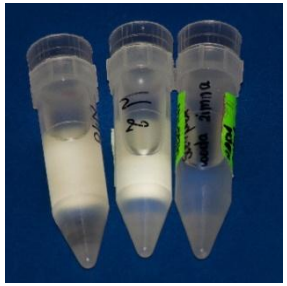
- Trees as bio-indicators of industrial air pollution during implementation of pro-environmental policy in Silesia region.
- Genetic diversity and habitat preferences of European red deer (*Cervus elaphus*) in Europe and Asia in the Late Pleistocene and Holocene.
- Isotopic method of anthropogenic CO_2 emission with use of annual tree-rings for Upper Silesia region
- Reconstruction of air pollution history in Europe over the last millennium: Comparative study of sedimentary and biological archives.
- PARAD: PeAt bog Records of Atmospheric Dust fluxes – Holocene palaeoenvironmental and paleoclimatic implications for Southern South America.
- CONTINENT - High-resolution continental paleoclimate record in the Lake Baikal: A key-site for Eurasian teleconnections to the North Atlantic Ocean and monsoonal systems.

Isotope Ratio Mass Spectrometry (IRMS) facility

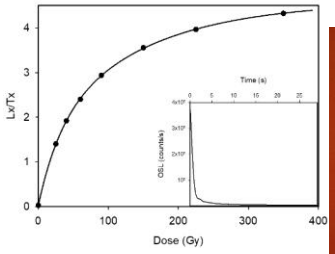
- IsoPrime IRMS mass spectrometer operating in continuous flow mode
- Elemental analyser EuroVector EA2000:
  - Automatic solid samples combustion for carbon and oxygen elemental and isotopic analyses
  - Automatic solid samples pyrolysis for oxygen elemental and isotopic analyses
- MultiFlow – automatic system for sample preparation for carbonates, water and carbon dioxide isotopic analyses
- Vacuum rigs for off-line samples preparation
- Two microbalances



Application: measurements of stable isotopes composition of hydrogen, carbon, nitrogen and oxygen for the need of geology, geography, archaeology, biology, environmental science as well as industrial application bio-fuels, food control and others



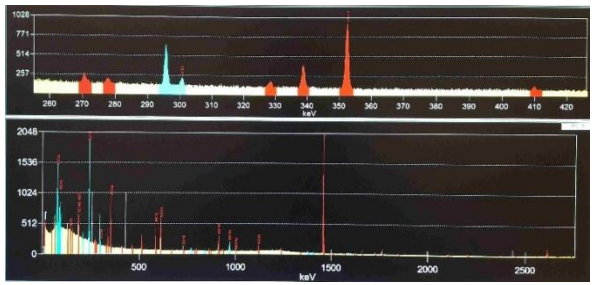
Laboratory of Luminescence Dating (LD)



Laboratory equipment:

- 4 automatic luminescence readers
  (3 by Daybreak, 1 by Risoe including a single-grain reader)
- 3 HPGe high-resolution spectrometers
- Scintillation gamma spectrometer – mobile

Application: Luminescence dating method applicable to sedimentary deposits, aeolian, fluvial, lacustrine, glaciogenic, coastal and marine applications ranging from a several dozen of years of age to about two hundred thousand years.



Laboratory of Luminescence Dating (LD)

- 2 alpha radiation spectrometers (Si - pin) - dating method using ^{210}Pb
- Laser-based grain analyzer - used for particle sizing technique for materials ranging from hundreds of nanometers up to several millimeters in size.
- Thick source alpha counter – used for small samples (ceramics) to estimate the dose rate for luminescence dating

Division of Solid State Physics

Division of Solid State Physics

experimental methods for

Technology:

- **Sonochemical preparation of nanomaterials**
- Ultrasonic welder for nanowires and nanotubes
- Setups for monocrystal growth from gaseous phase

Measurements:

- Systems for measurements of **optical parameters** of materials including photoluminescence measurements in UV-VIS
- Setup for measurements of **electric and dielectric parameters** using impedance spectroscopy in vacuum, in different gases, and for different temperatures
- Setups for **semiconductors** measurements: diffusion length, recombination rate, carriers time of life, mobility of carries, photo-conductance, photo-magneto-electric effects, Hall effect

Nano-sensors and nano-generators:

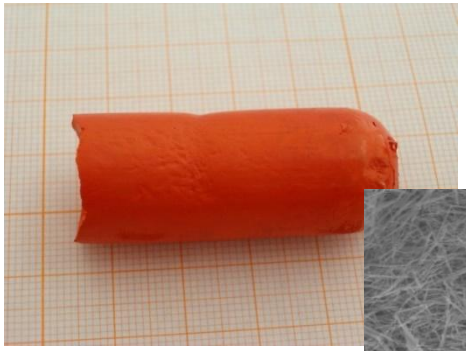
- Setup for desorption and absorption measurements in nanomaterials
- Nanogenerators based on SbSI

Material processing:

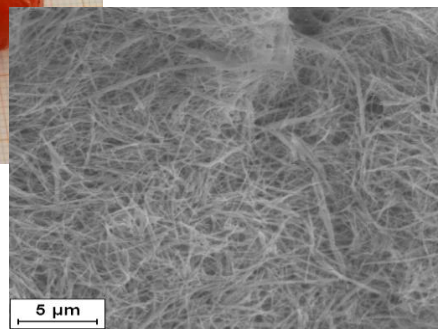
- Molecular CO_2 laser

Sonochemical preparation of nanomaterials

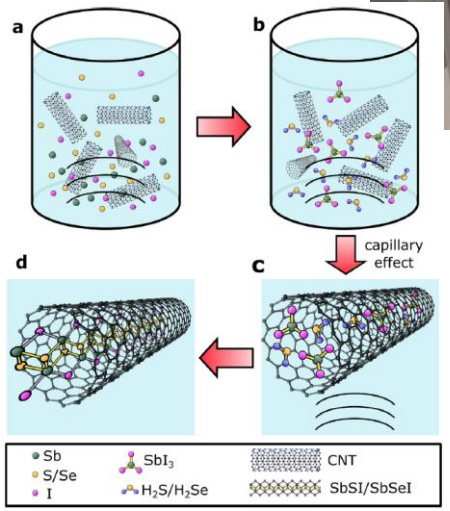
- Vibra-Cell Ultrasonic Processors VCX 750 to safetly process a wide range of organic and inorganic materials, for small and medium volume application (from 250 µl to 1l).
- Control of sonication power range up to 1500 W (with optional accerssories)
- Monitors the amount of energy, that is being delivered to the probe, and terminates the ultrasonics when the desired amount of energy has been dispensed.
- Automatic tuning and frequency control, that eliminates the need for constant adjustment of the power supply.



SbSI ethanogel consisted of nanowires



Carbon nanotubes filled with SbSI, Ultrasonics 83 (2018) 179–187

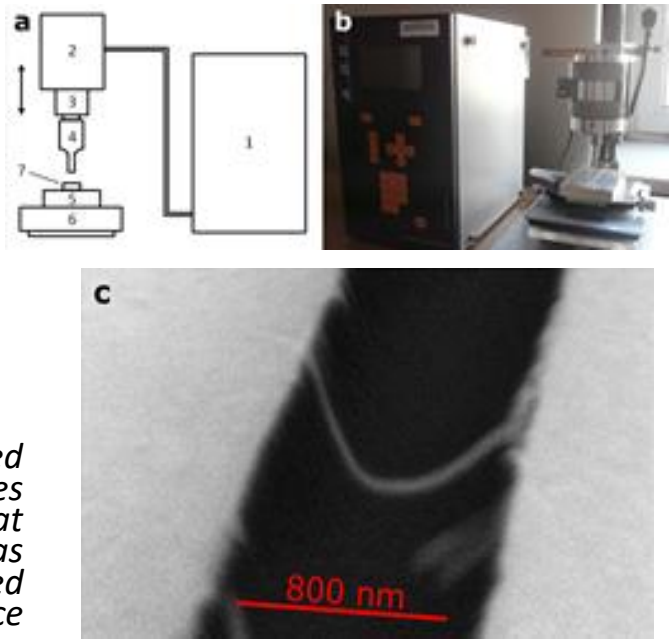


Ultrasonic welder for nanowires and nanotubes

The set up for ultrasonic welding consists of following elements:

- ultrasonic generator ADG70-100P-230-NO (Rinco Ultrasonics) with working frequency 70 kHz and max power 120 W (1);
- frame of the welding head (2);
- transducer C 70-2 (Rinco Ultrasonics) (3);
- Sonotrode (4).

A sample (7) is placed on X-Y stage (5) mounted on a digital scale (6), that is used to adjust the clamping force applied by the welding head to press the nanowires against electrodes. In order to apply ultrasonic energy successfully for bonding at nanoscale, the special sonotrode was designed and fabricated. The sonotrode was made of chromium copper alloy (99.12 % Cu, 0.8 % Cr, 0.08 % Zr) and was ended with single crystal silicon carbide (SiC) head. The average roughness of SiC surface is 2.6(3) nm.



Schematic diagram (a) and photography (b) of experimental set up for ultrasonic processing of nanowires; (c) SEM images of a single SbSI nanowire after ultrasonic bonding to Au microelectrodes on glass substrate.

The laboratory is also equipped with HB05 Manual Wire Bonder:

- gold, aluminium, silver and coper wire;
- wire size from 17µm to 75 µm;
- wedge, ball and ribbon bonding;
- motorised wire clamp.

Setups for semiconductors and sensors measurements

- 10 Kelwin optical closed cycle refrigator system (Janis Research) – measurements within wide range of temperature (10-500K)
- Vacuum chambers ($p<10^5$ mbar)
- Keithley instruments (e.g.: picoammeters, ultra-sensitive current sources, nanovoltmeter, high resistance/low current electrometers)
- Hioki LCR meters (from DC to 5 MHz)

Owned equipment enables measurements of following parameters:

- diffusion length;
- recombination rate;
- carriers time of life;
- mobility of carries;
- conductance and photo-conductance;
- photo-magneto-electric effects;
- Hall effect;
- the influence of various gases on the sensor response.

Systems for measurements of optical parameters

The laboratory is equipped with setups for spectrogoniometric measurements, for measurements of transmittance and reflectance spectra at perpendicular incidence of light, and for measurements of diffusive reflectance and transmittance. Most measurements can be performed at various temperatures (80-400K).

The following parameters can be determined:

- spectral dependencies of absorption coefficients and real parts of refractive indices of the ordinary and extraordinary ray;
- thickness of thin films;
- energy gap in semiconductors;
- energy of excitons;
- anisotropy of the absorption edge;
- morphology of photonic crystals;
- orientation of crystals;
- and others.

Picture of the experimental set-up for spectrogoniometric measurements performed at various temperatures
1 – goniometer, 2 – cylinder with nitrogen gas and filter, 3 – rotameter, 4 – temperature controller, 5 – light source, 6 – refrigerator, 7 – vacuum pump)