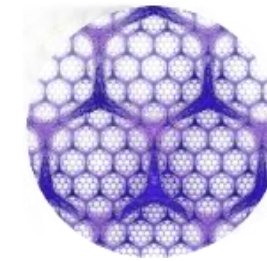


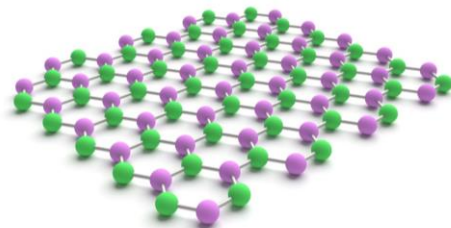
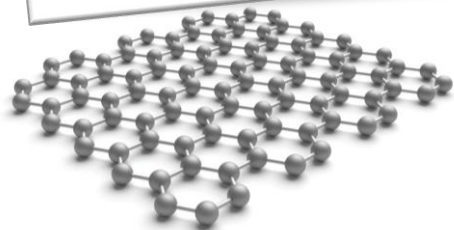
SURFACES, INTERFACES & 2D MATERIALS

RESEARCH GROUP (SIMAT)

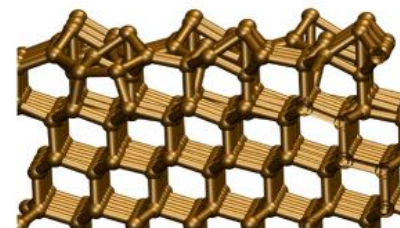
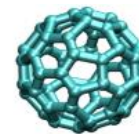


SIMAT
Surfaces Interfaces and 2D
Materials Group

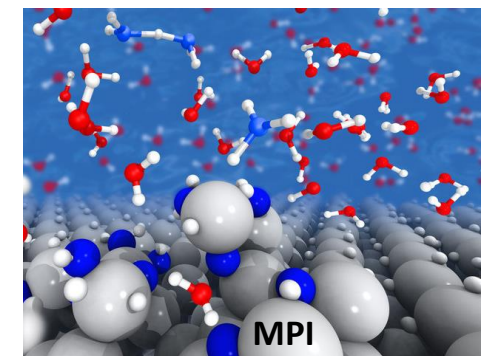
2D MATERIALS



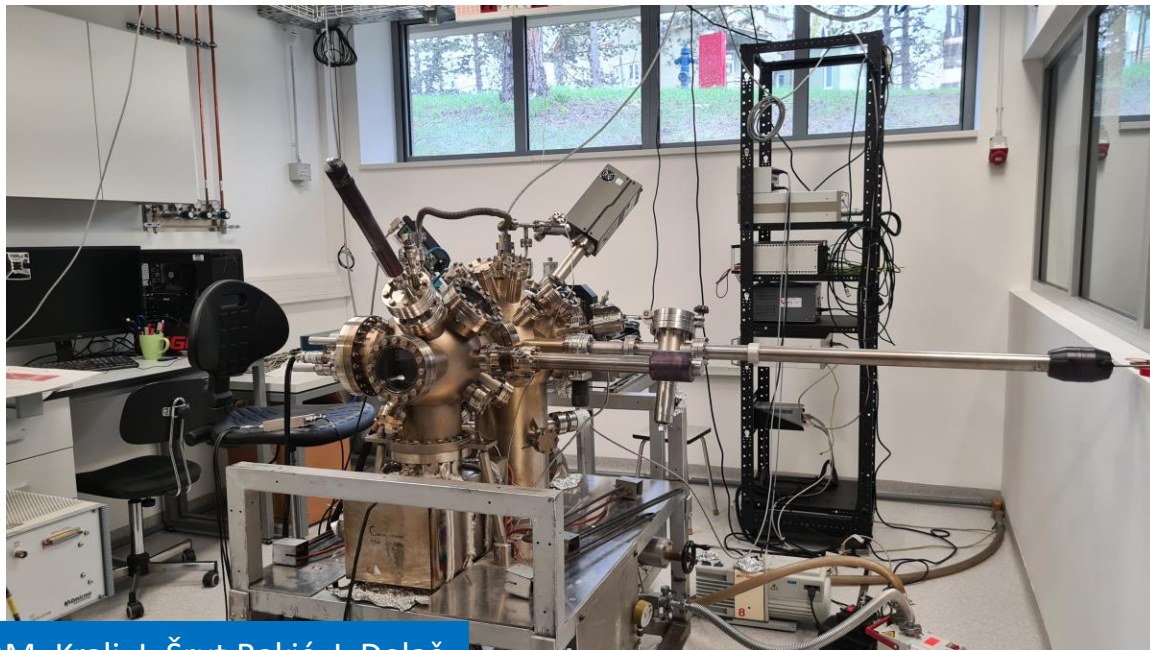
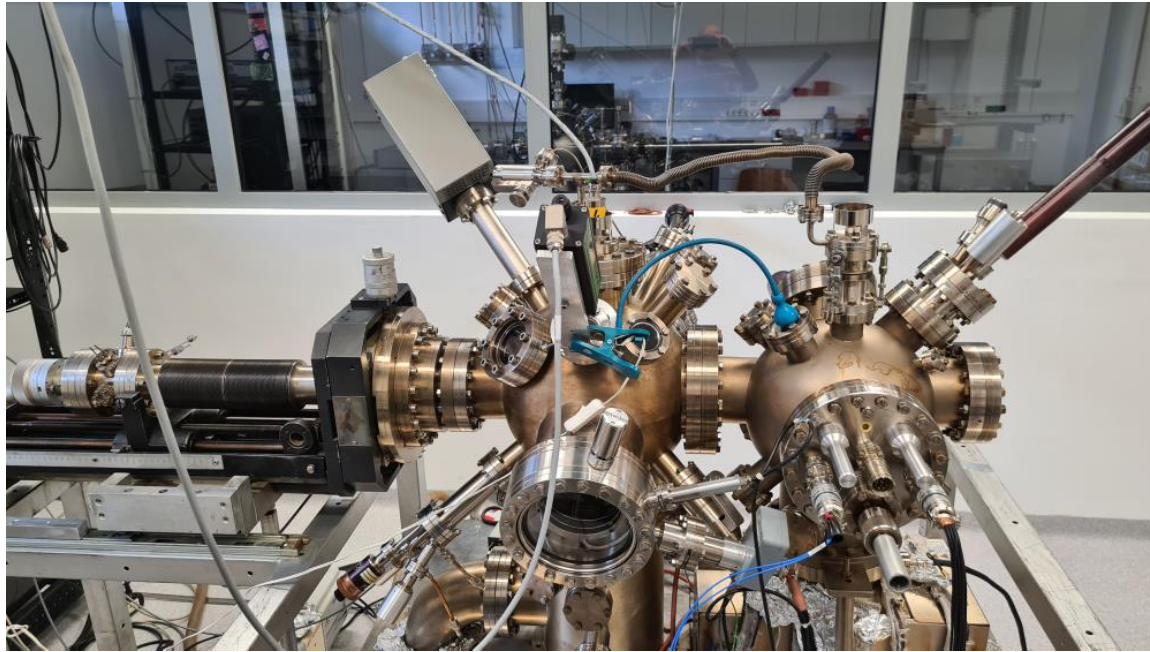
SURFACES



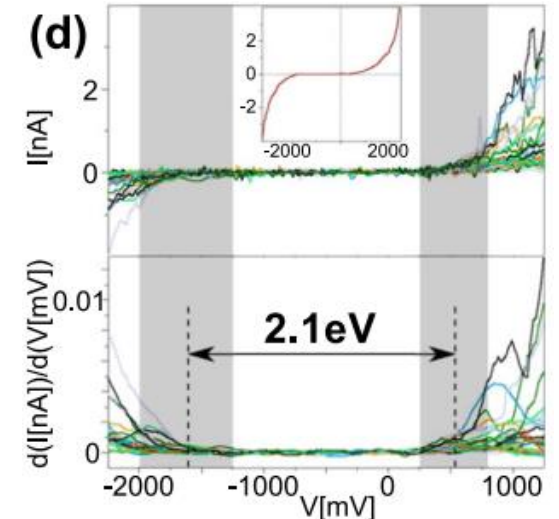
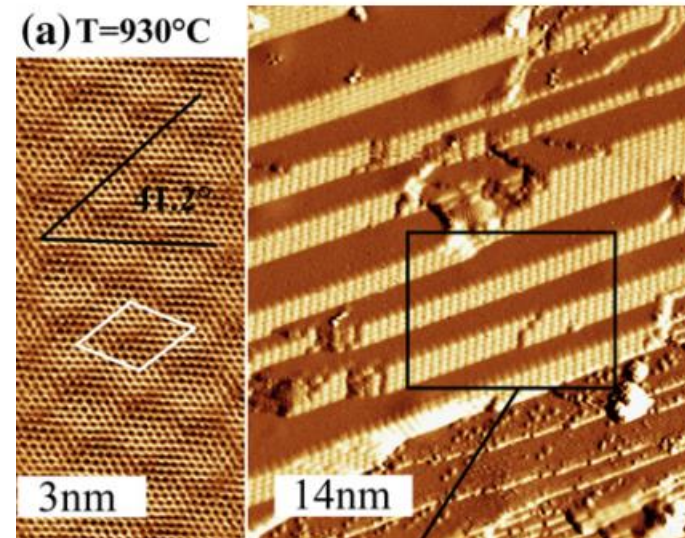
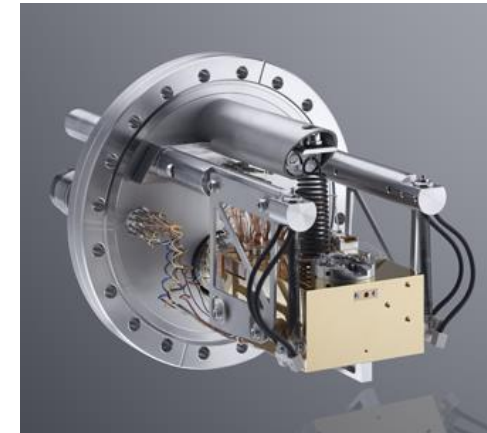
INTERFACES



Variable temperature Scanning Tunneling Microscopy (STM) - SPM Aarhus 150 (Specs)



- Samogradnja i nadogradnja od 2007. godine (2×kapitalna oprema, AvH donacija, UKF projekt [Kralj-Valla], HrZZ projekti [Pervan, Kralj, Delač], CEMS [Kralj], Šestar,...)
- Veliki broj članaka, diplomskih radova, doktorata
- Priprema **atomski čistih** površina u **UHV**, load lock
- **MBE** sinteza (e-beam evaporator, S-doziranje)
- **CVD** sinteza (kontrolirano doziranje plinova)
- Depozicija organskih molekula (Createc OLED)
- **STM** atomsko razlučivanje strukture površina
- **STS** lokalna elektronska struktura (LDOS)
- **LEED** difrakcija
- U tijeku **nadogradnja na AFM** funkcionalnost

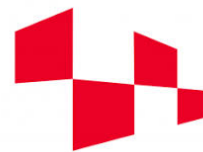


Ultrahigh vacuum (UHV) sample preparation system

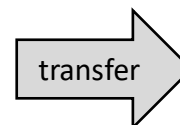
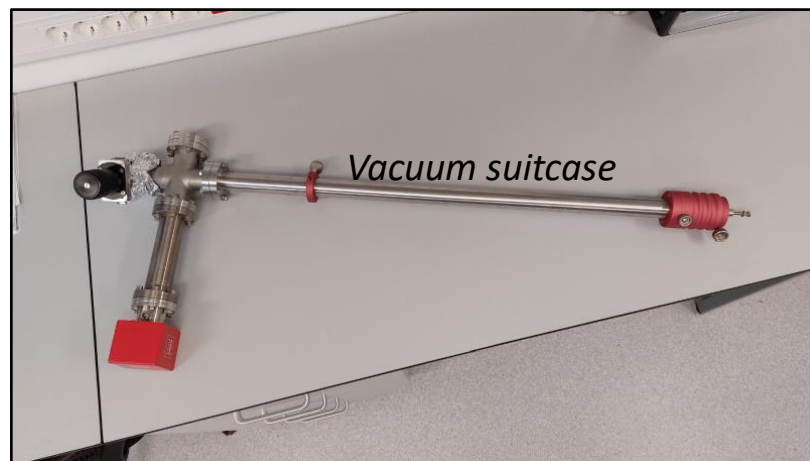
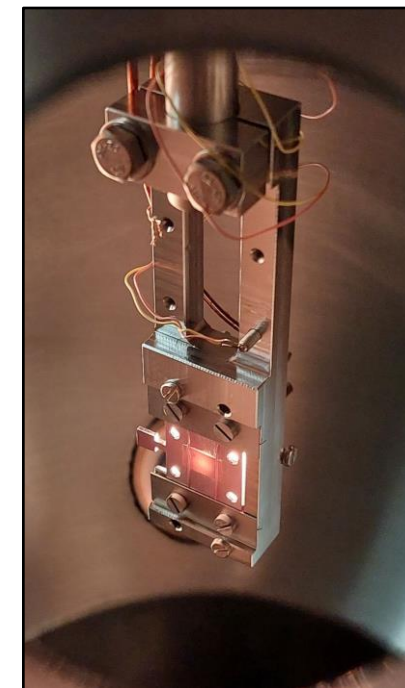
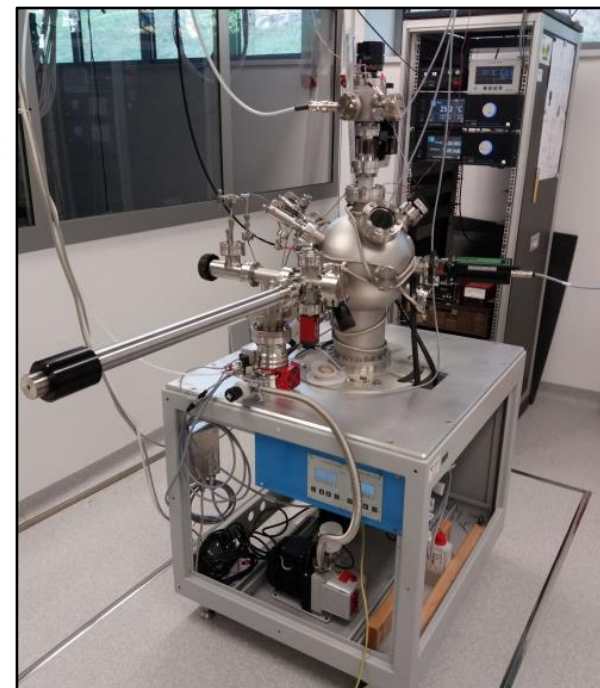
- **Sinteza** – *chemical vapor deposition (CVD)*
- **Grijanje (*annealing*)** – u vakuumu ili kontroliranoj atmosferi
- **Depozicija** atoma i molekula
- **Kristalna struktura** – LEED

- Osnovni tlak $\sim 10^{-9}$ mbar
- **Load lock** – brza izmjena uzoraka
- $T_s = RT - 1200$ °C
- Doziranje plinova – Ar, O₂, C₂H₄

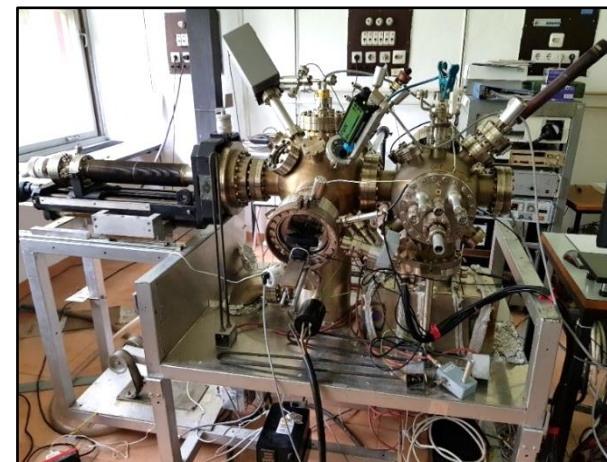
- Ograničenja: UHV-kompatibilni uzorci i materijali, metalni uzorci za grijanje
- Nadogradnje: MBE, TDS; Spajanje s drugim vakuumskim sistemima



Sinteza + osnovna karakterizacija



STM karakterizacija



ARPES karakterizacija

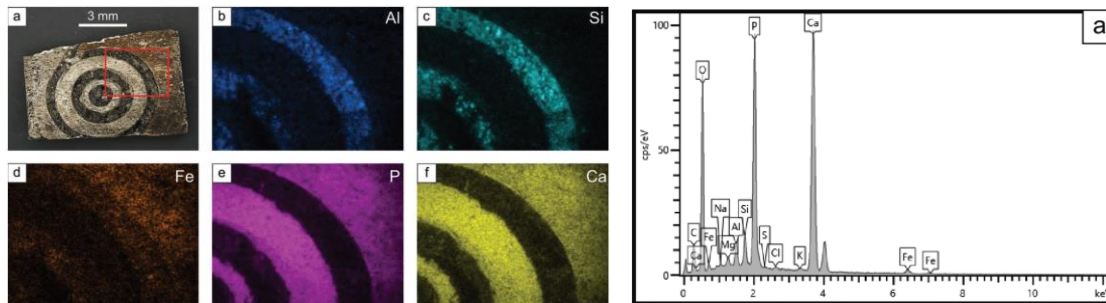
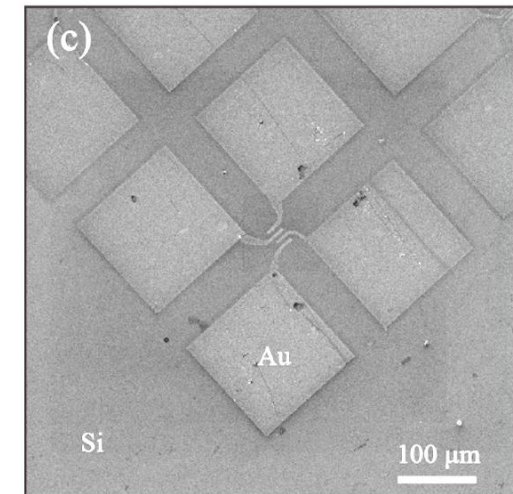
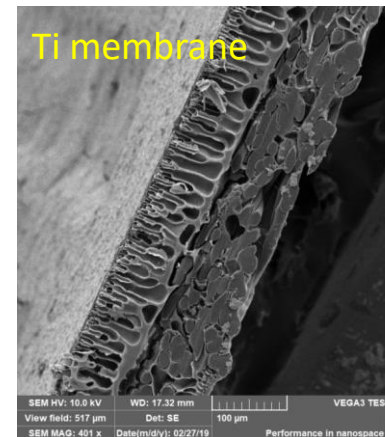
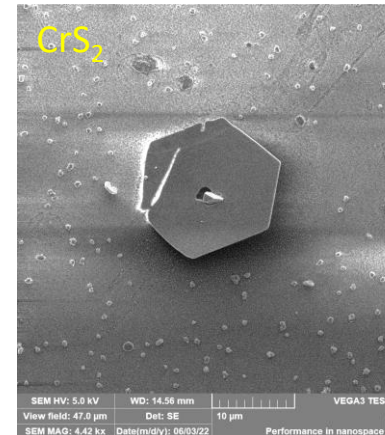


Scanning Electron Microscope (SEM, Tescan) + Energy Dispersive X-ray Spectroscopy (EDS, Bruker) + e-beam litho.

- **Morfologija** – *secondary electrons (SE) & back-scattered electrons (BSE)* detekcija
- **Kemijski sastav** – EDS detektor (više modaliteta)
- **e-beam litografija** – mikrometarske strukture

- W (LaB₆) katoda
- 200 V – 30 keV
- 2 (3) nm rezolucija
- Rad u niskom vakuumu do 500 Pa (nevodljivi uzorci)
- EDS rezolucija < 129 eV

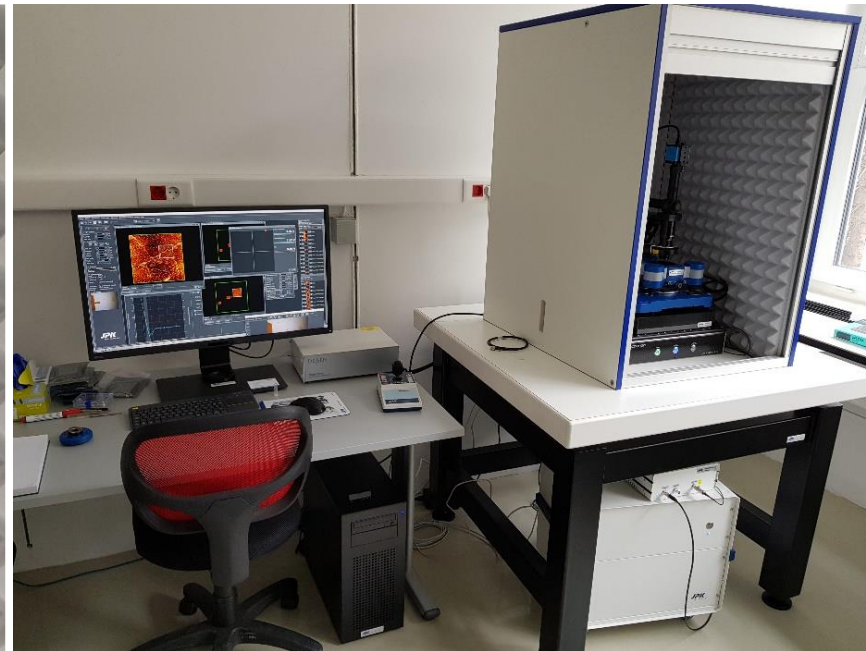
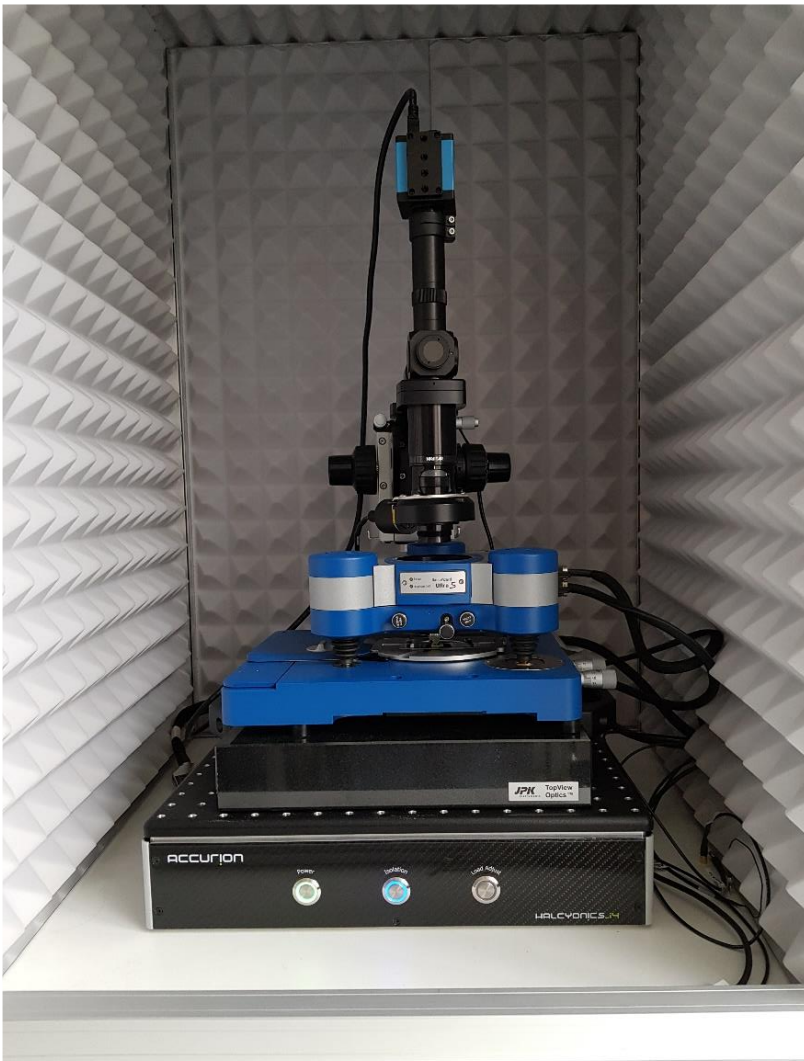
- Ograničenja: praškasti i magnetični uzorci, visina uzoraka < 81 mm, kompatibilnost s vakuumom
- Nadogradnje: STEM, CL, EBSD detektori; Postolja za hlađenje i grijanje uzoraka



Kovačević et al., IANSA 1/2023

Radatović, PhD thesis 2022.

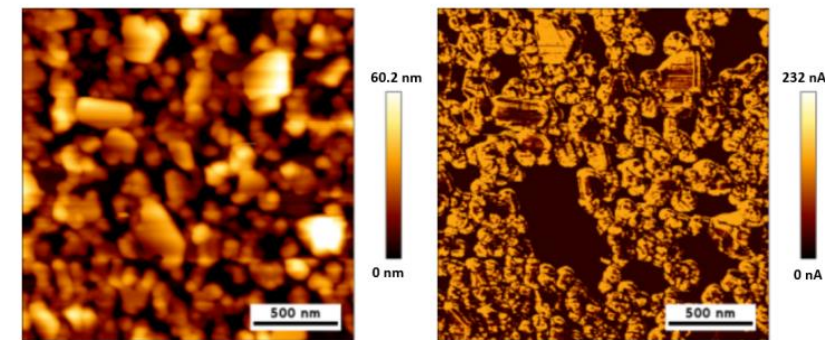
Atomic Force Microscopy (AFM) - NanoWizard ULTRA speed (JPK/Bruker)



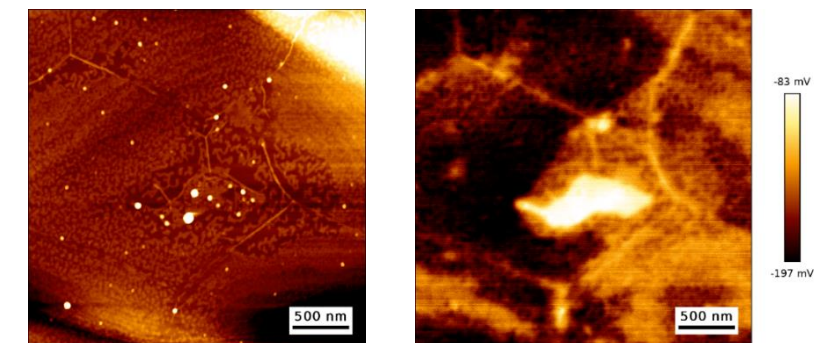
- AC & kontaktni mod,
- brzo skeniranje do 300 linija/s, atomska rezolucija,
- **Quantitative imaging QI,**
- **C-AFM,**
- **PFM,**
- **MFM,**
- **KPFM,**
- **EFM,**
- **STM,**
- **nanolitografija,**
- **stretching stage**

- 30x30x6 mikrometar x,y,z range
- Mogućnosti nadogradnje

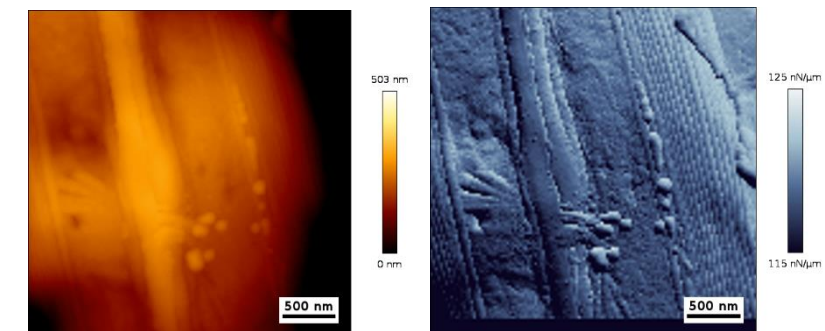
Perkolirani Au filmovi za primjenu u optici
Topografija C-AFM



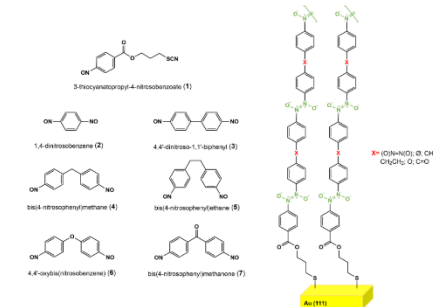
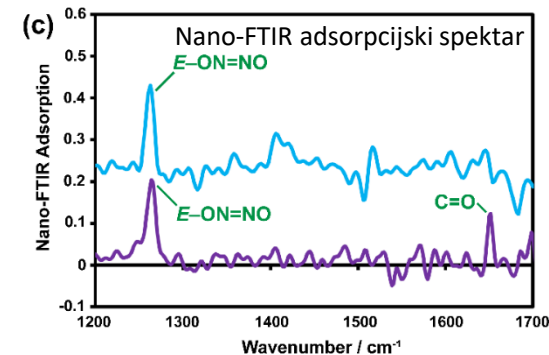
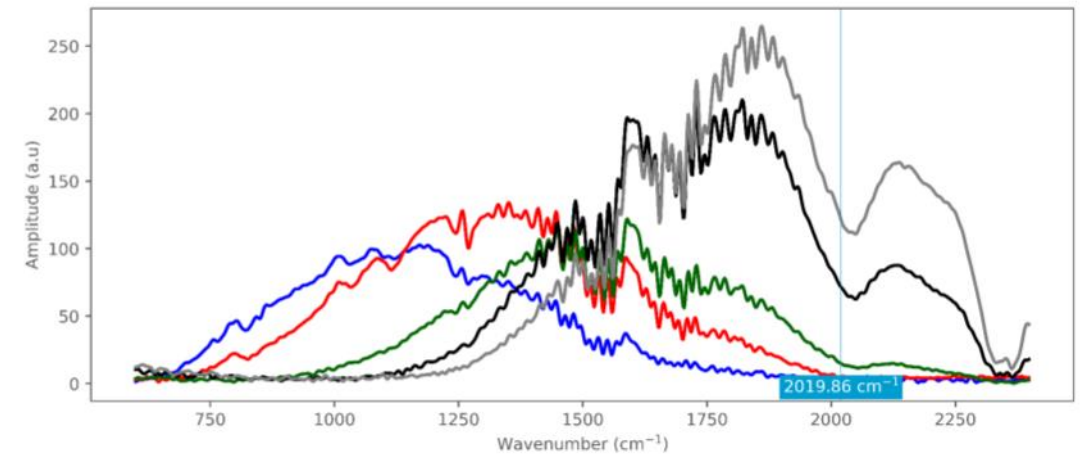
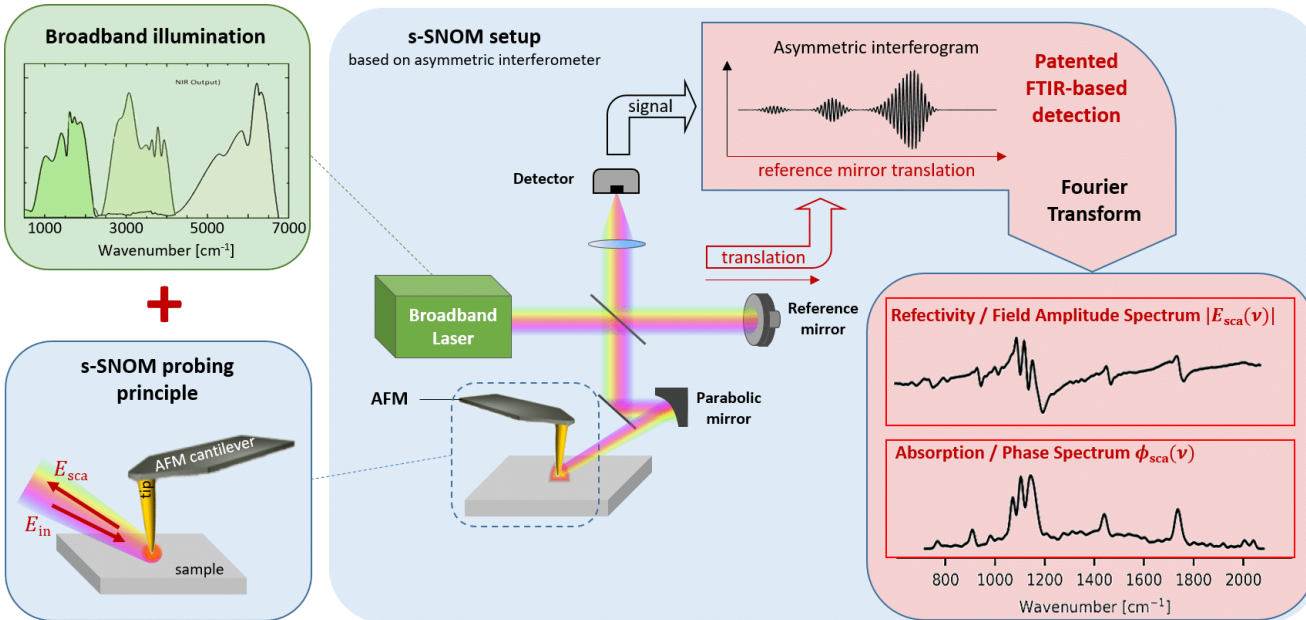
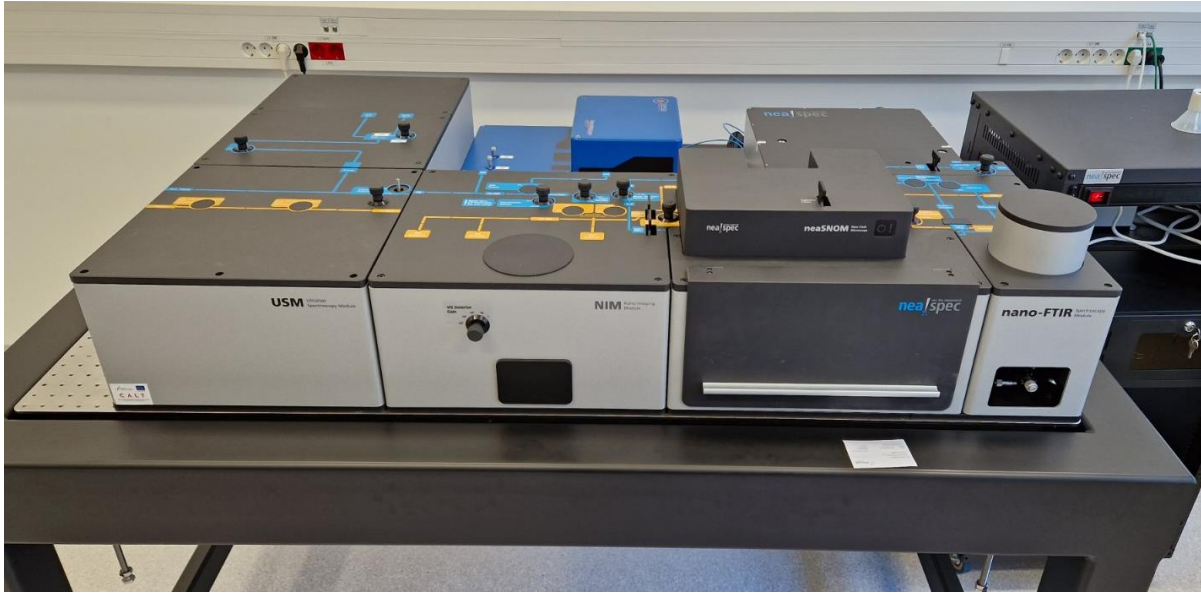
Topografija MoS₂/gr/Ir(111) KPFM



Alge kremenjašice
Topografija Youngov modul (nekalibrirani)



- Mikroskop bliskog polja
- Istovremeno daje topografiju i FTIR spektar
- Mjeri IR aktivne molekulske vibracije (dipolni moment) - može identificirati kemijski sastav (funkcionalne grupe)
- Rezolucija **20 nm**
- 100x100x2.5 mikrometara x,y,z range
- Moguće nadogradnje: sSNOM IR, VIS imaging, THz imaging, TERS...



➤ Technical Characteristics:

Excitation laser:

Wavelength: 532 nm (2.33 eV)

Power: 100 mW (min. Power < 1 μ W)

Upgrade with new laser sources (optional)

Gratings: 150, 600 and 2400 mm^{-1}

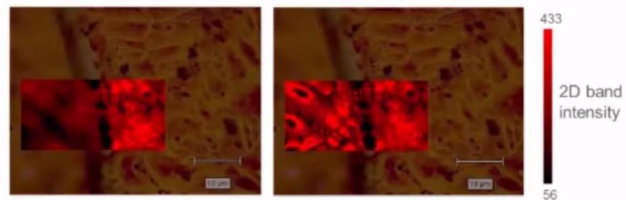
Low-energy Raman modes

Polarization optics



➤ Applications:

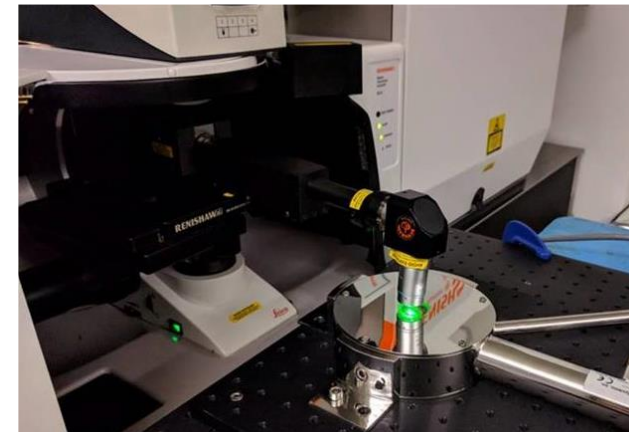
Raman & PL measurements



Z=-3 μm — Z=0 μm

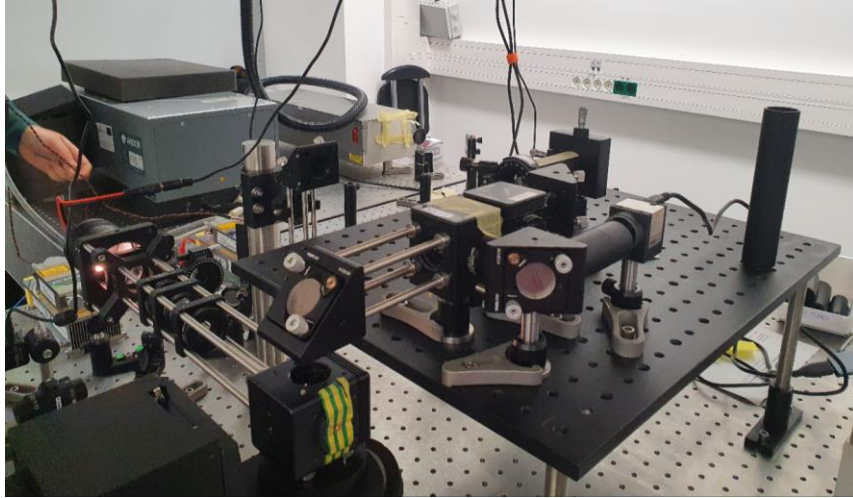
- ✓ Polarization dependent measurements
- ✓ Focus-tracking for tilted surfaces
- ✓ High-speed mapping

Magneto-optical measurements



- ✓ Integration of optical cryostat for temperature dependent measurements (4.2K -500K)
- ✓ Integration of magneto-optical cryostat with magnetic field up to 5T

Second Harmonic Generation (SHG) Setup



Technical Characteristics:

Oscillator:

Central Wavelength: 1044 nm

Rep. Rate: 80 MHz

Pulse Duration 220 fs

Average Output Power: 4.5 W

Energy per Pulse: 50 nJ

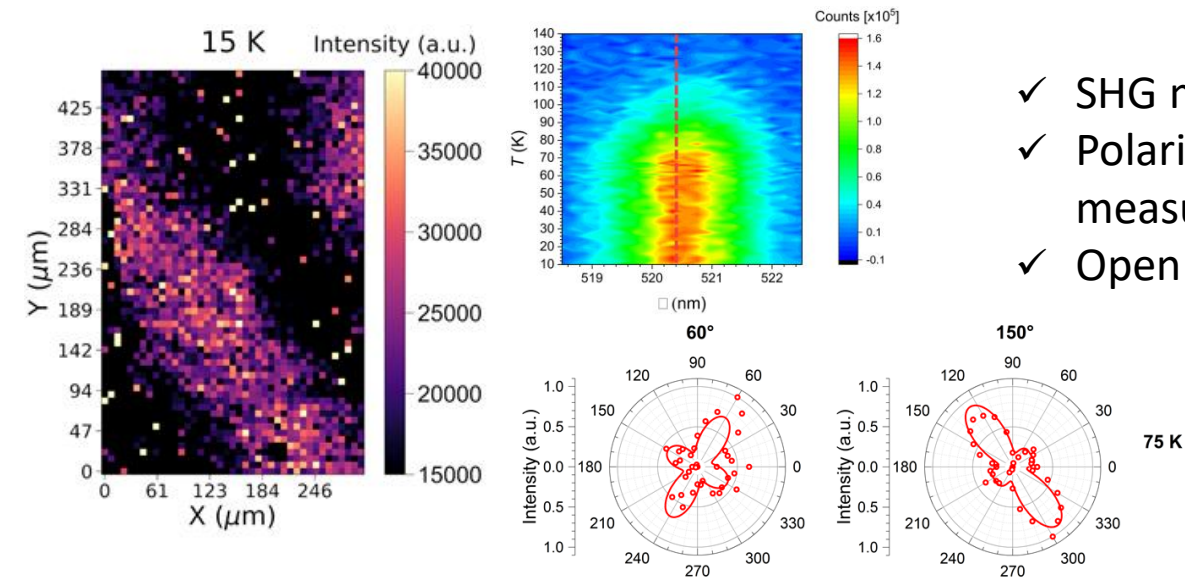
Spectrometer:

Gratings: 150, 300 and 1800 mm^{-1}
EMCCD

Optics:

Polarization optics

Applications:



- ✓ SHG mapping
- ✓ Polarization dependent measurements
- ✓ Open access

- ✓ Integration of optical cryostat for temperature dependent measurements (4.2K -500K)
- ✓ Integration of magneto-optical cryostat with magnetic field up to 5T
- ✓ Measurements under the strain



➤ Technical Characteristics:

Astrella:

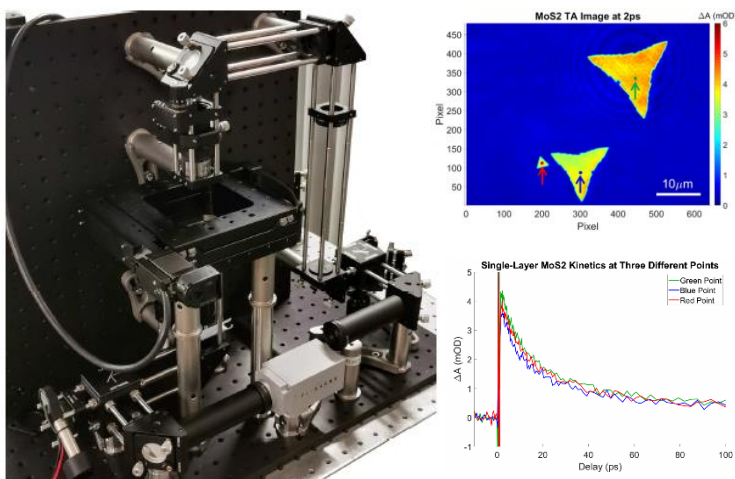
Energy: 7 mJ/pulse
 Central Wavelength: 800 nm
 Rep. Rate: 1 kHz
 Pulse Duration <90 fs;
 OPA1: 290 - 580 nm
 OPA2: 480 - 1150 nm

Oscillator Vitara:

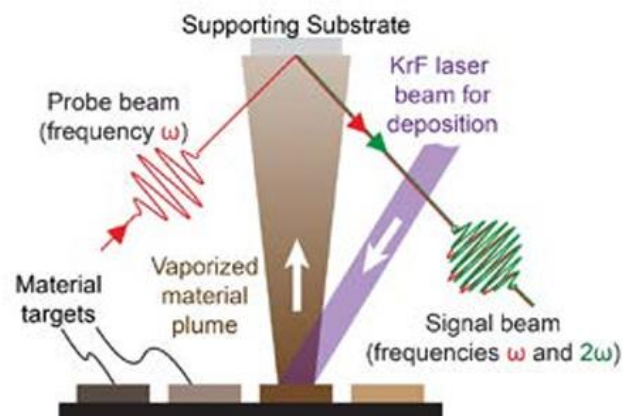
Central Wavelength: 800 nm
 Rep. Rate: 80 MHz rep. rate
 Tunability: 755 - 860 nm
 Average Output Power: 550 mW

➤ Applications:

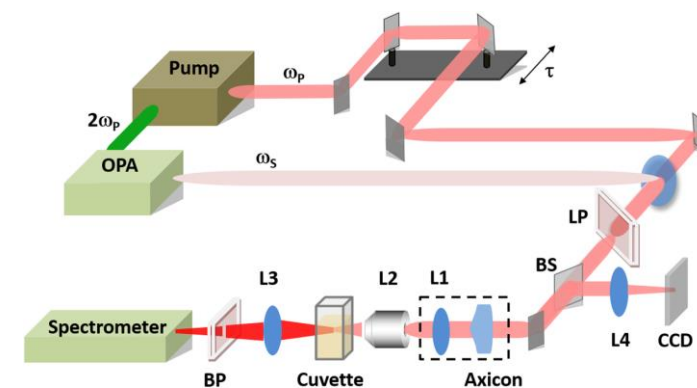
Transient Absorption Microscopy



In-situ Second Harmonic Generation (I-SHG) for ferroelectric film growth process monitoring



Coherent Anti-Stokes Raman Spectroscopy (CARS)





→ Server broj 1:

4 node-a s ukupno 192 CPU (AMD EPYC 7352), 1 TB ECC DDR4, 2 TB NVMe SSD

→ Server broj 2:

4 node-a s ukupno 256 CPU (AMD EPYC 7452), 1 TB ECC DDR4, 2 TB NVMe SSD

→ Pristupni server:

1 node s ukupno 8 CPU (AMD EPYC 7232p), 32 GB ECC DDR4, 4 TB SATA HDD

- Serveri se uglavnom koriste za računalnu fiziku i izračune iz fizike kondenzirane materije i znanosti materijala, uglavnom na bazi teorije funkcionala gustoće
 - Specifično: računi elektronske strukture i dinamike rešetke novih materijala, many-body perturbativni računi i optička svojstva (RPA, GW+BSE), strukturne nestabilnosti i supravodljivost iz prvih principa, strojno učenje, računi površine potencijalne energije, anharmonička svojstva...
- Serveri su povezani s već postojećim serverima na Zavodu za teorijski fiziku Instituta Ruđer Bošković, što povećava dostupnost računalne snage