Infrastructure of Thin Films Laboratory in Institute of Molecular Physics Polish Academy of Sciences

Outline

- Sample preparation
  - Magnetron sputtering
  - Ion-beam sputtering
  - Pulsed laser deposition
  - Electron-beam litography

- Structural characterization
  - SEM – Scanning Electron Microscopy
  - XRR – X-ray Reflectometry
  - XRD – X-ray Diffraction
  - XRF – X-ray Fluorescence
  - Profilometer

Outline

- Static magnetic measurements
  - VSM – Vibrating Sample Magnetometer
  - GMR – Giant Magneto Resistance
  - P-MOKE Magnetometer
  - P-MOKE Microscopy

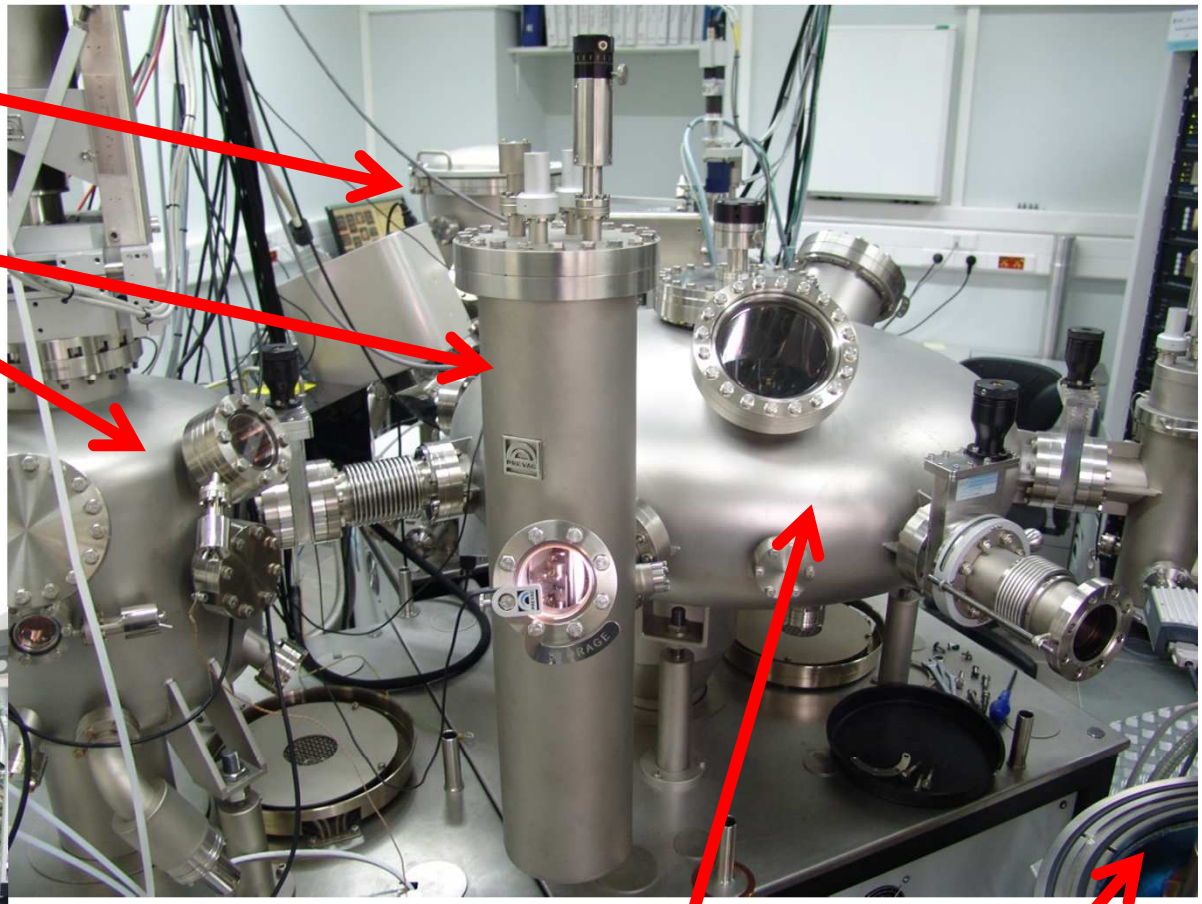
- Dynamic magnetic measurements
  - VNA-FMR – Vector Network Analizer – Ferromagnetic Resonance
  - FMR – Ferromagnetic Resonance
  - PIMM – Pulsed inductive microwave magnetometer

UHV system

Ion-beam sputtering

Sample storage

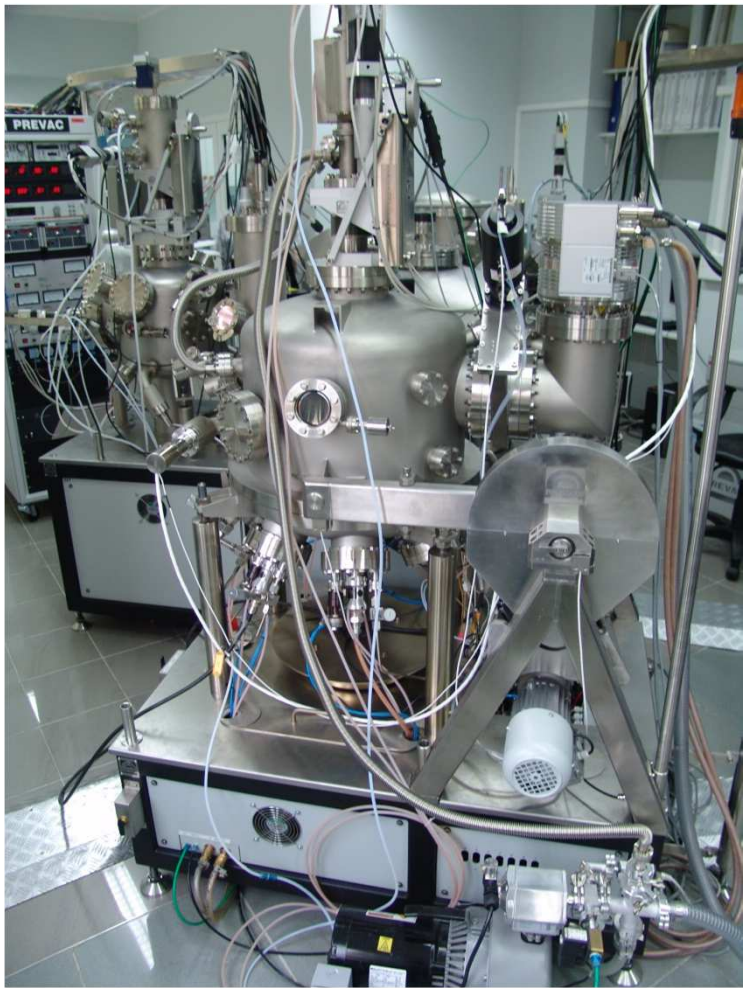
Pulsed laser deposition



Distribution chamber

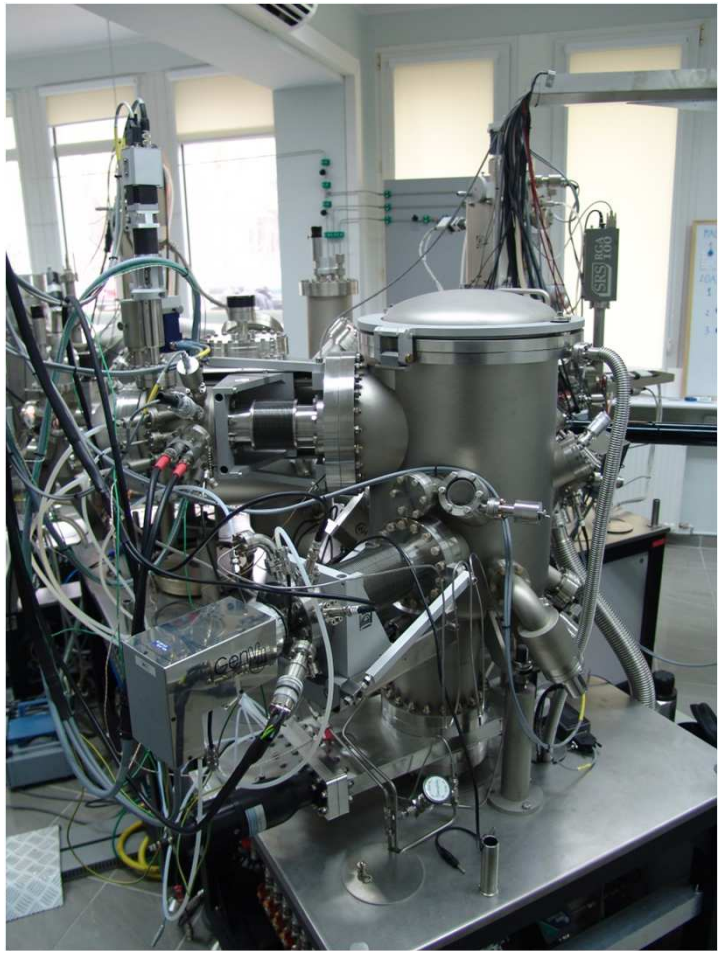
Magnetron sputtering

Magnetron sputterings

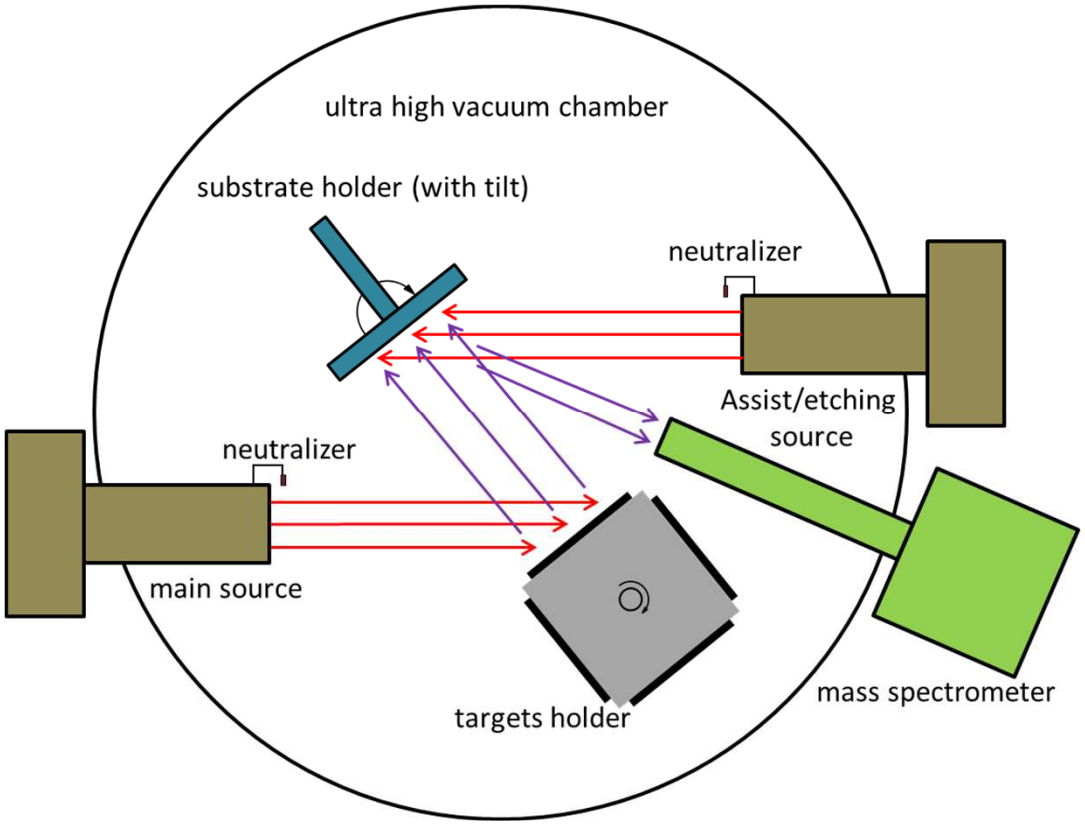


- Base pressure <5x10^{-9} mbar
- Up to 6 ultrapure 2 inche targets
- Possibility to prepare multilayer systems or alloys (confocal setup)
- Possible to make wedge layers
- Sample size - up to 15x20mm

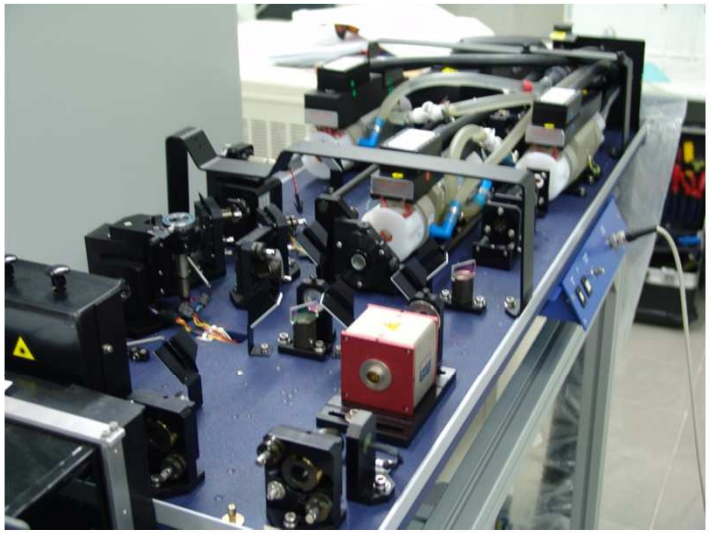
Ion-beam sputtering



- Base pressure <5x10^{-9} mbar
- Up to 4 ultrapure 2 inches targets
- Sample size up to 15x20mm
- Two ion sources – for sputter and etching
- Mass spectrometer



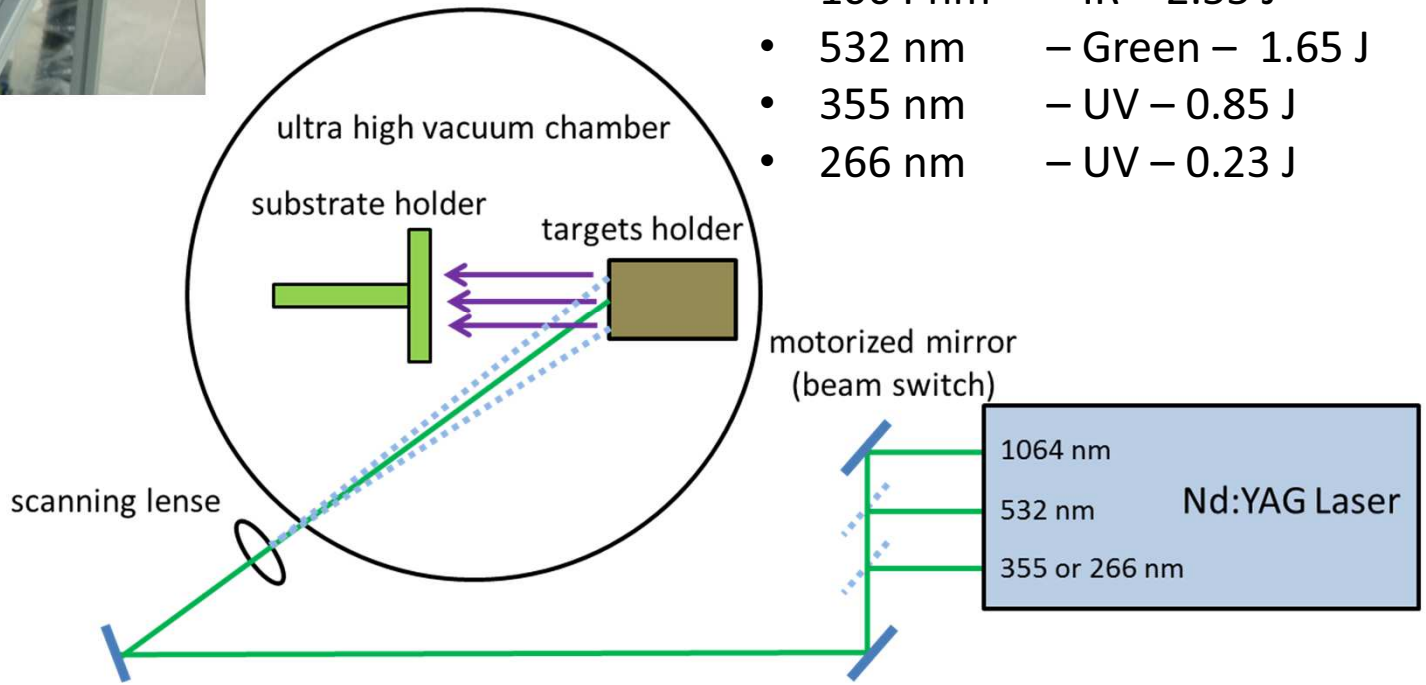
Pulsed laser deposition



- Base pressure <5x10^{-9} mbar
- Up to 6 ultrapure 1 inch targets
- Sample size up to 15x20mm
- Ion source – for etching

Laser:

- 1064 nm – IR – 2.55 J
- 532 nm – Green – 1.65 J
- 355 nm – UV – 0.85 J
- 266 nm – UV – 0.23 J



Electron-beam litography

- Preparation of samples in CleanRoom class 1000
- PMMA and MMA electron resists in thickness range from ~50nm to a few microns
- Max. wafer size - 150mm (6in.)

SEM

With FEI Nova NanoSEM 650 we can:

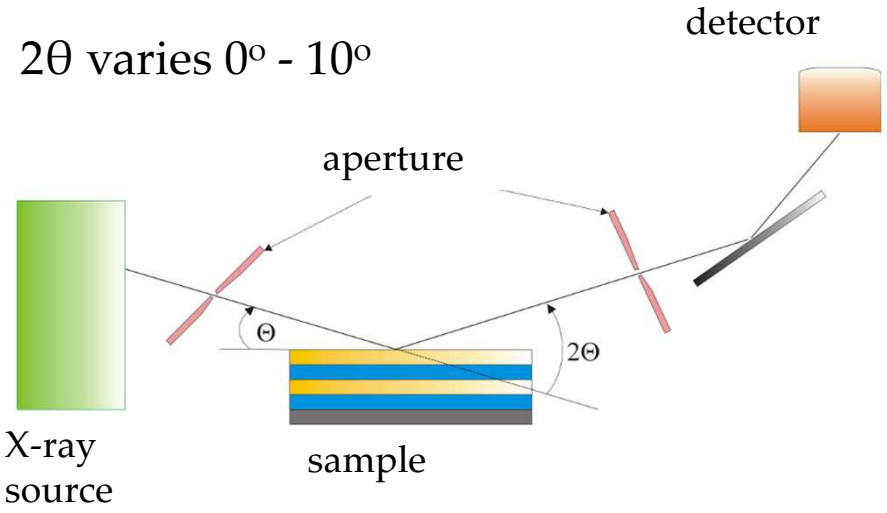
- Expand our research capabilities by handling a wider range of sample types
- Perform high resolution imaging - low voltage [1kV] resolution is 1.8nm in low vacuum mode and 1.4 nm in high vacuum mode, so we can still use all the benefits offered by low vacuum imaging without having to sacrifice resolution in images
- Both a high current beam (essential for rapid EDS/EBSD/CL/analytical research) and high resolution at high and low voltage which is essential for image quality across a wide range of sample type are available

Moreover our system includes:

- Bruker EDS system
- Raith litography system

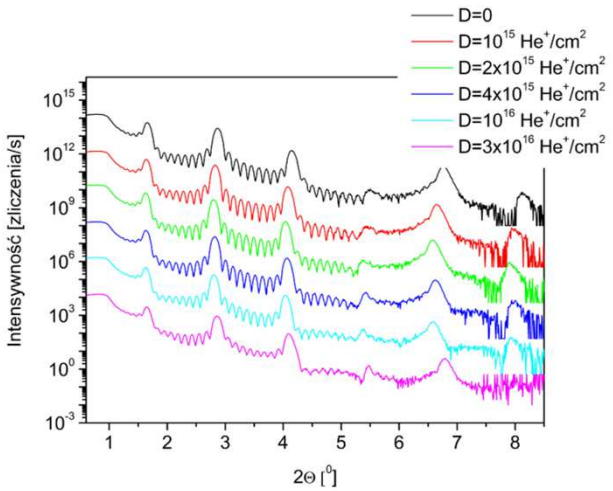
XRR/XRD

Seifert, model XRD 3003,
X-ray source Cu-K *(*wavelength
λ=0.15419 nm)



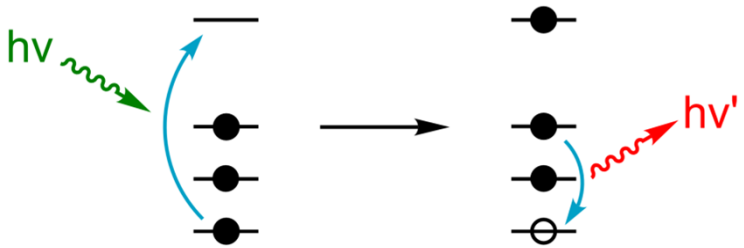
Interference of the wave reflected from surface of the film and the surface of the substrate results in **Kiessig fringes**.

Allows to measure thickness and structure of thin films



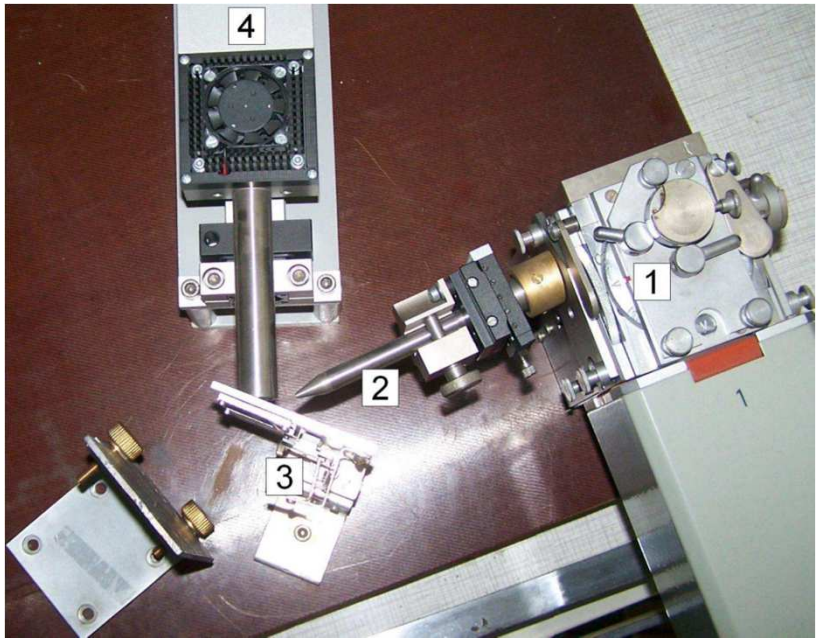
XRF

Characteristic radiation



Multichannel analyzer 10 keV / 1024 channels

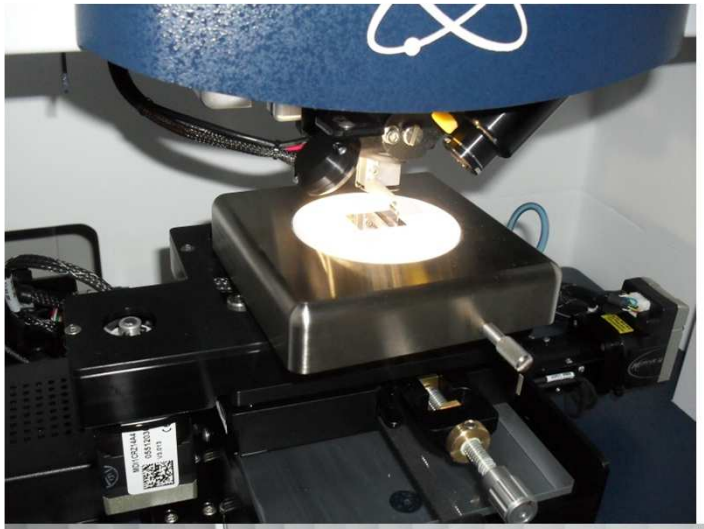
- We can measure:
  - Thickness of thin films (up to 200 nm)
  - Chemical composition



1 – X-ray source, 2 - collimator,
3 – sample holder, 4 - detector

$$t_{sample} = \frac{I_{sample}}{I_{refference}} \cdot t_{refference}$$

Profilometer

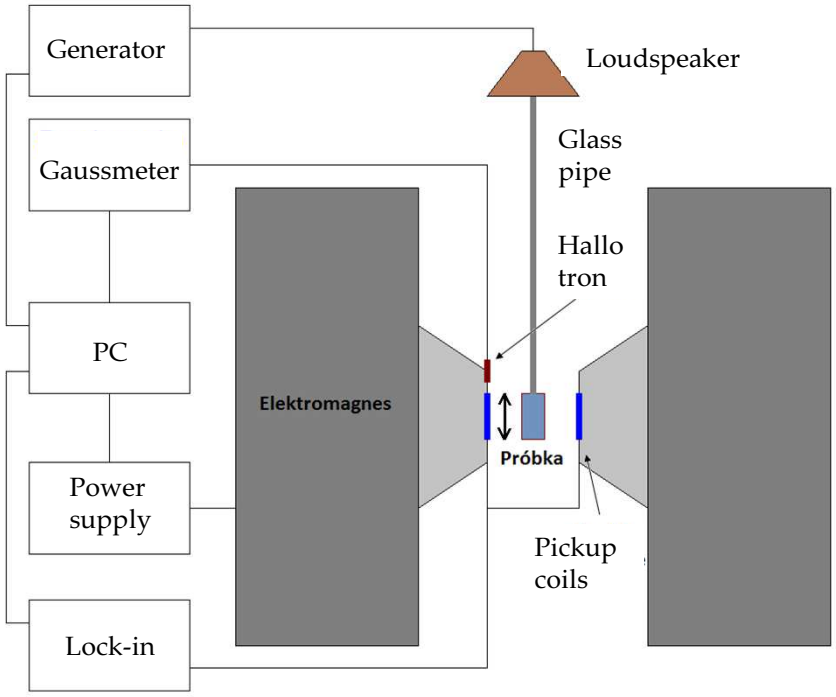


BRUKER – Dektak XT

- Measurement Technique - Stylus profilometry (contact measurement)
- Measurement Capability - Two-dimensional surface profile measurements
- Stylus Force – 0,03 to 15 mg with LIS 3 sensor
- Stylus Options - Stylus radius from 50nm to 25µm
- Scan Length Range - 55mm (2 in.)
- Max. Sample Thickness - 50mm (1.95 in.)
- Max. Wafer Size - 200mm (8 in.)
- Step Height Repeatability <5 Å, 1 sigma on 0.1 µm step
- Vertical Resolution – 1 Å max. (@ 6.55 µm range)

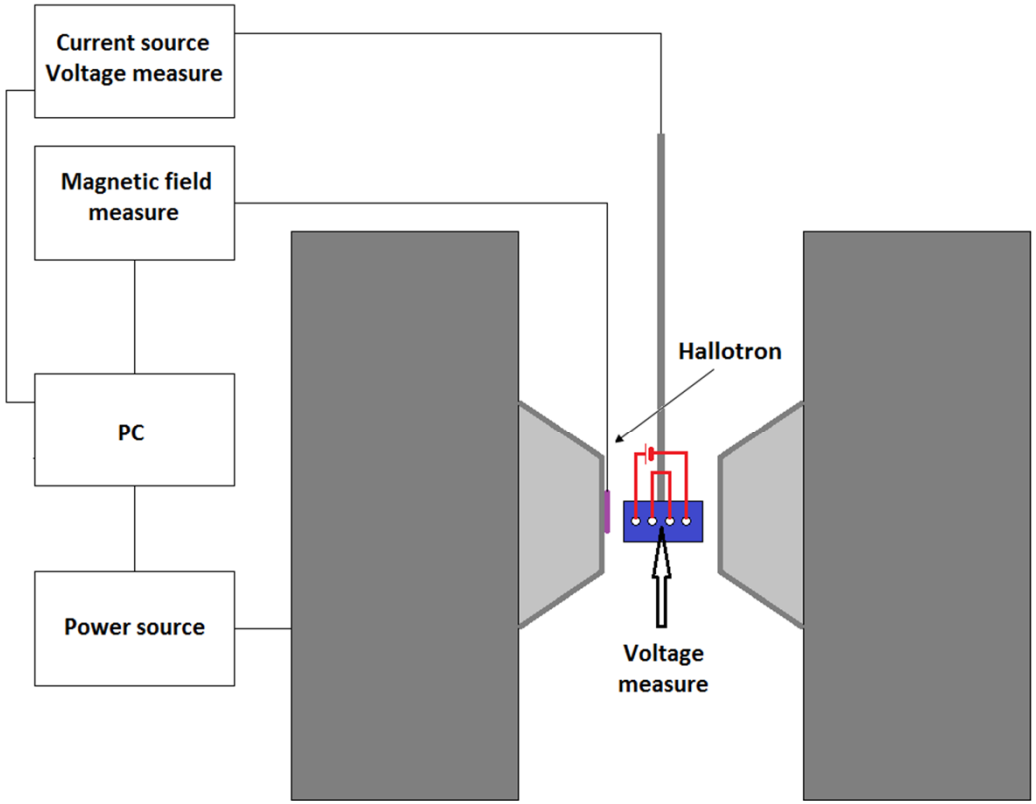
VSM

- Frequency: 35 Hz
- Dual pickup coils
- Magnetic field: up to 16 kOe
- Temperature: -100°C to 250°C

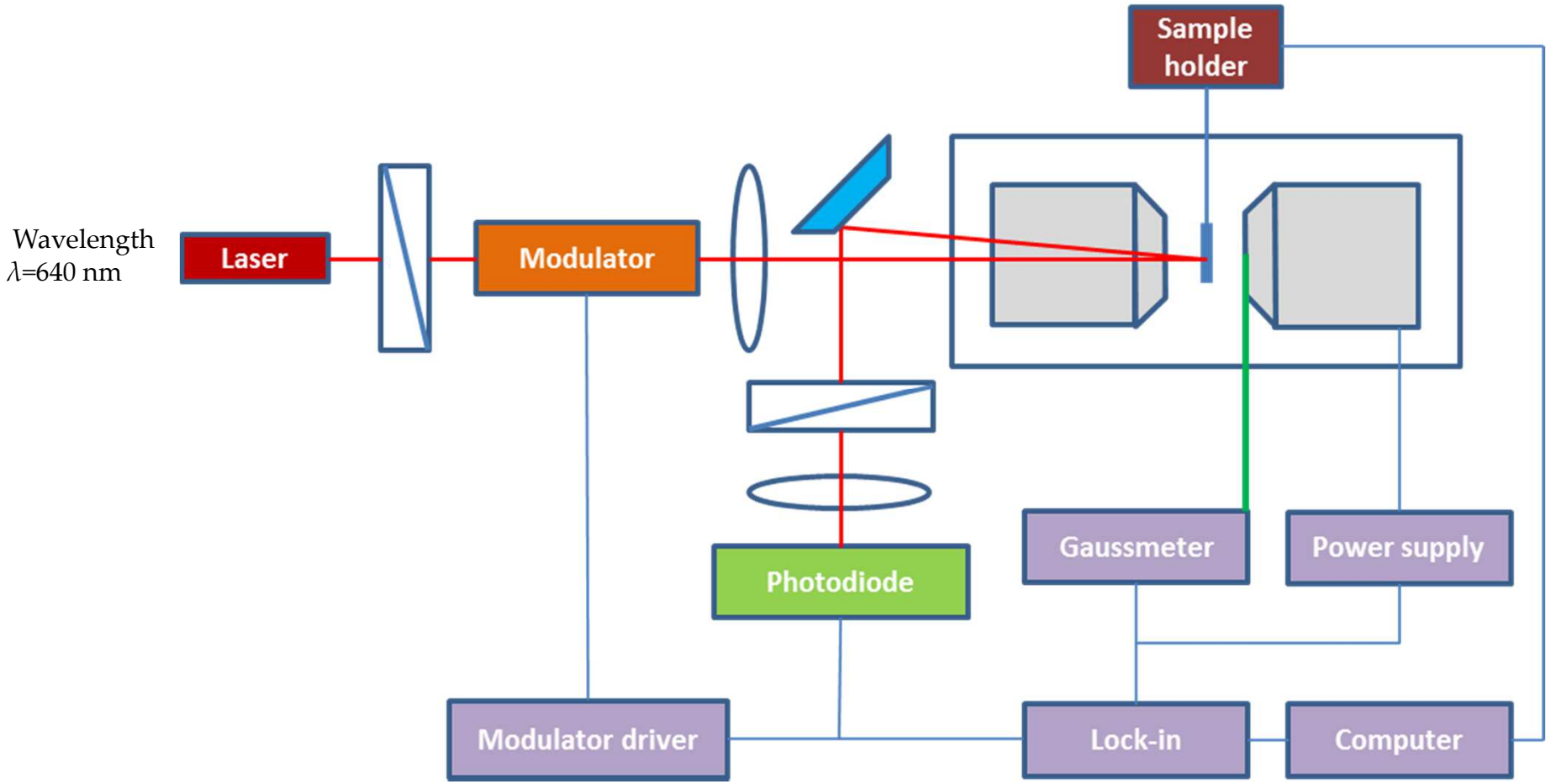


GMR

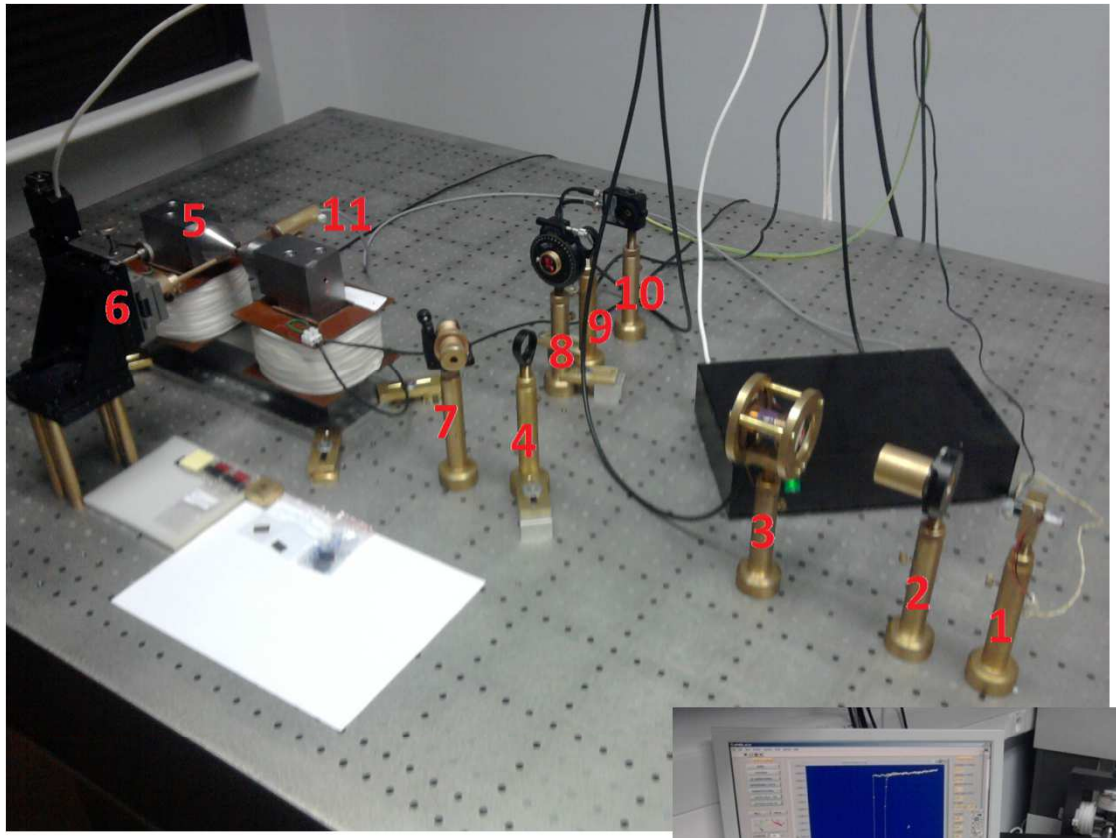
- Four point probe (4 pins) resistivity measurements (2 current / 2 voltage) with magnetic field up to 16 kOe
- Possibility to measure in coils using 11 points (2 current / 9 voltage - for wedge samples) with magnetic field up to 0.3 kOe
- Current source 100 nA – 100 uA



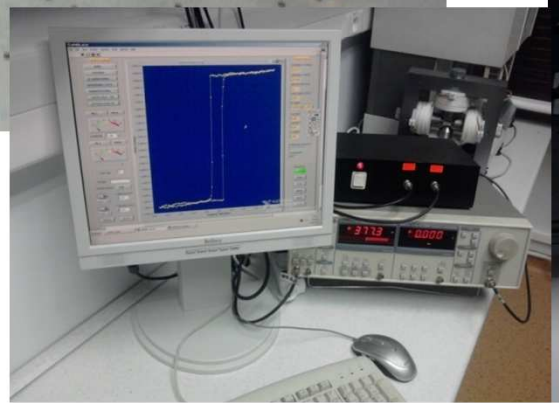
P-MOKE

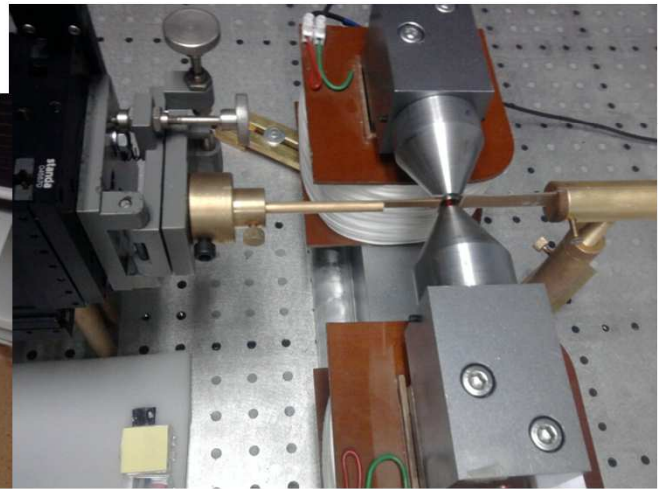

Wavelength
λ=640 nm
Laser
Modulator
Sample holder
Photodiode
Gaussmeter
Power supply
Modulator driver
Lock-in
Computer

P-MOKE

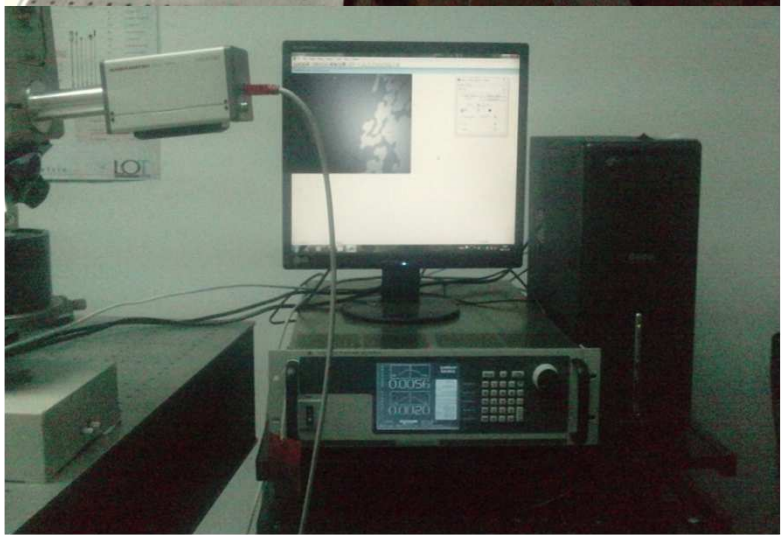


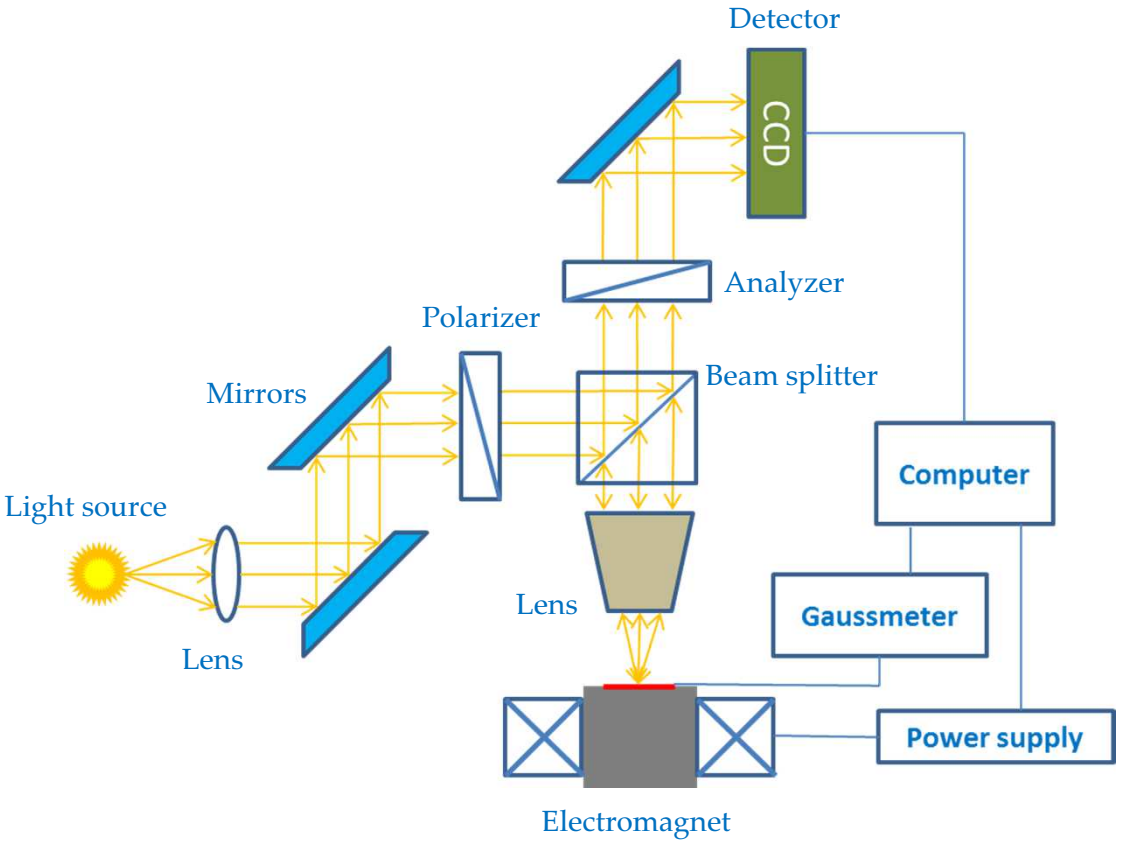
1. Laser diode
2. Polarizer
3. Modulator
4. Lens
5. Electromagnet
6. Sample holder and table
7. Mirror
8. Analyser
9. Lens
10. Detector (fotodiode)
11. Magnetic field sensor



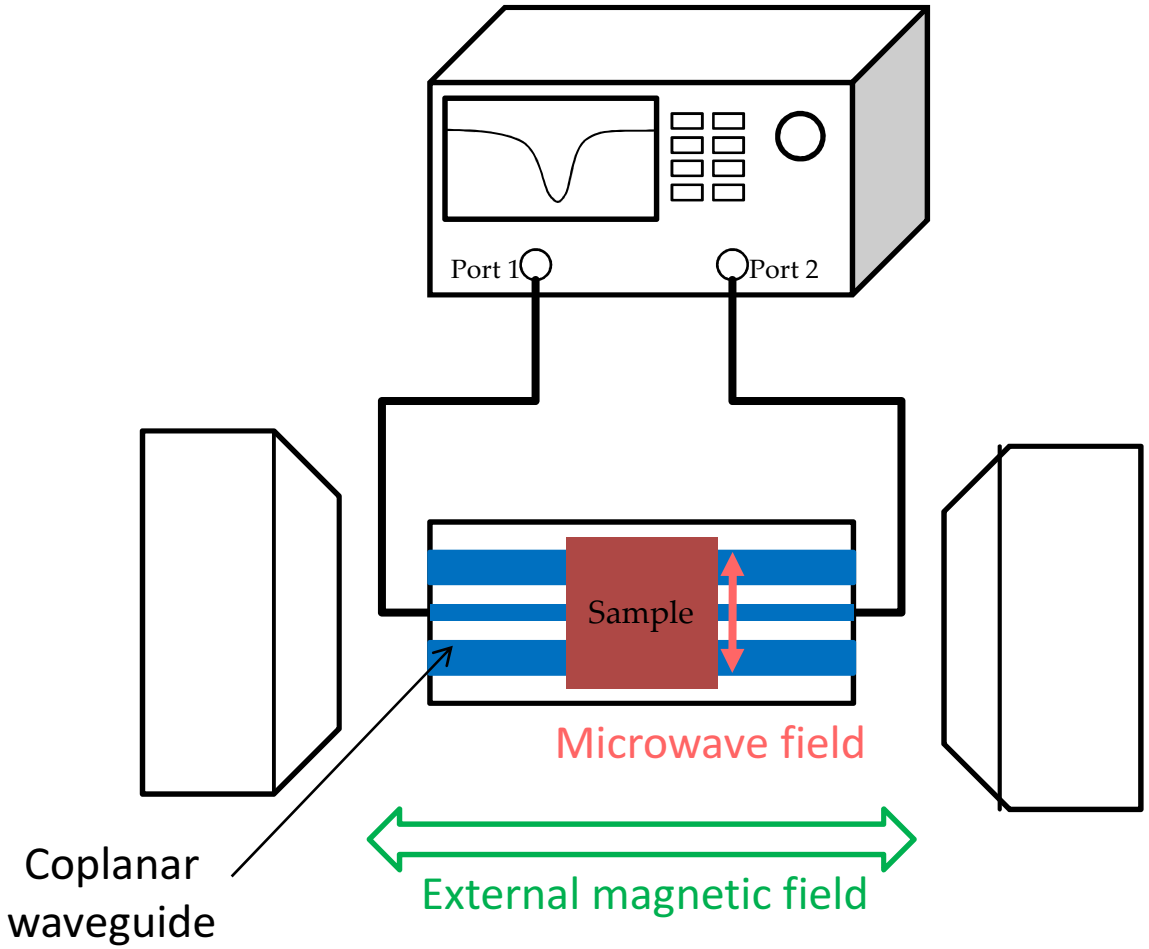


MOKE - Microscopy





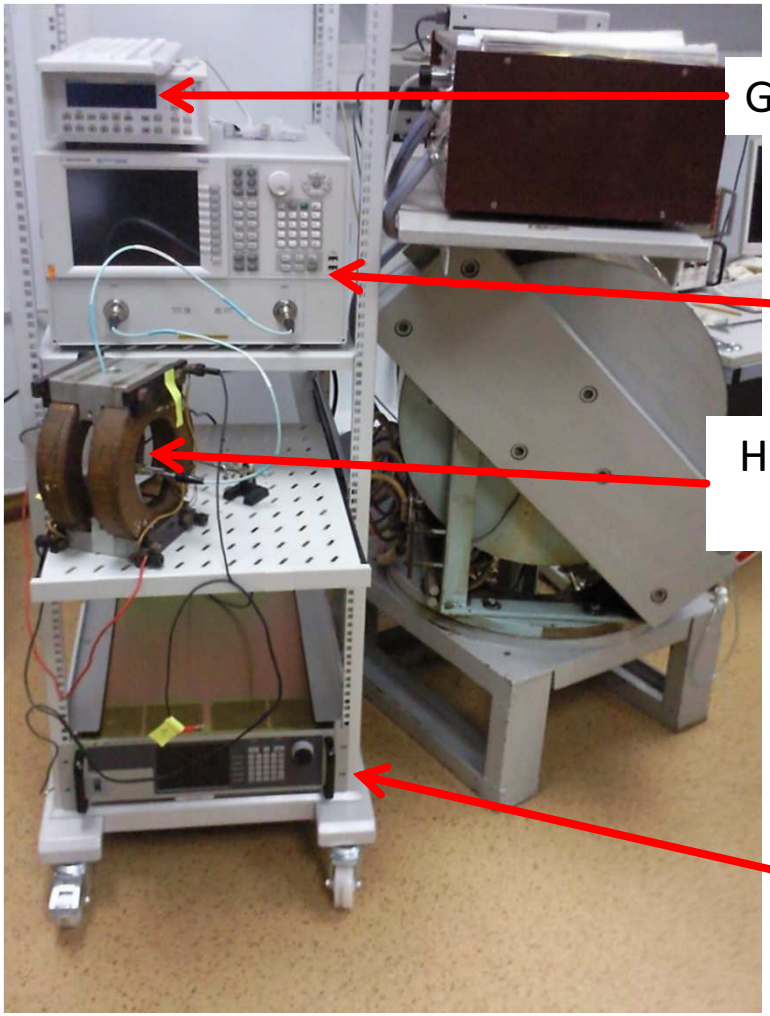
VNA-FMR

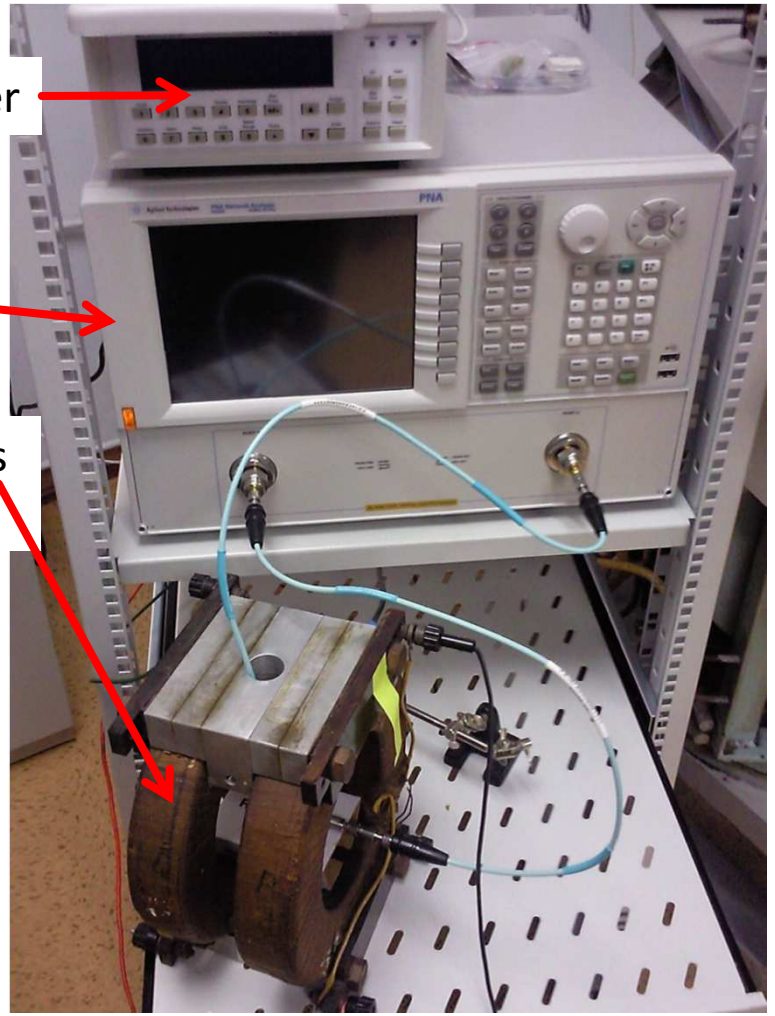


On frequency sweep FMR experiment magnetization vector does not change its direction

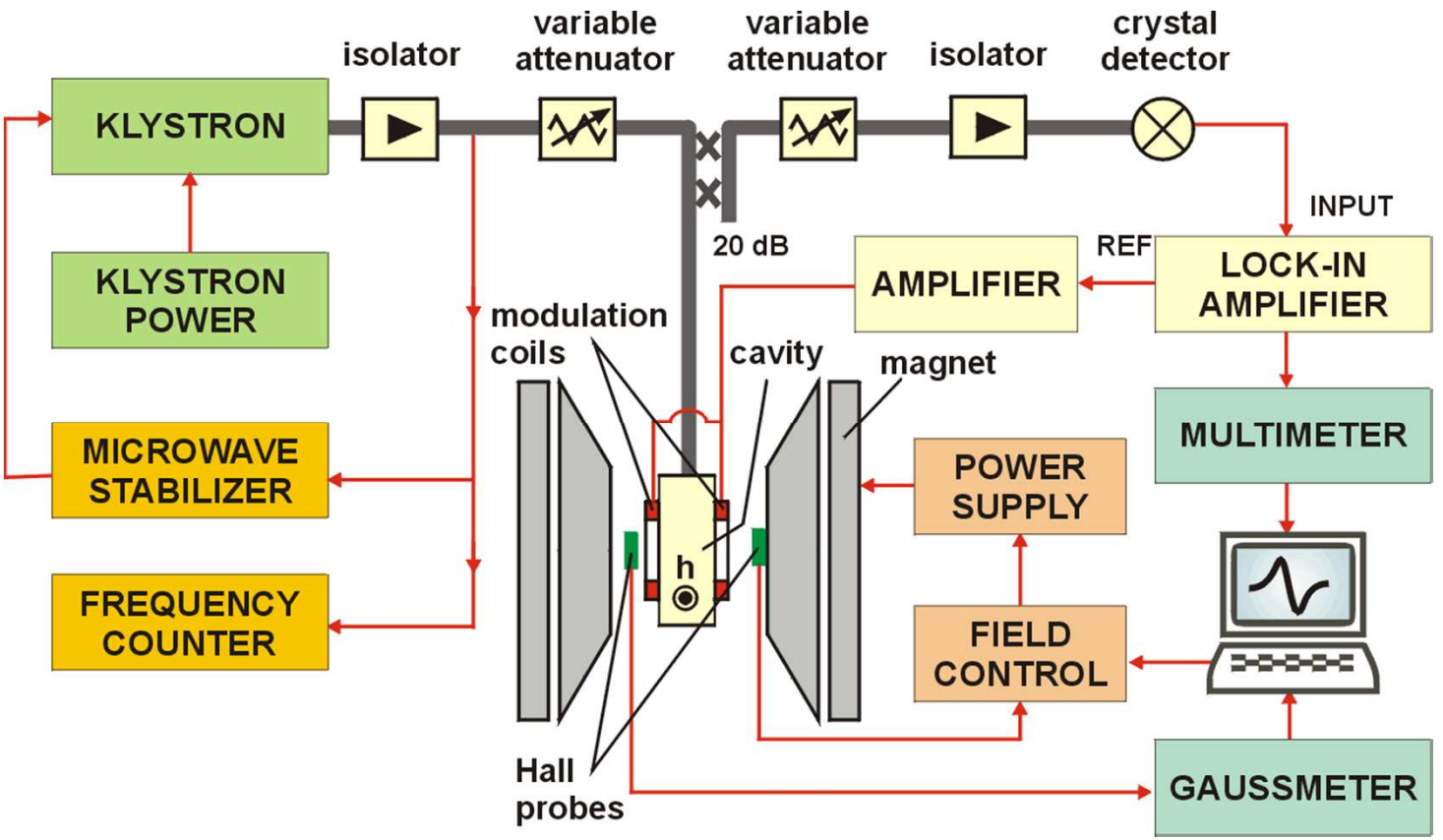
Frequency up to 40 GHz

VNA-FMR





FMR



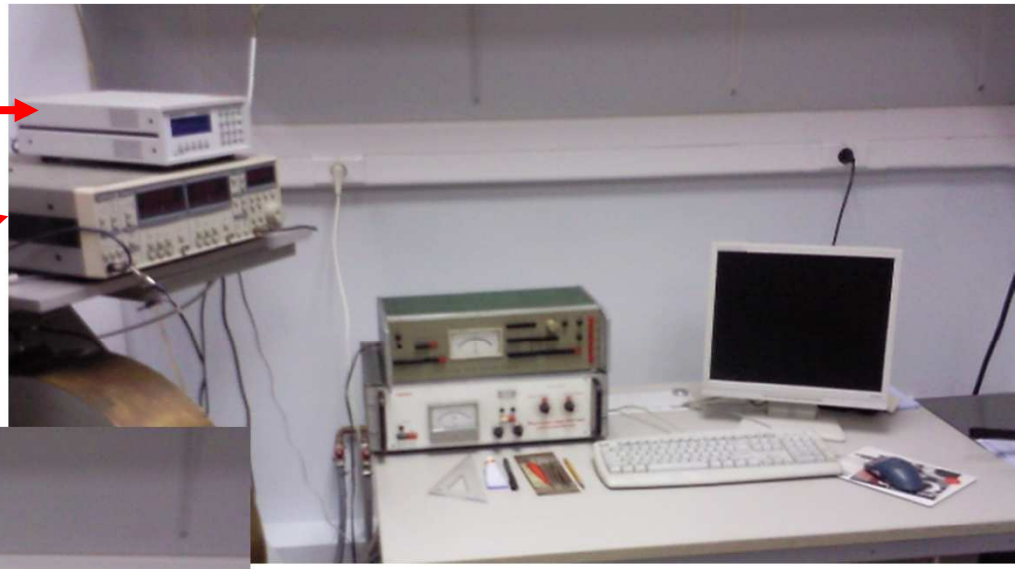
During field sweep FMR experiment magnetization vector changes its direction

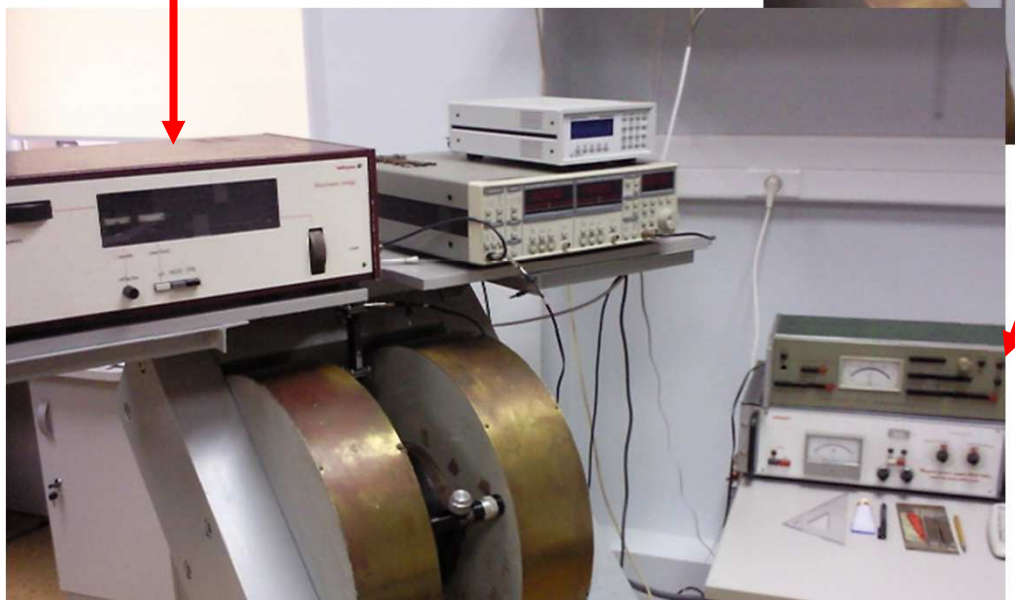
FMR

Gaussmeter

Lock-in

Microwave bridge

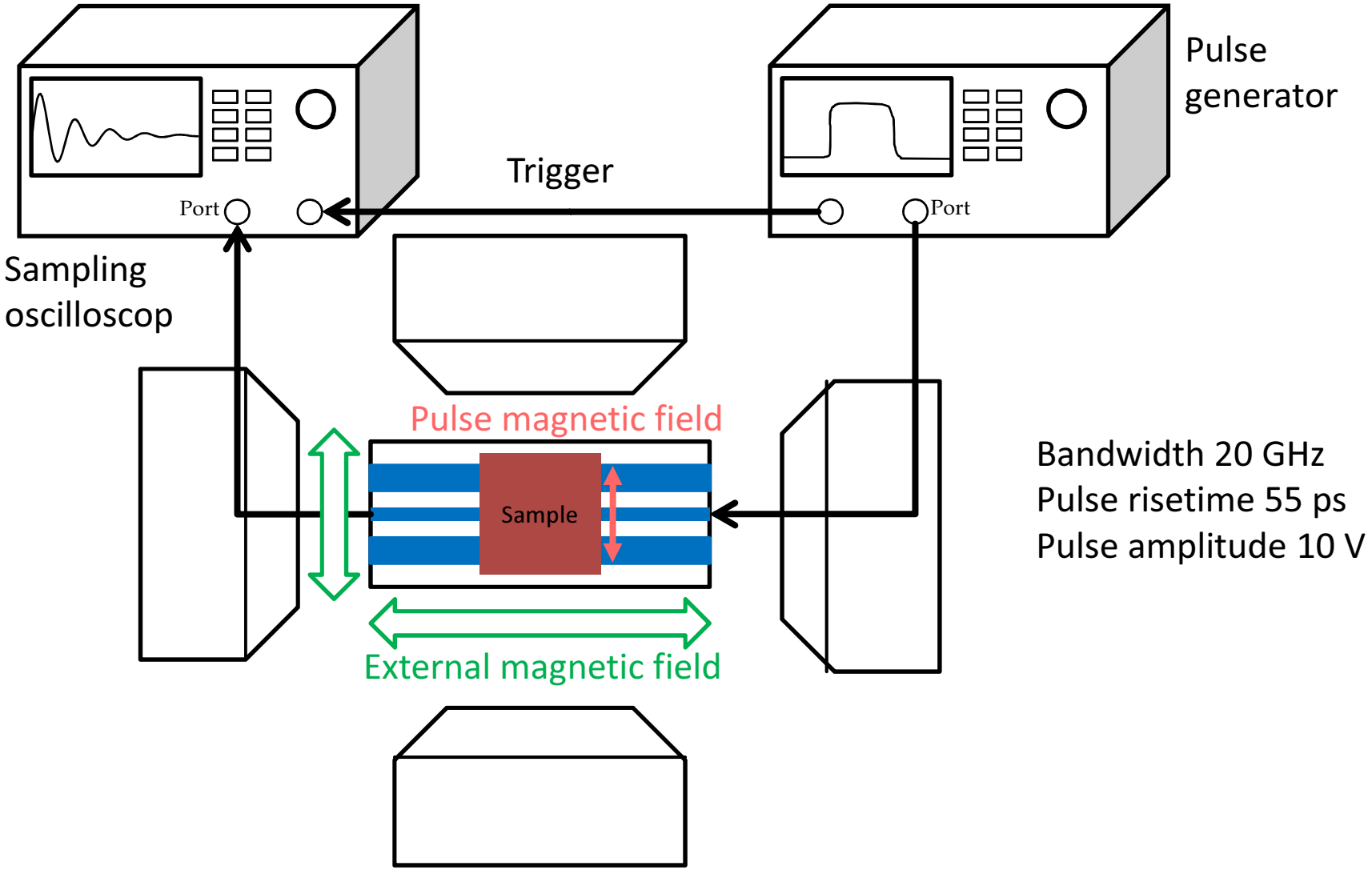




Field sweep controller

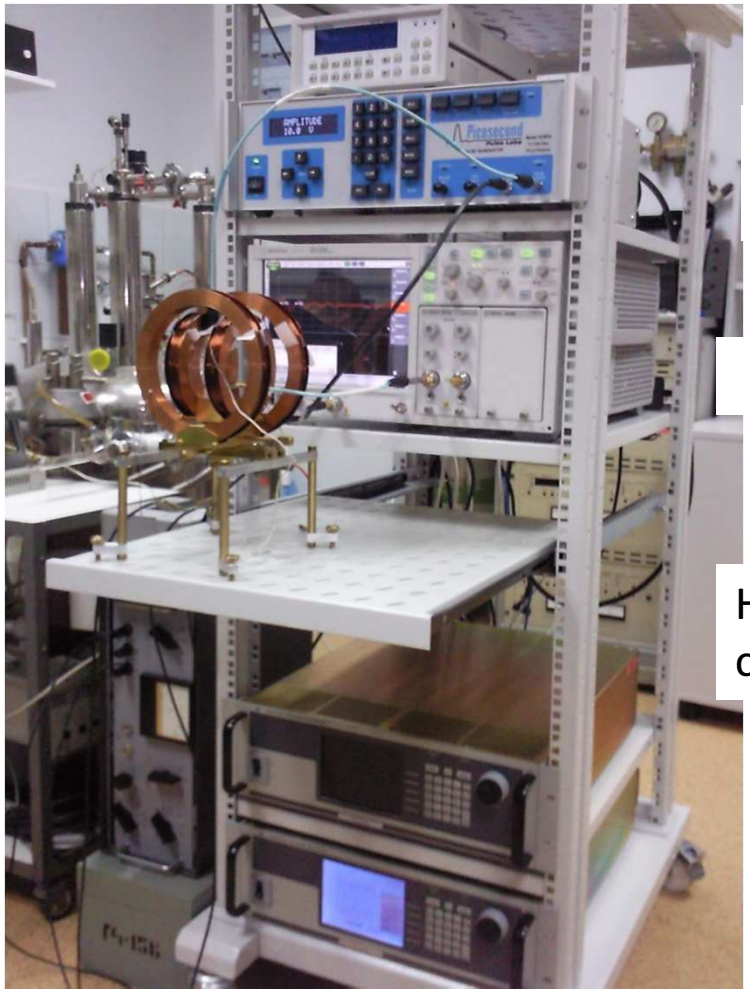
- X-band spectrometer 9.18 GHz
- Field up to 11 kOe

PIMM



Bandwidth 20 GHz
Pulse risetime 55 ps
Pulse amplitude 10 V

PIMM



Pulse generator

Oscilloscop

Helmholtz's coils

Power supply