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ROZWOJU REGIONALNEGO

Nowy system do epitaksji z wiązek molekularnych i charakteryzacji *in-situ* otrzymywanych nanostruktur

Lech Tomasz Baczewski

ON 3.4

European Union Operational Program for Innovative Economy 2007-2013

National Centre: Magnetic Nanostructures for Spintronics Applications

SPINLAB

Total amount: 10 mln Euros

Participants: Members of National Scientific Network ARTMAG

„Magnetic Nanostructures for Spintronics"

Institute of Molecular Physics PAS, Poznan, Poland
Institute of Physics PAS, Warsaw, Poland
University of Bialystok, Bialystok, Poland
University of A. Mickiewicz, Poznan, Poland
University of Science and Technology, AGH, Krakow, Poland
Institute of Catalysis and Surface Physico-chemistry PAS, Krakow, Poland

http://spinlab.ifpan.edu.pl

INNOVATIVE ECONOMY
NATIONAL COHESION STRATEGY

spinLAB

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Project goal:

Development of scientific infrastructure in the laboratories studying magnetic nanostructures, nanotechnology and nanoelectronics in Poland

Project coordination:

Coordinator: Prof. F. Stobiecki, IFM PAN, Poznan

Partners coordinators:

Prof. L. T. Baczewski - IF PAN Warsaw
Prof. T. Stobiecki - AGH WE Krakow
Prof. A. Maziewski - UwB WF Bialystok
Prof. J. Barnas - UAM WF Poznan
Prof. J. Korecki - IKiFP PAN Krakow

http://spinlab.ifpan.edu.pl

Scientific equipment to be purchased in the frame of *SPINLAB* project:

IF PAN Warsaw: new MBE system with in situ MOKE, ion gun and VT SPM microscope, He-3 cooler (50 mK) for PPMS, and also EDX together with cathodoluminescence (CL) and nanopatterning option for SEM Zeiss microscope

IFM PAN Poznan: Magnetron sputtering, IBS and PLD system for thin films deposition

AGH Krakow: equipment for dynamical time resolved magnetoresistance measurements and computer cluster for simulations, RT AFM/MFM

IKiFP PAN Krakow: LEEM-PEEM (PhotoEmission Electron Microscope – Low Energy Electron Microscope, resolution 8 nm) together with a deposition chamber for adaptation at synchrotron beamline

UAM Poznan: powerful computer cluster for modelling and simulations

University of Bialystok: BLS spectrometer, femtosecond lasers for magnetooptical measurements, optical criostat with superconducting coils for high magnetic fields up to 8T

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Multi-chamber Prevac MBE system configuration :

- Growth chamber (1)
- Load-lock chamber (2)
- Preparation chamber (3)
- Ion source 30 keV chamber (4)
- Storage chamber (5)
- Magnetooptical characterization (MOKE) chamber (6)
- Scaning probe microscope SPM chamber (7)
  (Omicron microscope VT AFM/STM XA 50/500)
- Reorientation chamber - connected to SPM (8)
- SPM probes loading chamber (9)
- Distribution chamber (10)

Multi-chamber MBE system from PREVAC

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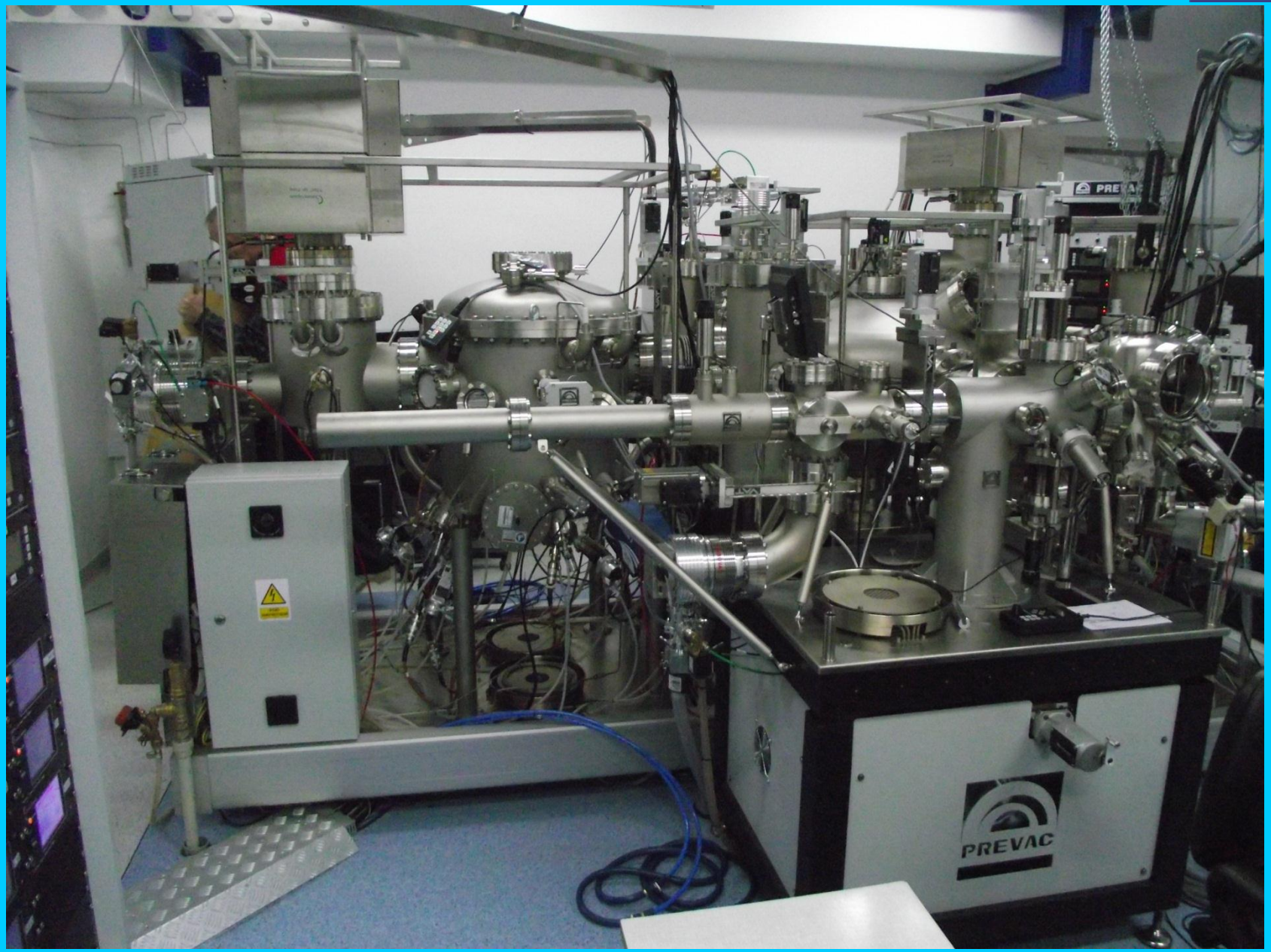
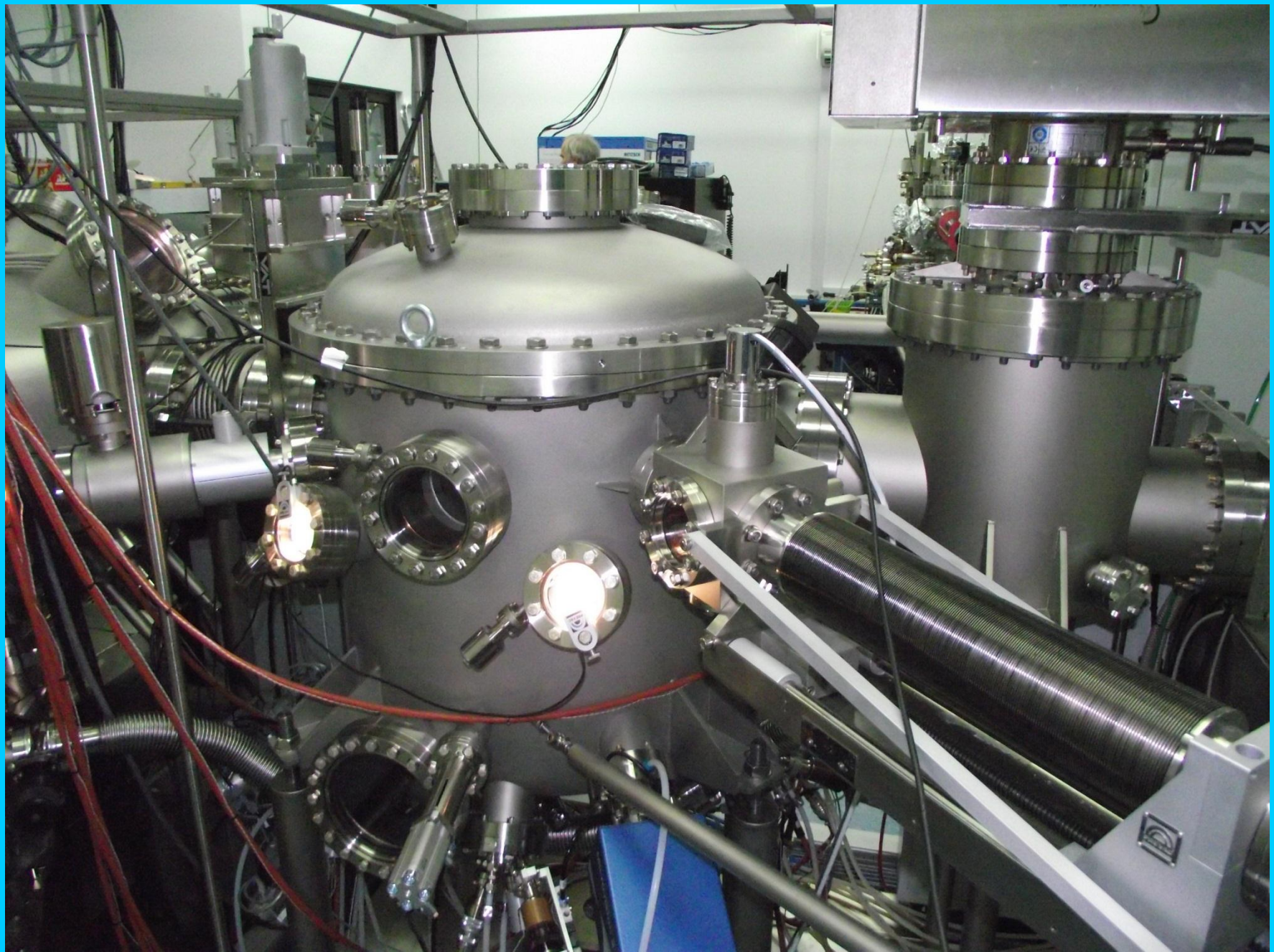


Deposition Chamber



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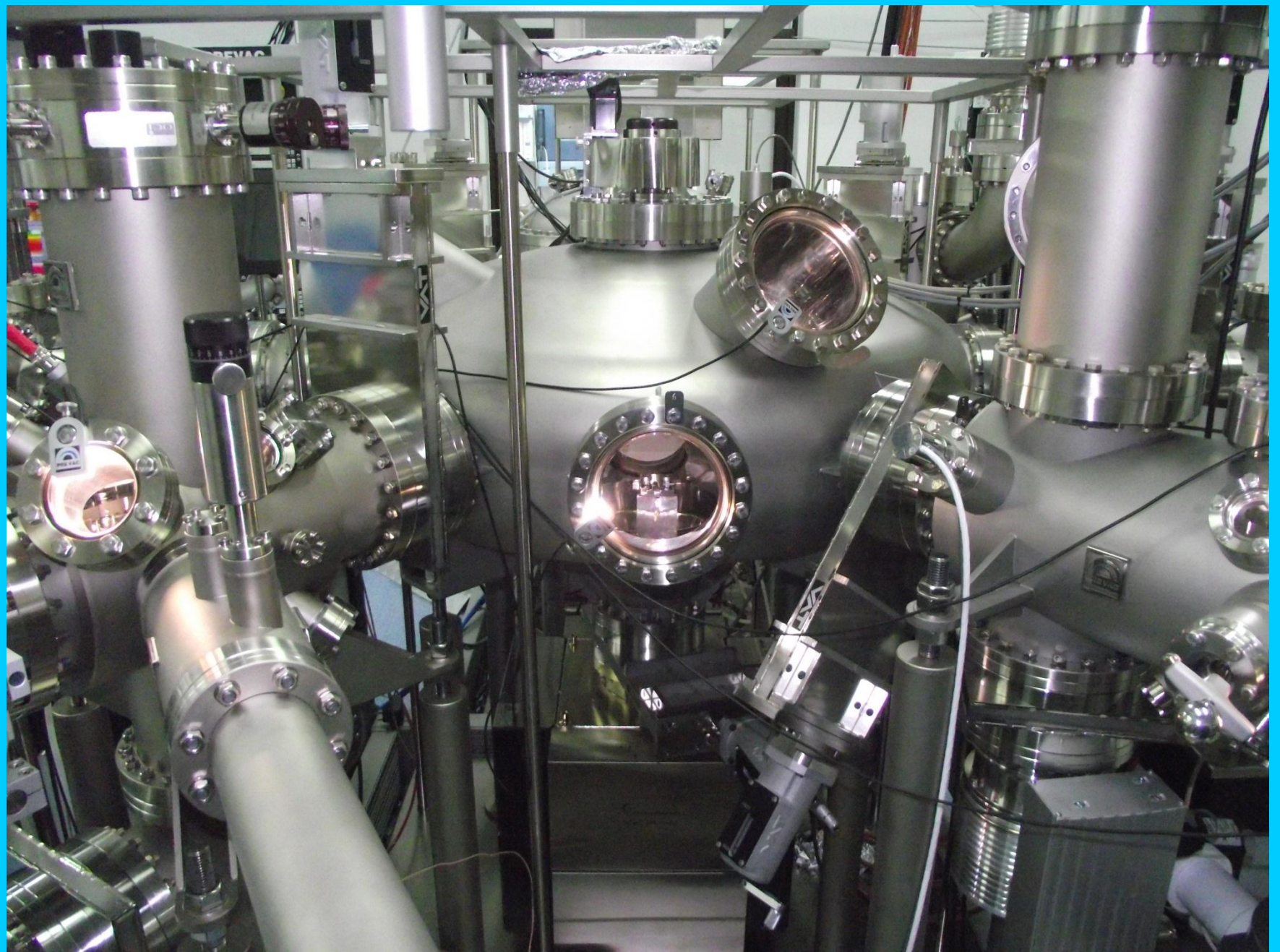
Growth chamber equipment:

- Vacuum < 5 x10^{-11} Torr
- 3 inches moliblock heating up to 1400 C by electron bomardement
- Two electron guns Telemark 10kV, 6 targets each
- Eight effusion cells:

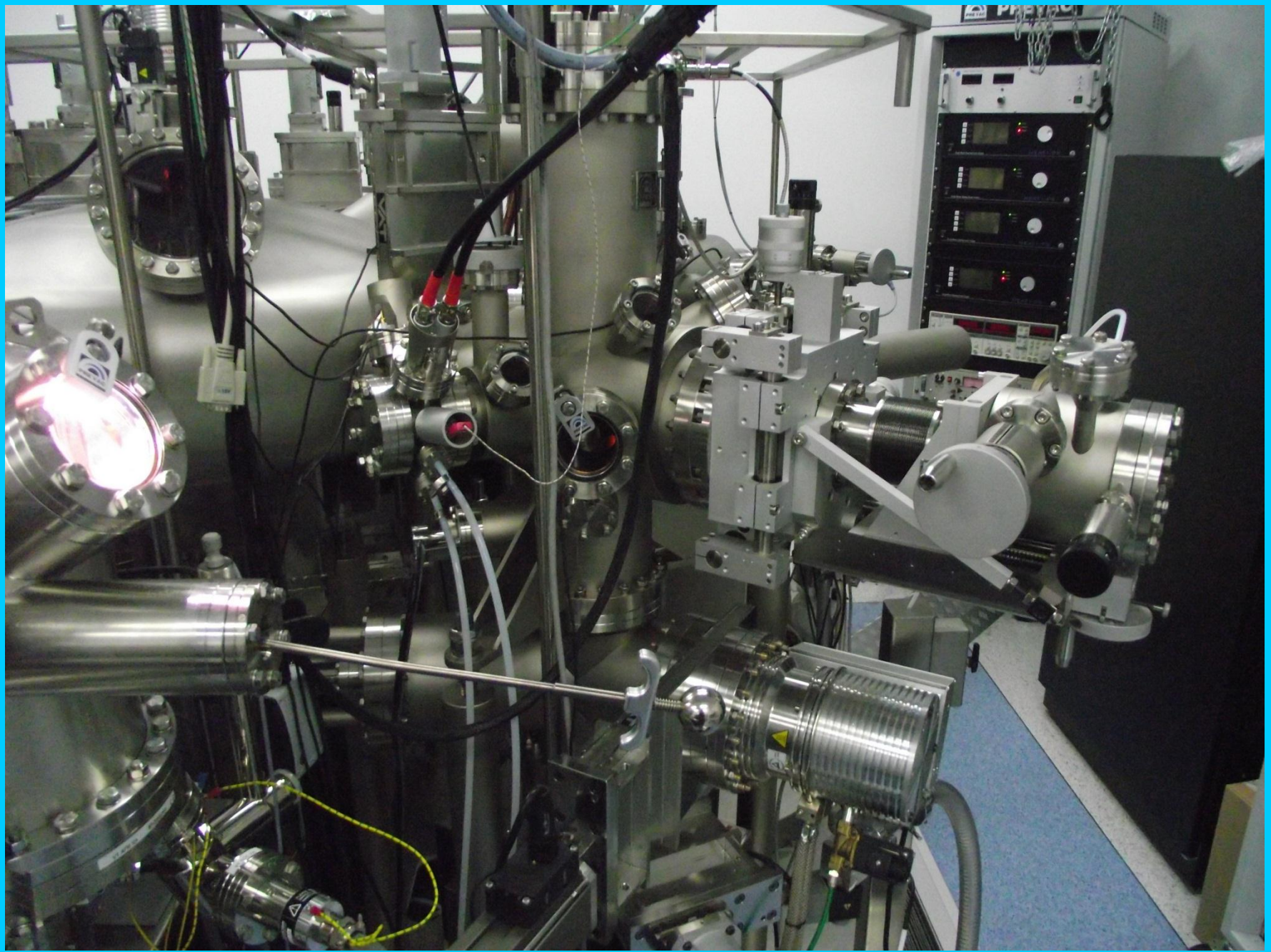
  - 6 high temperature cellls up to 1700 C
  - 2 dual filament cells up to 1400 C

- Movable shutter controlled by step motor for wedge structures
- Movable Quartz oscillator
- Two MKS mass spectrometers for flux control of e-guns down to 0.001 nm/s
- RHEED - STAIB 20 kV
- Color CCD camera for moliblock observation – computer controlled
- Heitronics pirometer for temperature control on a moliblock surface in the range 200 – 1700 deg C
- Software controlling all technological processes

Distribution Chamber (UFO)



Preparation chamber



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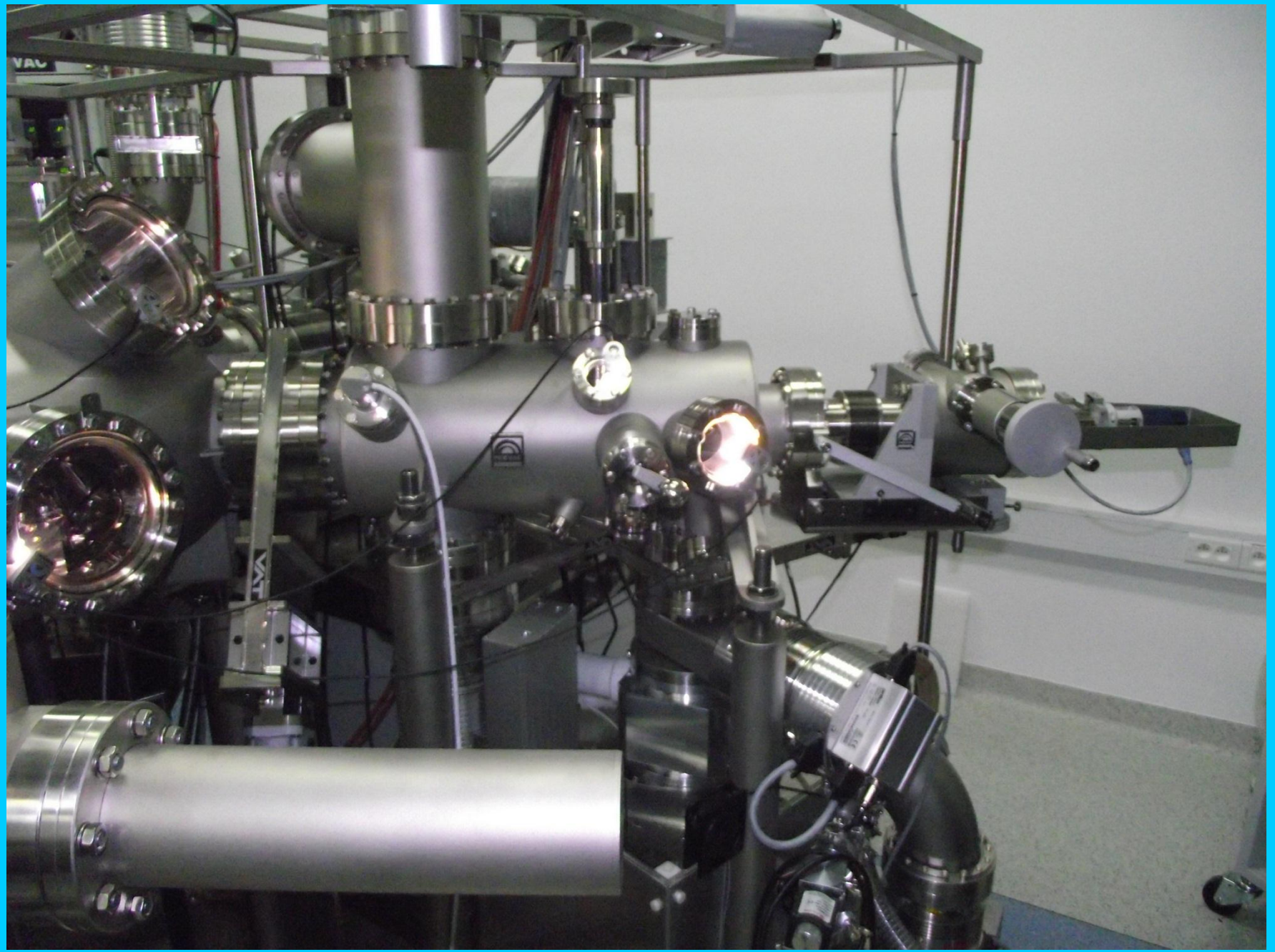
Preparation chamber

- Annealing of samples and substrates on SPM holders by electron bombardement up to 1700 C
- Annealing station of samples and semicoductor substrates by direct heating of electric current on special holders provided by Omicron
- Manipulator for transport of SPM holders between moliblocks and annealing stations
- LEED and Auger spectrometer AES (with LaB_6 cathode) allowing to measure every point on a 3 inches moliblock
- (with adequate software)

Ion gun chamber



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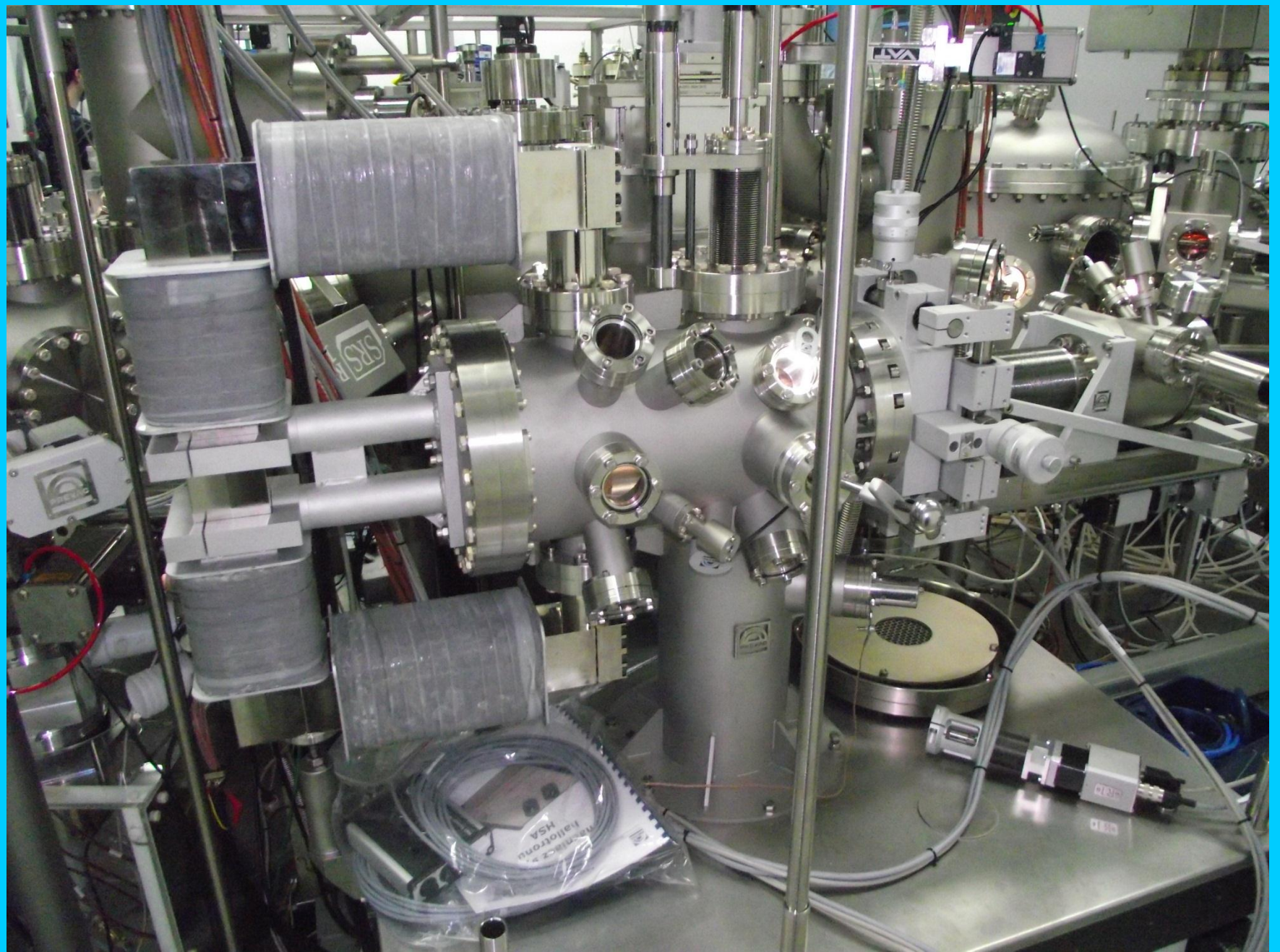
Ion gun chamber

- Ion gun for noble gases (Ar and He) - Peabody Scientific
- with regulated ions energy from 2 to 30 keV,
- uniform energy distribution on 10x10 mm^2 substrate,
- doses regulation,
- water cooling system
- Movable shutter
- Manipulator allowing to change the angle between the ion beam and a substrate plane in the range 0 -90 deg
- Differential pumping facility with two independent turbo pumps

Storage chamber

- Connected to the distribution chamber with gate valve
- Turbo and ion pumps – 10^{-11} Torr
- Six position stage for moliblocks storage

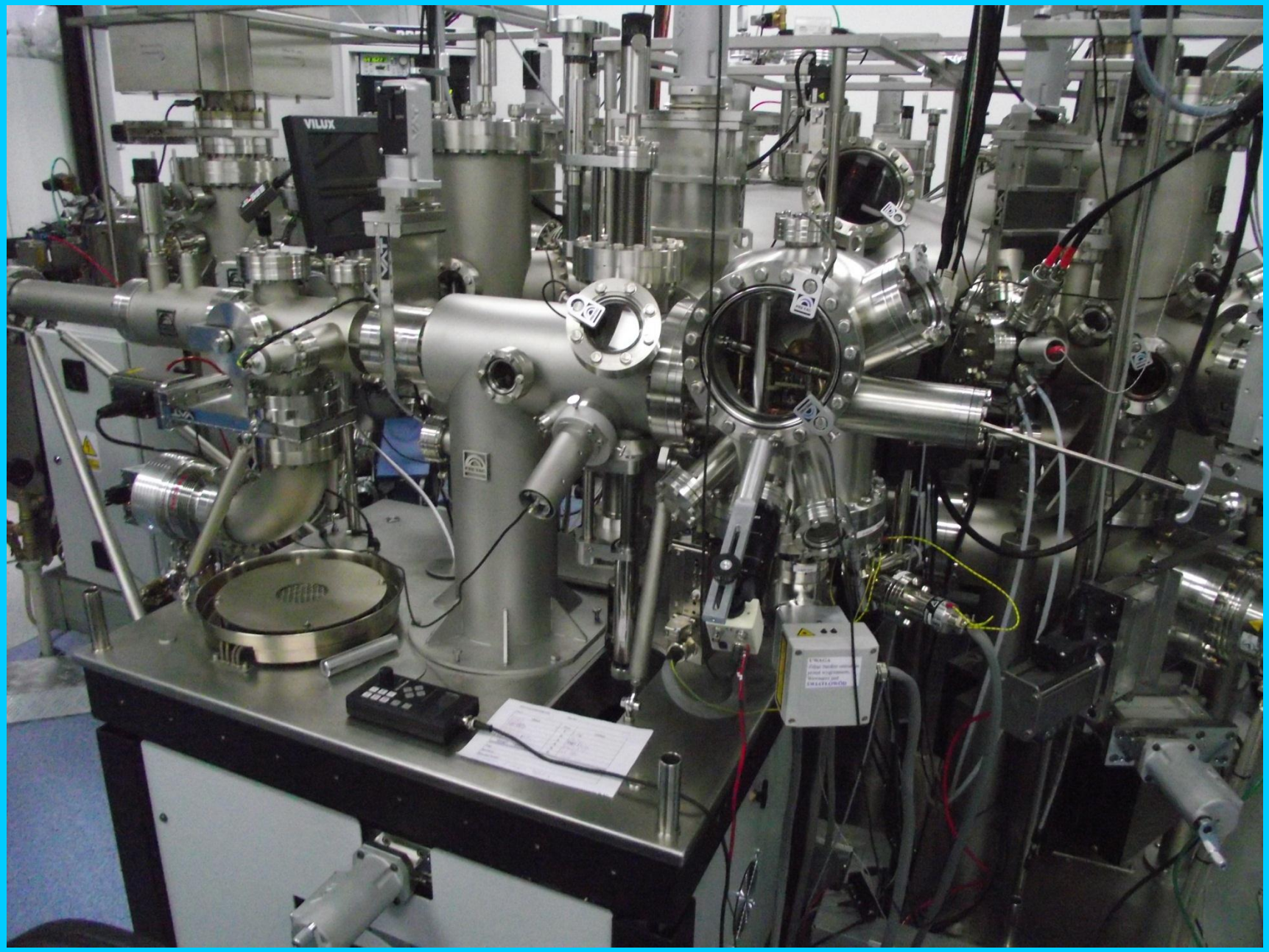
Magnetooptical characterization chamber



Magnetooptical characterization chamber

- Electromagnet providing magnetic field of +/- 0. Tesla
- Possibility of MOKE measurements in polar and longitudinal configurations given by a special rotating manipulator
- Bi-polar power supply KEPCO for inductance load
- Step motor controlled manipulator for sample positioning with precision 10 microns and rotation with resolution 0.1 deg for in-plane anisotropy measurements
- Manipulator with wobble stick to handle SPM holders
- Two optical lines for detection of polar and longitudinal Kerr effects
- Laser of 640 nm wave length, regulated power of 30mW, PEM modulator, Glan-Thompson polarizer, Glan-Tyler analizer, photodetectors, beam splitters, lock-in amplifier
- CCD color camera for observations of sample and laser spot
- Hallotrons for measuring the amplitude of magnetic field
- Ion pump of 600l/s, vacuum 10^{-11} Torr
- Software for data aquisition
- Anti-vibrational pneumatic system

Reorientation and SPM chamber



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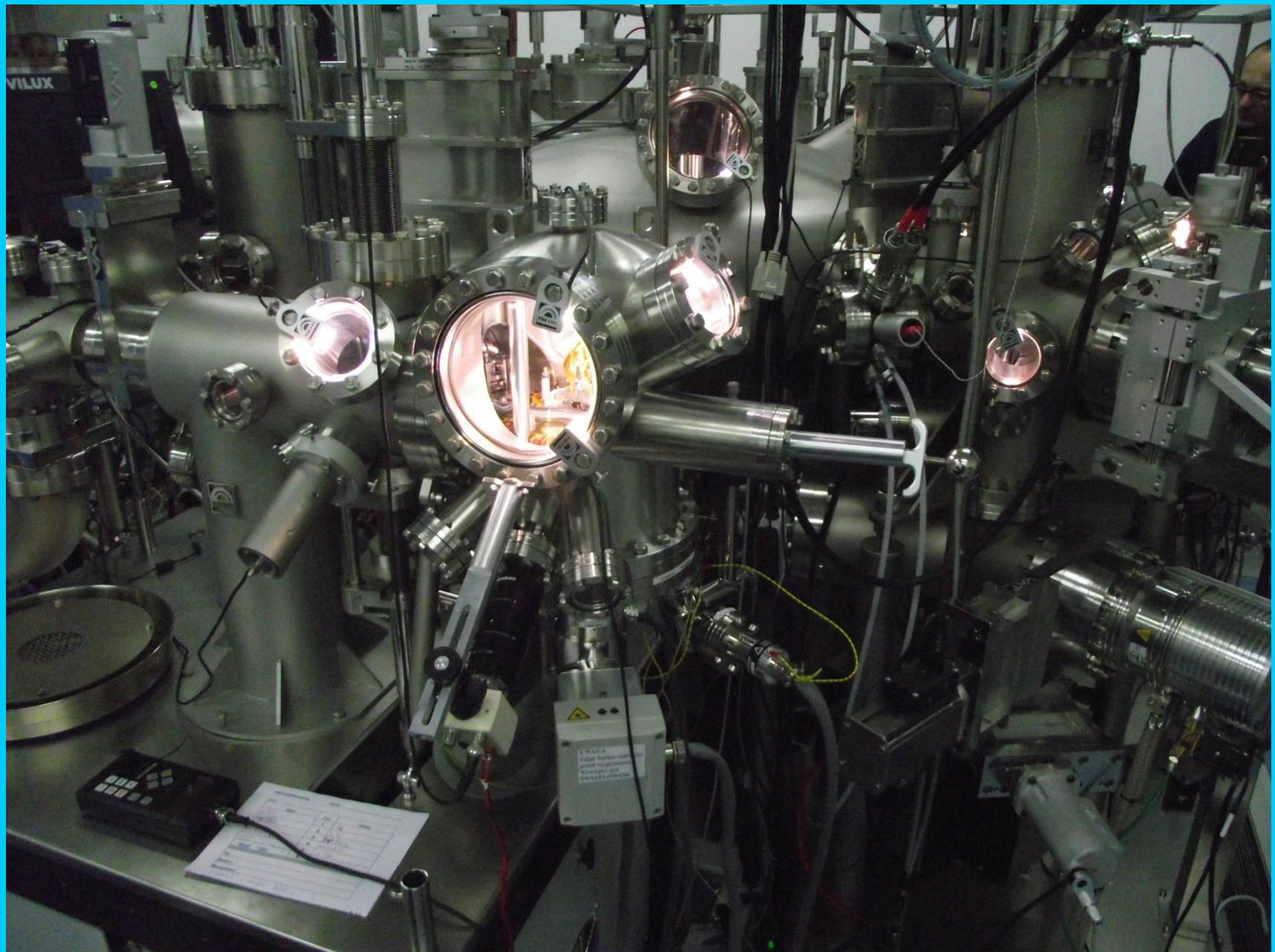
Reorientation chamber

- Attached to the distribution chamber UFO – for transportation of SPM holders from moliblock to the transfer system of SPM
- Connected to the SPM Omicron chamber
- Manipulator and transfer system to microscope holder station

SPM probes loading chamber

- Designed for quick loading of SPM probes (and samples) directly into the SPM microscope without necessity to transport them through a whole MBE system
- Electron bombardement heating of SPM probes facility up to 150 C
- Docking station for 3 probes

Omicron SPM VT 50/500 model



SPM Omicron VT 50/500 model

- Microscope working in:
  - contact mode AFM-CM
  - non-contact mode AFM-NCM
- Magnetic force microsopy MFM
- Electrostatic force microsopy EFM in non-contact mode
- ScanningTunneling Microscopy STM (constant hight and constant current modes)
- Tunneling spectroscopy STS - CITS, I(V), I(Z), I(V,Z), dI/dV, d^2I/dV^2
- Laser beam detection of cantilever deflection
- AFM signal detection:
  - cantilever deflection,
  - oscillation amplitude,
  - phase and/or oscillation frequency
- Scan size 10x10 microns
- STM/STS – atomic resolution, tunneling current detection in the range of 1 pA – 200 nA
- I/V charactersitics in the voltage range +/- 10 V

2010 – W ramach projektu **Krajowe Centrum Nanostruktur Magnetycznych do Zastosowań w Elektronice Spinowej – SPINLAB** mikroskop ZEISS Auriga (Neon 40) został **doposażony** o **rentgenowski spektrometr energii EDX** oraz o **system katodoluminescencji**.

W ramach **SPINLAB-u** zakupiono:

- **SEM** EVO HD 15 firmy Zeiss,
- **Układ do pomiaru katodoluminescencji** firmy Horiba,
- **Kriostat niskotemperaturowy** firmy K&W,
- **Stolik Peltier** firmy Deben,
- **Rentgenowski spektrometr energii EDX** firmy Bruker,
- Oprogramowanie **Nanopatterning Engine** do cyfrowej kontroli działa jonowego FIB

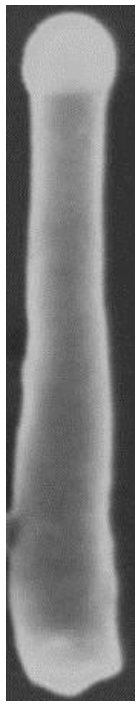
SEM EVO CL Zeiss

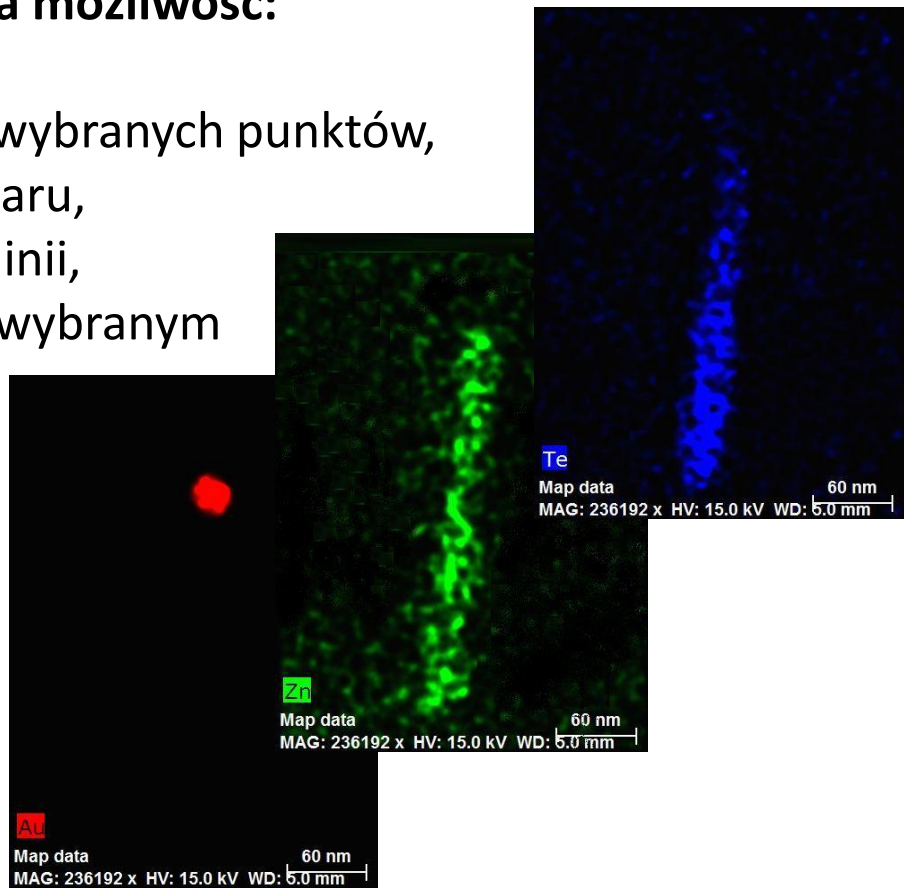
Widma CL (CCD, PMT mono) od RT do LHe
Mapy CL (CCD, PMT poli) od RT do LHe

System do Mikroanalizy Rentgenowskiej EDX firmy Bruker

Spektrometr EDX zapewnia możliwość:

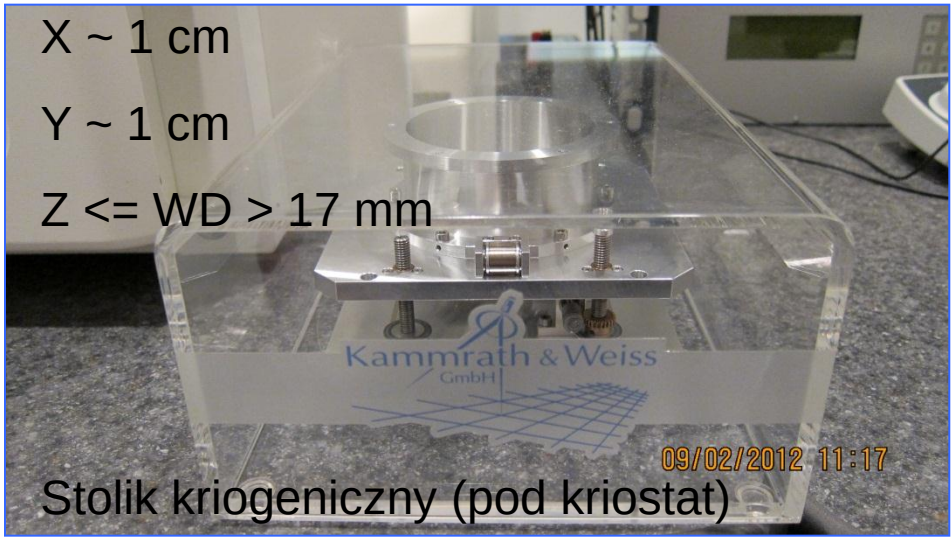
- analizy punktowej,
- analizy z wielu wstępnie wybranych punktów,
- analizy z wybranego obszaru,
- analizy wzdłuż dowolnej linii,
- rozkład pierwiastków na wybranym obszarze - mapowanie,
- analizy fazowej.

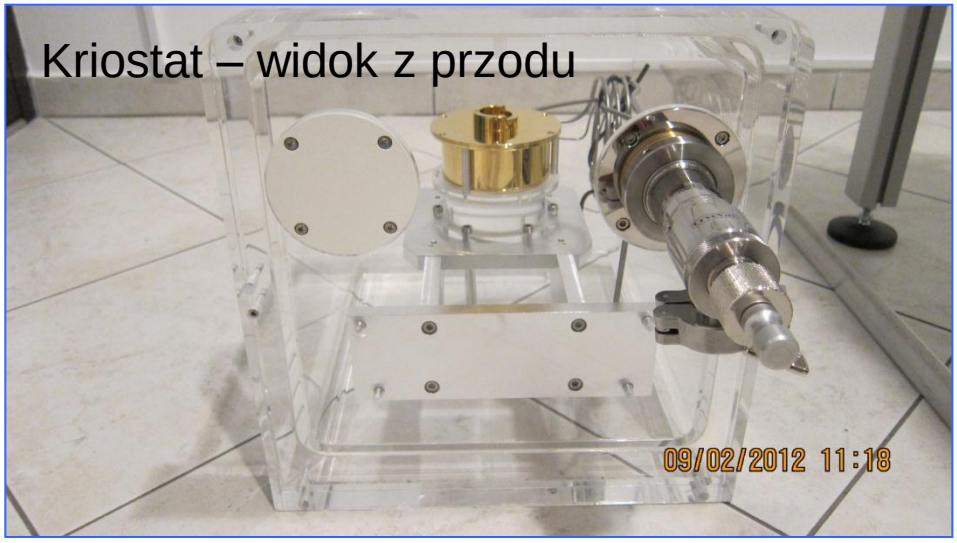


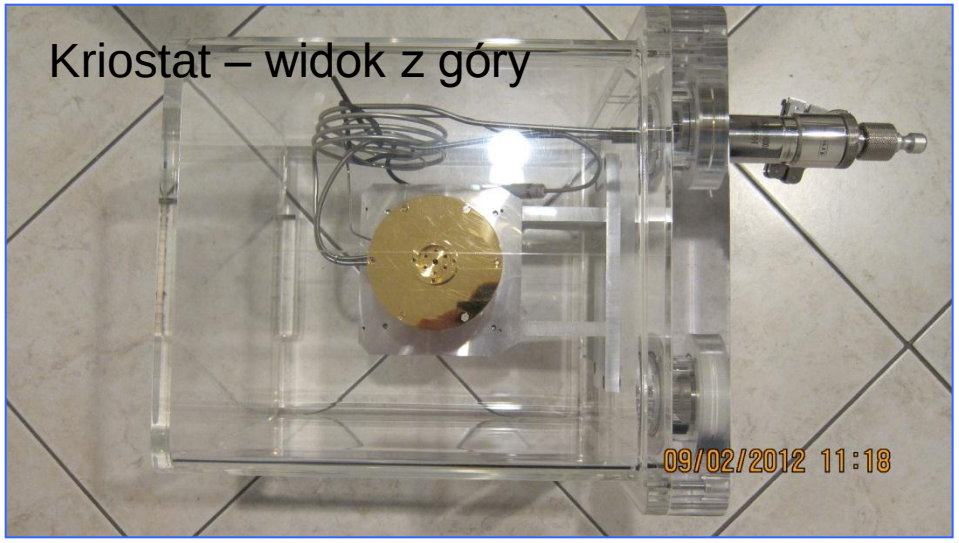


Mapy rozkładu pierwiastków nanodrutu ZnTe.

Kriostat - niskie temperatury (4.2 K do 300 K)







He-3 dilution refrigerator (temperature down to 50 mK) for PPMS