Super Surfer

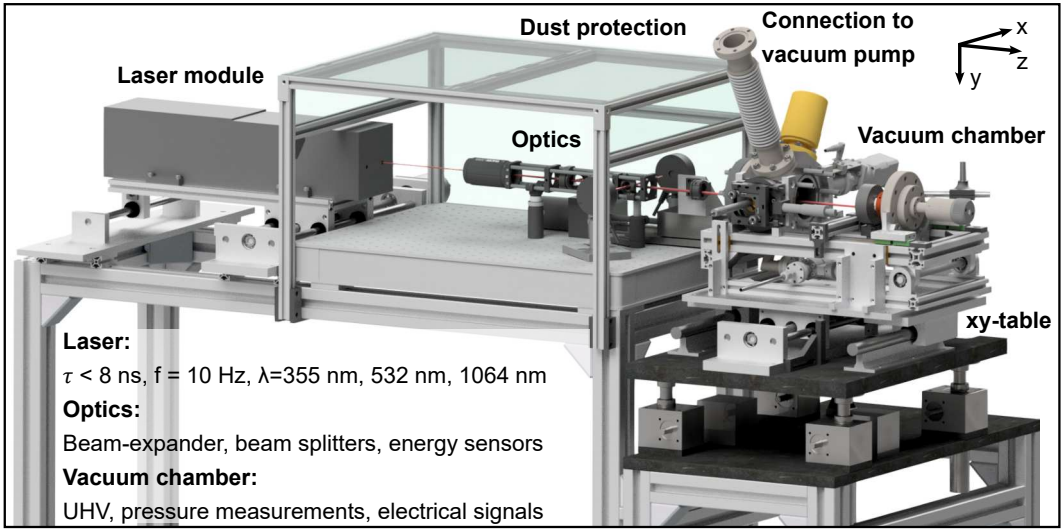
Overview of the activities of the University of Wuppertal

Florian Brockner, Dirk Lützenkirchen-Hecht

2. Dezember 2024

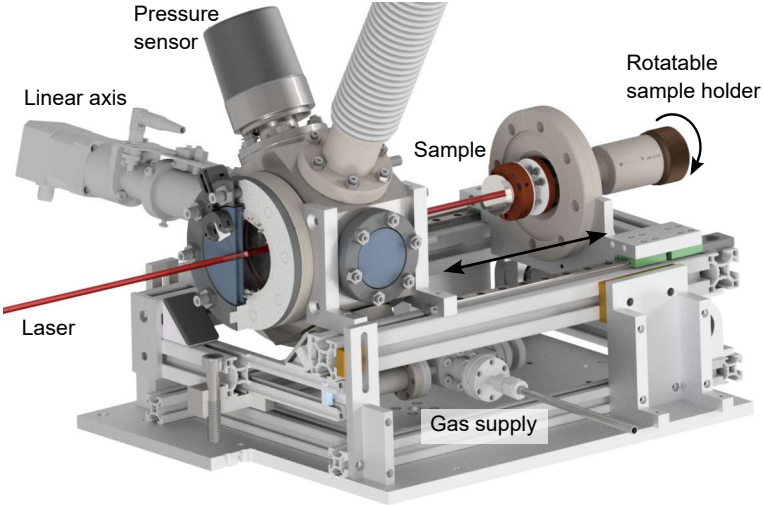
Setup for laser polishing @ University of Wuppertal

Setup for laser polishing



Setup created in last project ⇒ Point and area polishing of samples under vacuum and defined atmospheres

Vacuum chamber



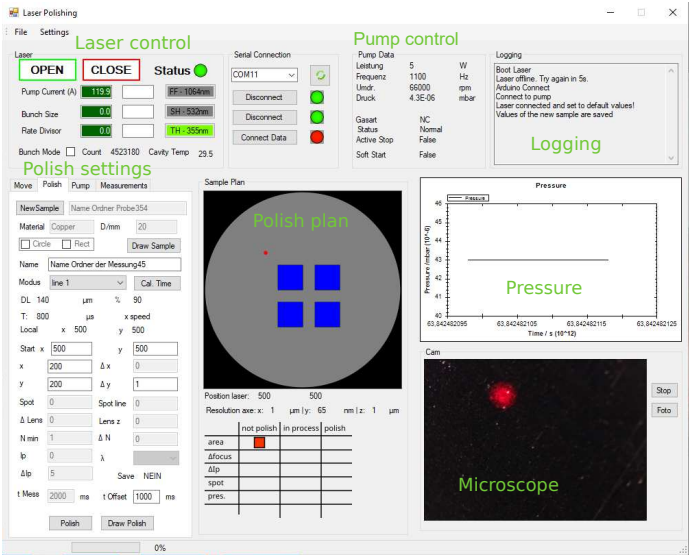
High demands on the chemical composition of surfaces

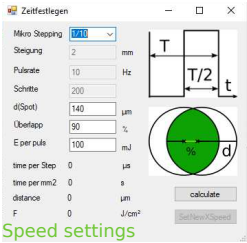
- **Chamber**
  - Heatable up to T=80°C
  - Oil-free (no C source)

$\Rightarrow$ $P_{min} = 5 \cdot 10^{-8}$ mbar

- **Sample Holder:**
  - Electrically isolated
  - Rotatable & tilting
  - Quick sample change
  - Different sample holders for foils, bulk samples, ...
- **Gas supply:**
  Fine leak valve;
  10^{-6} mbar$< P(N_2) <$ 1 mbar

Possibilities:
Investigation of Nb doping, influence of polarisation and solid state structure on the polishing result, investigation of different sample systems.





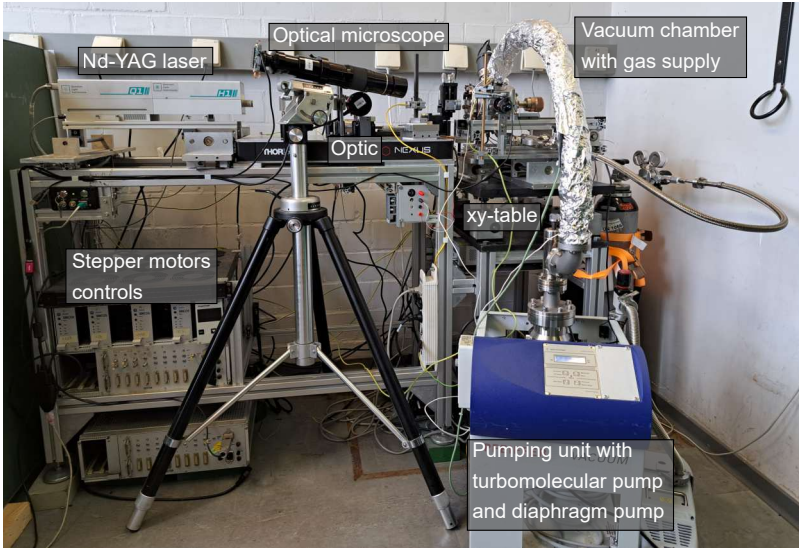
New laser software

- Control of the new pumping station (oil-free)
- Stepper motors are controlled via an Arduino so that the motor speeds can be changed

➔ 30 % faster polishing speed, 10 min/mm, limit f=10Hz

- visualisation of the polished areas

Current experimental setup



Nanosecond laser
λ=355 nm, 532 nm, 1064 nm, τ<8ns

xy-Table
Δx≈1μm, Δy≈70 nm

Variable optics
Beam expander, λ/4, energy monitor, motorised focus lens

Vacuum chamber
UHV, gas supply, oil-free

Detected signals
pressure, reflected laser energy, optical images of the surface, electrical signals

To dos in Super Surfer

BERGISCHE UNIVERSITÄT WUPPERTAL

Goals of the project:

1. Laser polishing of different materials: niobium, copper, thin-film systems
2. Tunnelling spectroscopy to investigate the superconducting properties

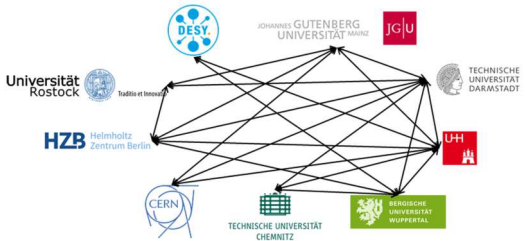
PhD students	only one of two approved	354,868.92 € / 157,719.52 €
Student employees	not approved	18,977.81 € / 0 €
only enough manpower funded for the laser topic, tunneling spectroscopy: University - funded students		
Beam Profiler	6,600 € / 6,902 €	Top-Hat-Optic 5,500 €
Laser energy regulation	6,000 € / 8,925 €	Long-range microscope 6,850 €
Vacuum accessories	5,050 €	Lock-in amplifier 9,850 €
Niobium single crystals	2,000 €	
Investments: authorised in full		41,850 €
Small orders	vacuum flange, oxygen-free copper, ...	5,320 € / 5,320 €
Business trips	DPG, DESY, IPAC	10,000€
Total expenditure		293,627.42 €

Project plan

BERGISCHE UNIVERSITÄT WUPPERTAL

Work packages / milestones	2024		2025				2026				2027	
	III	IV	I	II	III	IV	I	II	III	IV	I	II
Modifications to the setup (laser), new hardware / software; first investigation of laser polishing of niobium and copper	x	x	x	o								
Modification + commissioning of scanning tunnelling microscope; first measurements of tunnelling spectroscopy on niobium, low T	x	x	x	x	o							
Publication: Polishing of niobium with circularly polarised radiation; DPG-Spring + IPAC 2025			x	o								
Tunnel spectroscopy on laser-polished samples; optimisation of laser polishing; investigation of defects, determination of T_c					x	x	x	o				
Presentation: Tunnelling spectroscopy measurements on laser-polished niobium samples; EMRS								x	o			
Measurement of parasitic field emission of laser-polished material samples (Nb, Cu, layer systems); Publication + DPG-Spring		x	x	x	x	x	x	x	x	x	x	o

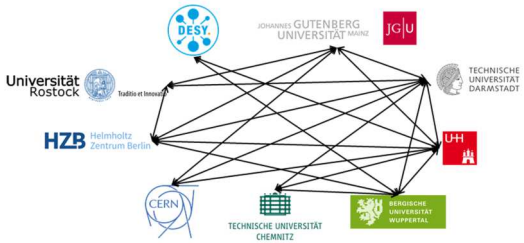
Work packages / milestones	2024		2025				2026				2027	
	III	IV	I	II	III	IV	I	II	III	IV	I	II
Correlation of superconducting properties and laser polishing publication at the DPG-Spring + publication										x	x	o
Field emission measurements, tunnelling microscopy and tunnelling spectroscopy in the Verbund Joint publication(s)		x	x	x	x	x	x	x	x	x	x	o



Focus on the study of laser polishing of various materials

Project plan

Work packages / milestones	2024		2025				2026				2027	
	III	IV	I	II	III	IV	I	II	III	IV	I	II
Correlation of superconducting properties and laser polishing publication at the DPG-Spring + publication										x	x	o
Field emission measurements, tunnelling microscopy and tunnelling spectroscopy in the Verbund Joint publication(s)		x	x	x	x	x	x	x	x	x	x	o



Focus on the study of laser polishing of various materials

Summary & Outlook

Setup

- Experimental setup available for systematic study of laser polishing
- Complex vacuum chamber, improved optics, new software (faster polishing)

$\Rightarrow$ Further optimisation of setup through new investments $\Rightarrow$ Beam profiler and energy regulators already purchased $\Rightarrow$ Reduction of measurement errors + thin film polishing due to lower laser energy

Approved project scope

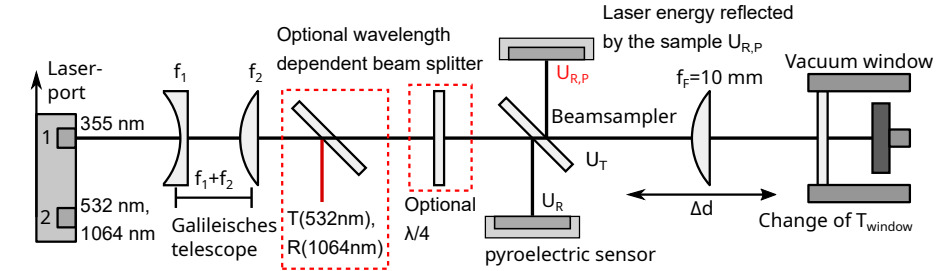
- Only laser polishing can be investigated due to reduction in human resources
- Approved funding allows further optimisation of facility

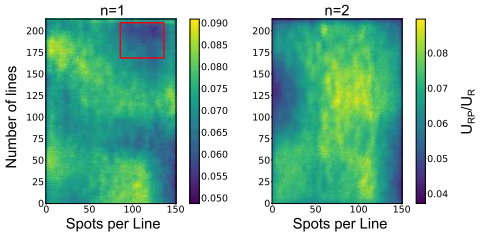
Measurements

- First Measurements of the dependence of laser polishing on polarisation direction and crystal structure

Thank you very much for listening!

Questions? Ideas?





- **Telescope:** Change of laser diameter, d
- **Beamsampler:** Energy measurement, $U_{R,P}$, U_R
- **Focus lens:** Change of F=U/A
- **$U_{R,P}/U_R$**: Influence of the transmission of the window + change in the reflectivity of the sample
  $\Rightarrow$ Changes observable as a result of the LP