



# Superconductivity in strongly disordered systems

PhD seminar 2021

2021 Košice

Marek Kuzmiak, 2<sup>nd</sup> year

# Content

- my study
- my teaching
- my research



# My study

## APMM

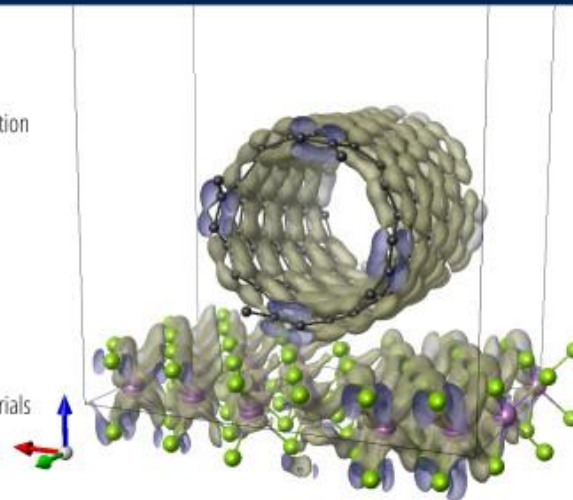
ÚFV/APMM/19  
Martin Gmitra

Atomistické počítačové modelovanie materiálov

Atomistic Computer Modeling of Materials

### CONTENTS

Crash course to Many-body Schrodinger Equation  
Introduction to Density Functional Theory  
Numerical Methods for Realistic Calculations  
Equilibrium Structures of Materials  
Elastic Properties of Materials  
Vibration of Molecules and Solids  
Phonons and Vibrational Spectroscopy  
Photoelectron Spectroscopy  
Dielectric Function and Optical Spectra  
Density Functional Theory and Magnetic Materials



### LITERATURE

F. Giustino, Materials Modelling using Density Functional Theory, Oxford University Press 2014  
J. Kohanoff, Electronic Structure Calculations for Solids and Molecules, Cambridge University Press 2006  
M. P. Marder, Condensed Matter Physics, John Wiley & Sons 2010  
R. M. Martin, Electronic Structure, Cambridge University Press 2004  
S. Bluegel et al., Computing Solids, Lecture Notes of the 45th IFF Spring School 2014

# My study

Technická univerzita v Košiciach  
Fakulta elektrotechniky a informatiky

## Supravodivosť v silne neusporiadaných systémoch

Písomná práca k dizertačnej skúške

Študijný program: Fyzikálne inžinierstvo progresívnych materiálov  
Študijný odbor: Elektrotechnika  
Školiace pracovisko: Katedra fyziky (KF)  
Školiteľ: Mgr. Pavol Szabó, CSc.  
Konzultant: prof. RNDr. Peter Samuely, DrSc.

Košice 2021

Ing. Bc. Marek Kuzmiak

# My teaching

- FEI TUKE, Physics I. – 2 hours x 3 groups per week



# My teaching

UNIVERZITA PAVLA JOZEFA ŠAFÁRIKA V KOŠICIACH  
NÁZOV FAKULTY

**EXPERIMENTÁLNE ŠTÚDIUM SUPRAVODIVOSTI V  
ULTRATENKÝCH FILMOCH**

**BAKALÁRSKA PRÁCA**

Študijný program: Fyzika  
Pracovisko (katedra/ústav): Ústav fyzikálnych vied  
Vedúci diplomovej práce: Mgr. Pavol Szabó CSc.

Košice 2021

**Levente FABER**

UNIVERZITA PAVLA JOZEFA ŠAFÁRIKA V KOŠICIACH  
PRÍRODOVEDECKÁ FAKULTA

**SKENOVACIA TUNELOVÁ MIKROSKOPIA  
A SPEKTROSKOPIA VRSTEVNATÝCH SUPRAVODIČOV  
NA BÁZE NBSE2**

**DIPLOMOVÁ PRÁCA**

Študijný program: 4.1.1 Fyzika  
Pracovisko (katedra/ústav): UFV – Ústav fyzikálnych vied  
Vedúci diplomovej práce: Mgr. Pavol Szabó, CSc.

Košice 2021

**Bc. Filip KOŠUTH**

# My research

- graphite (with PAN – EMP project)
- LSNS (our Superconductivity group)
- MoN (my thesis)



# My research

(graphite)

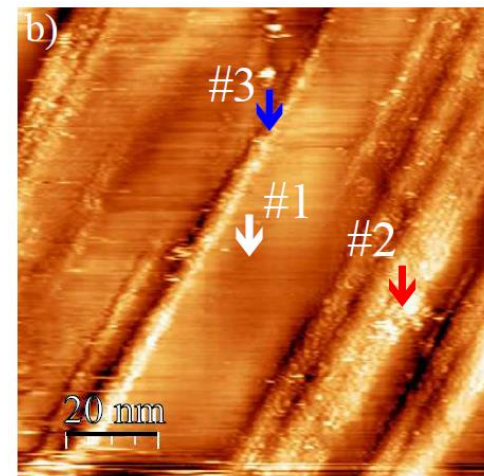
AUTHOR SUBMITTED MANUSCRIPT - JPCM-118856

## Macroscopic-ranged proximity effect in graphite

author

(Dated: June 11, 2021)

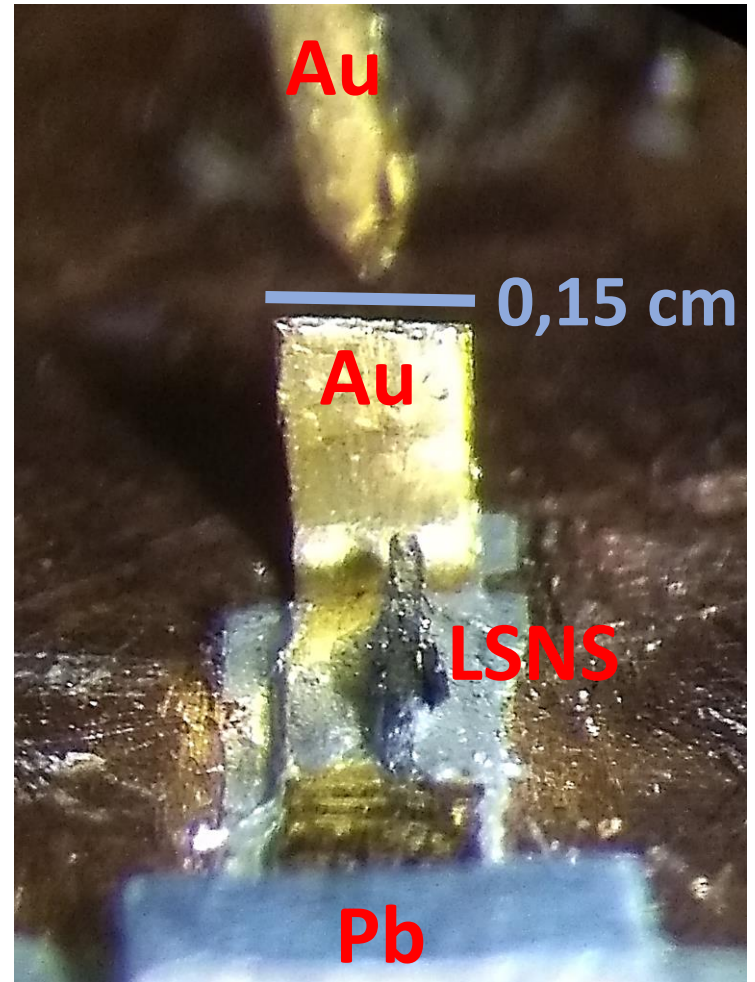
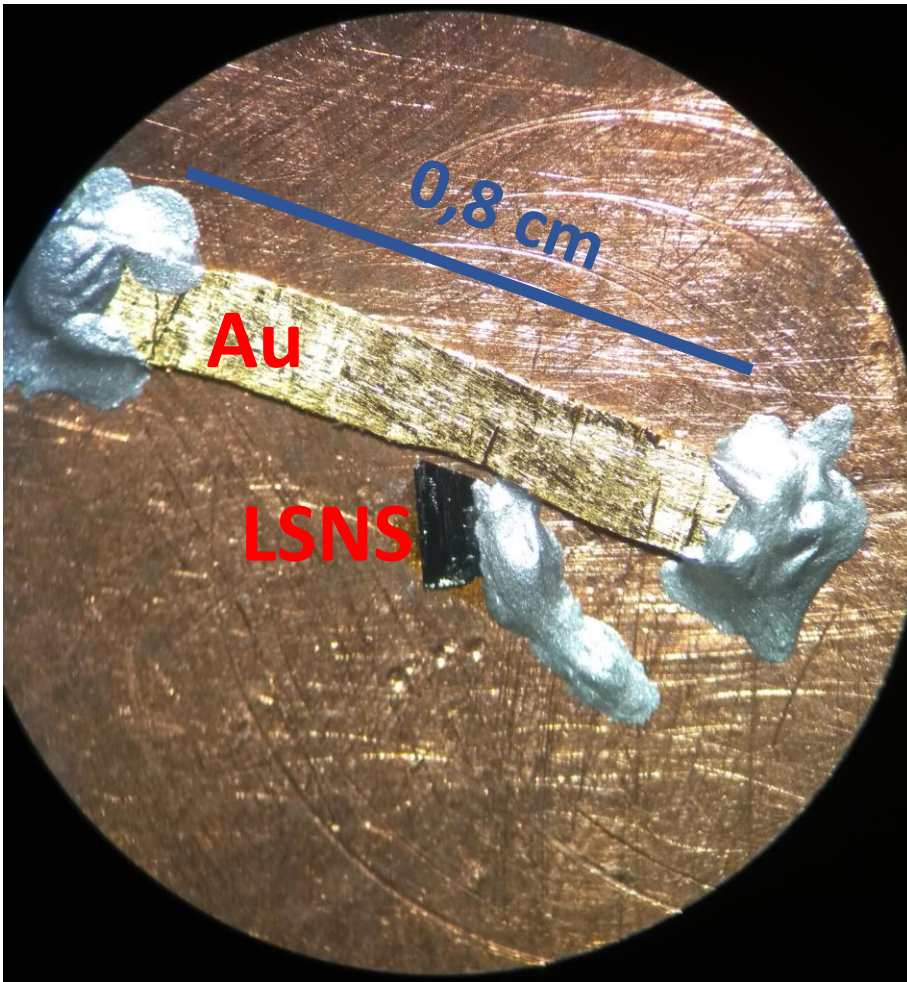
We report the induction of proximity-induced superconducting features over macroscopic lengths in highly oriented pyrolytic graphite (HOPG). The phenomenon is triggered when electrical currents are injected in the material through superconducting electrodes, few millimeters apart from each other. Such large range is anomalous, as proximity-induced features in normal conductors hardly surpass few micrometers. The results can be explained as due presence of pre-existing superconductivity in graphite on small, localized regions.





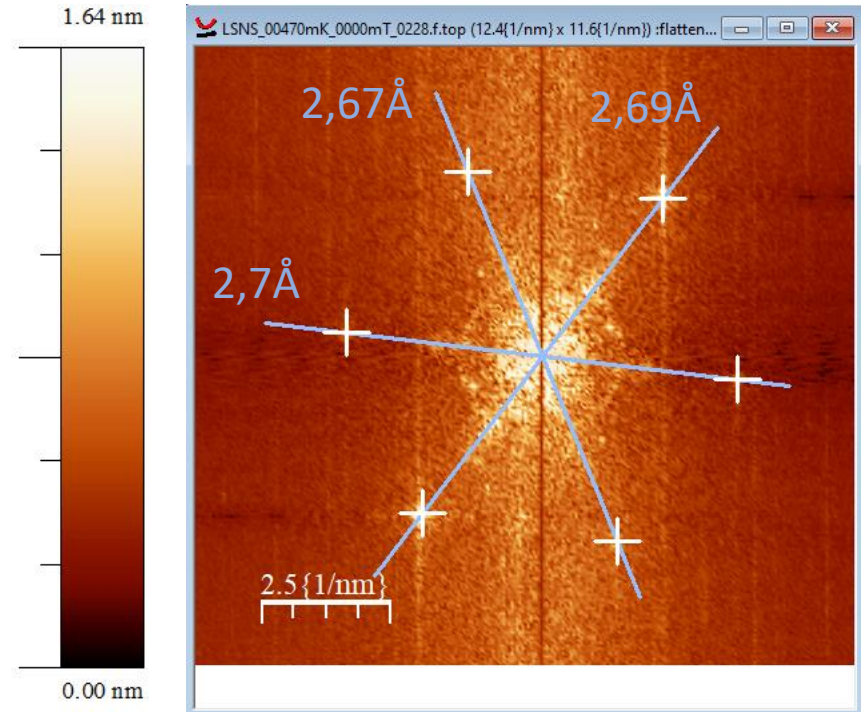
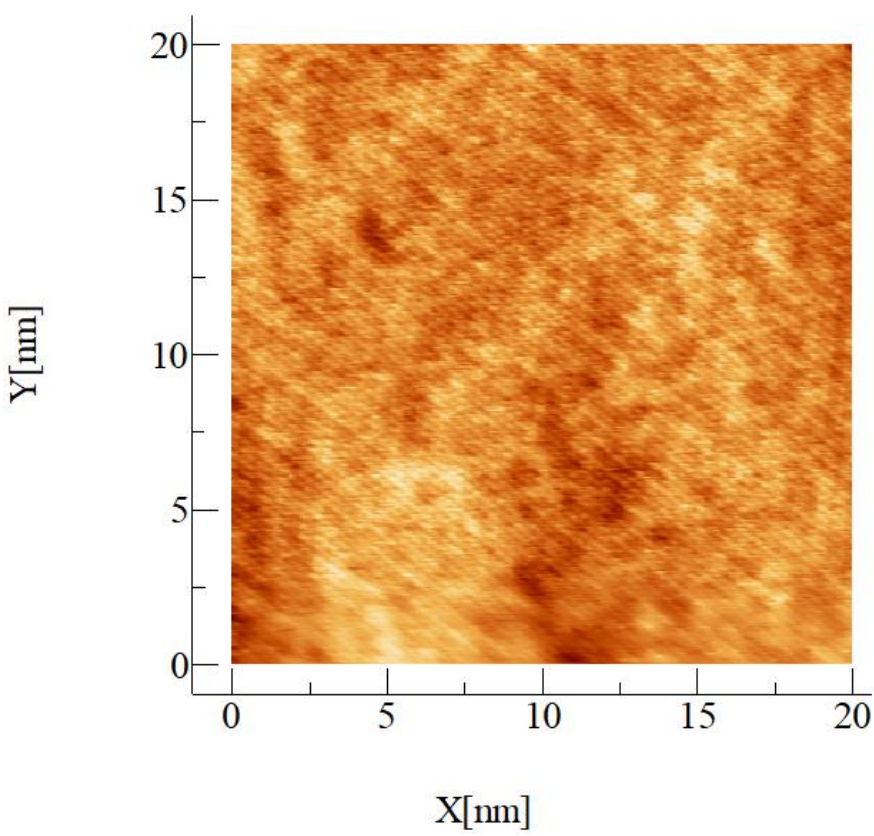
# My research

(LSNS)



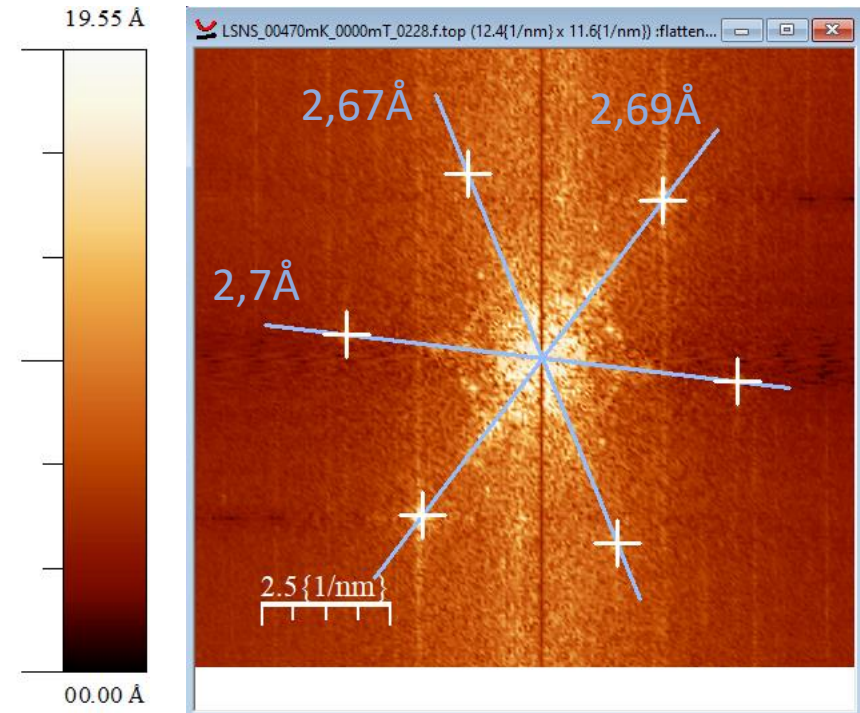
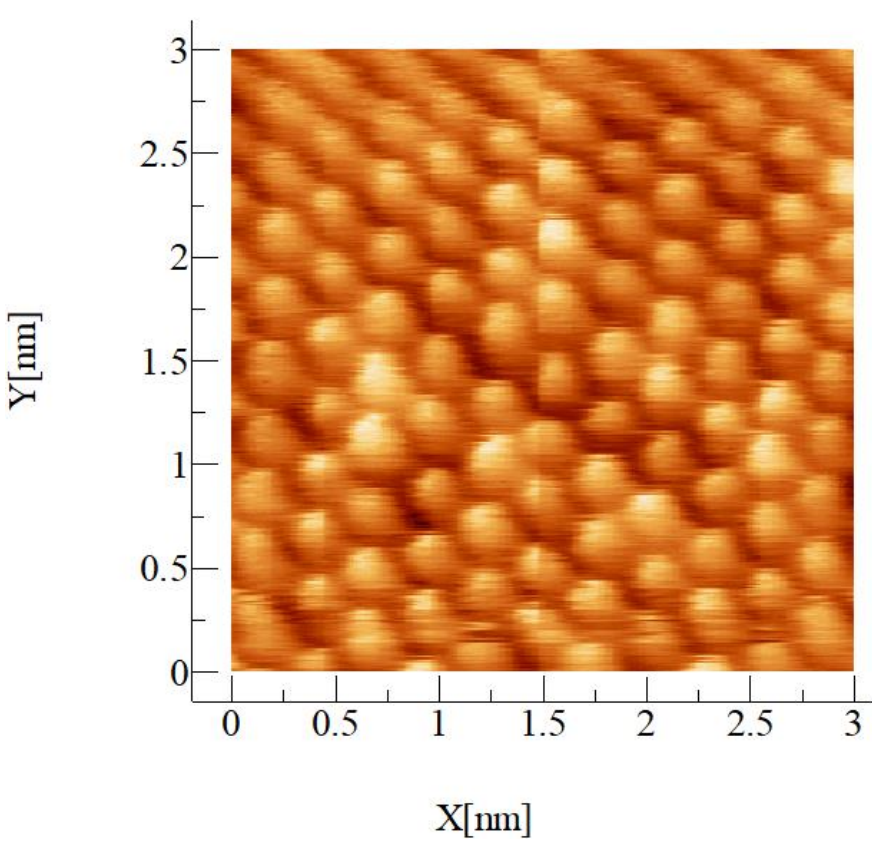
# My research

(LSNS)



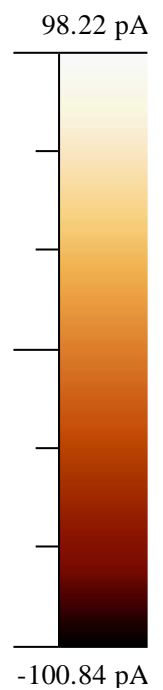
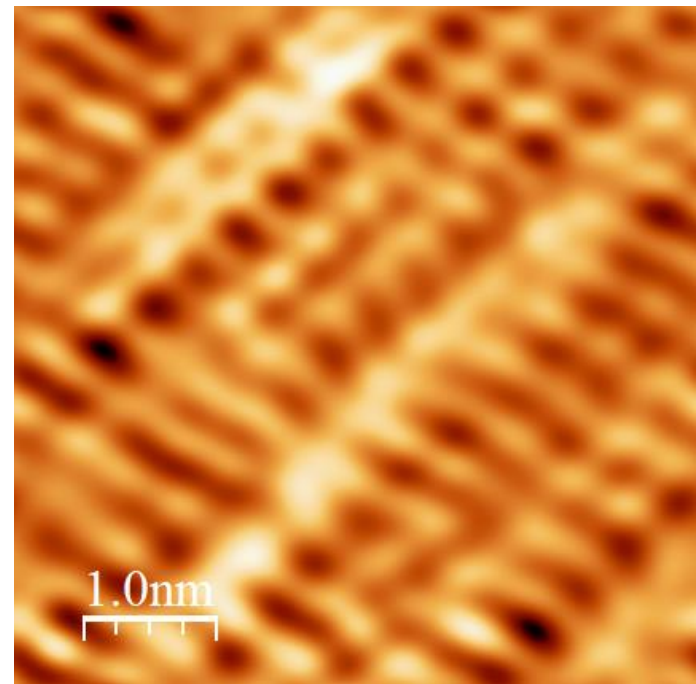
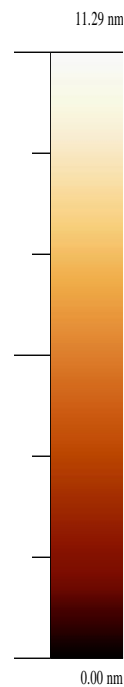
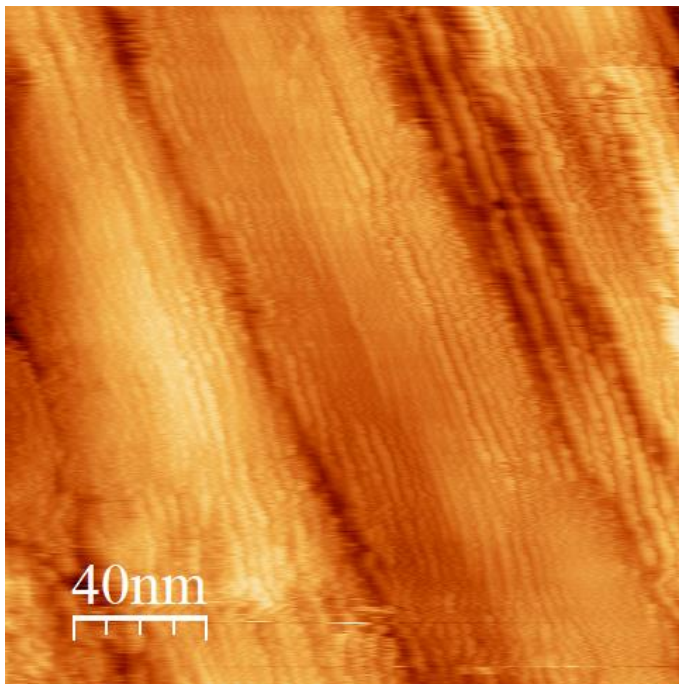
# My research

(LSNS)



# My research

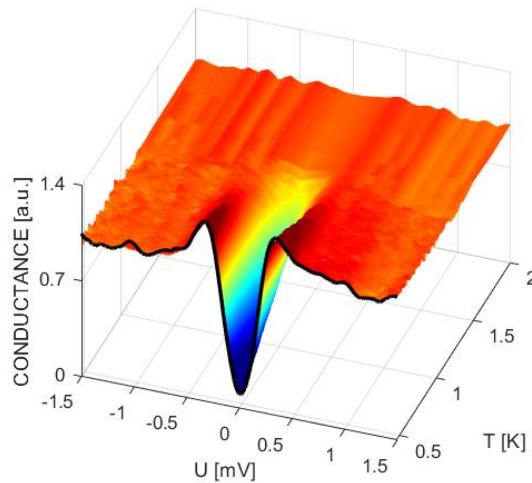
(LSNS)



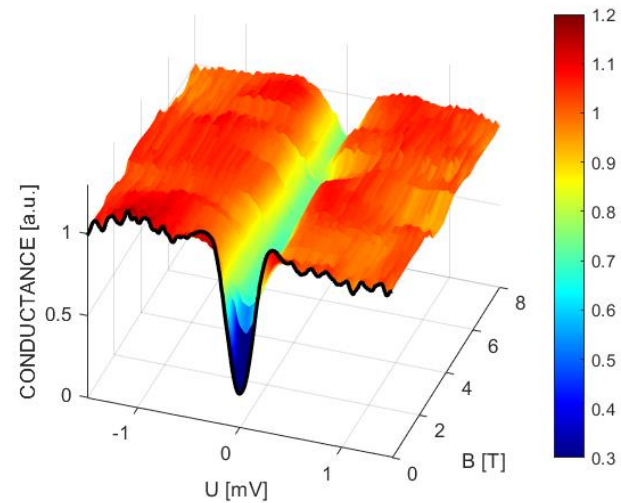
# My research

(LSNS)

- I made STS on LSNS too, but Dr. Šofranko will tell you more about it ...



$B = 0$  T

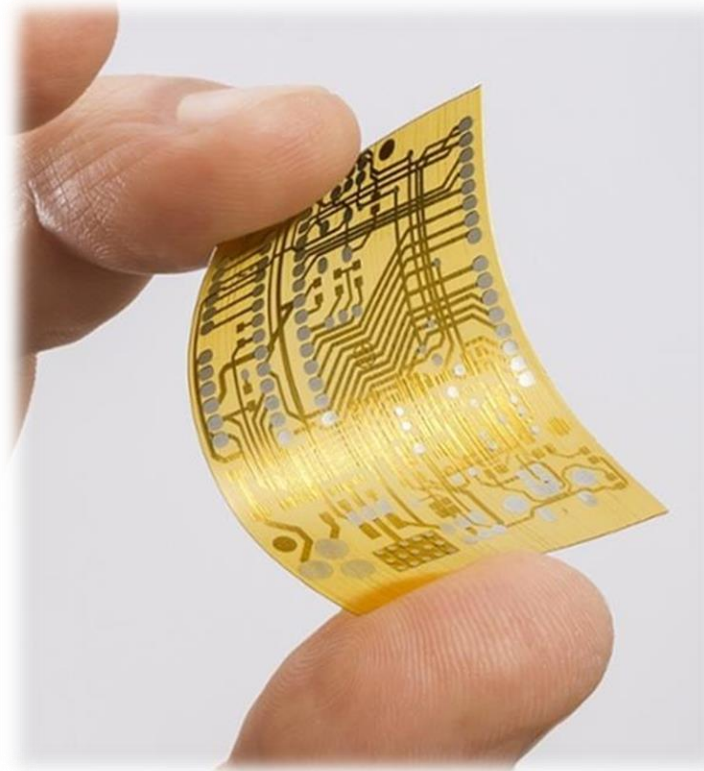


$T = 0.470$  K

# My research

(MoN)

*Our motivation*

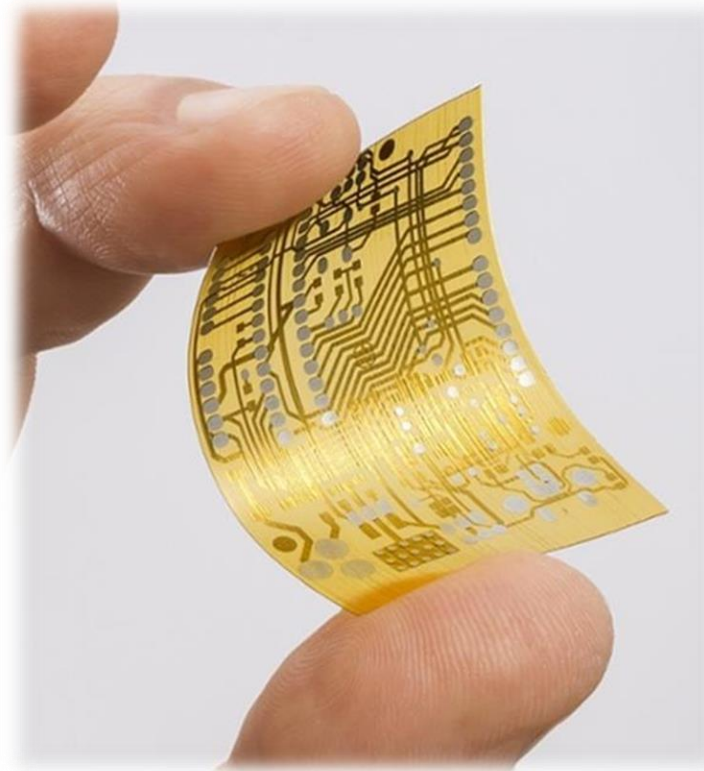


*reduction*

# My research

(MoN)

*Our motivation*

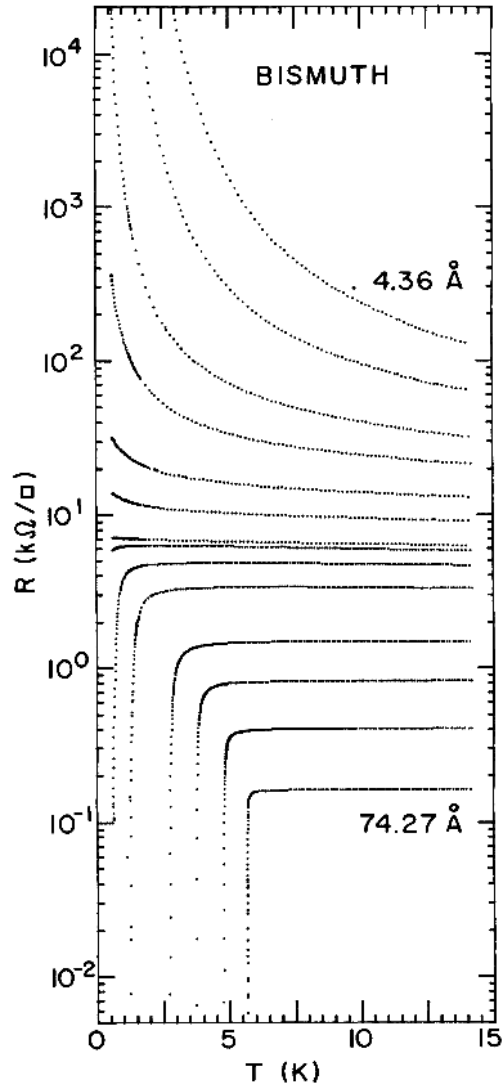


*reduction*

*... but as long as*

# My research

(MoN)

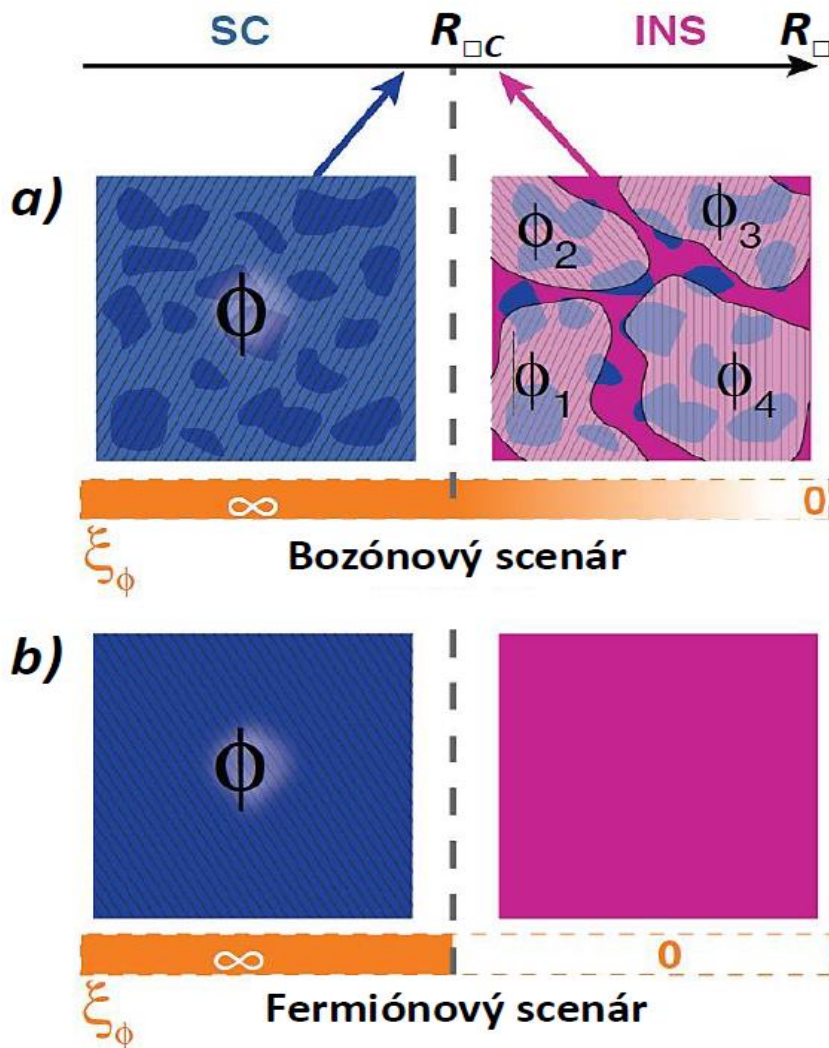


D. B. Haviland et al., PRL 62, 2180 (1989)



# My research

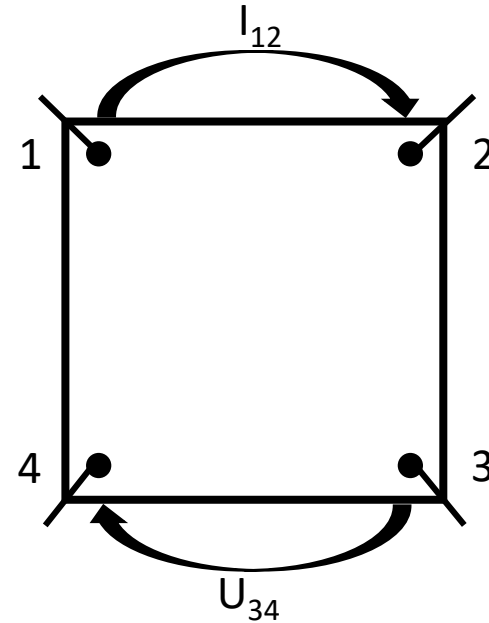
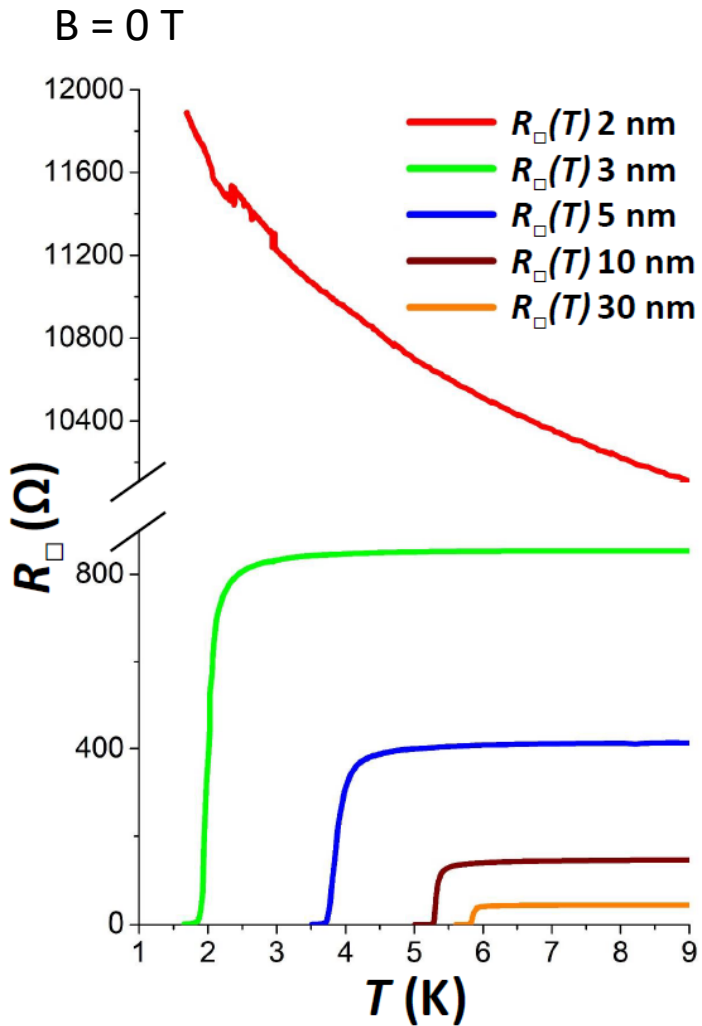
(MoN)



S. M. HOLLEN et al., PRB 87, 054512 (2013)

# My research

(MoN)

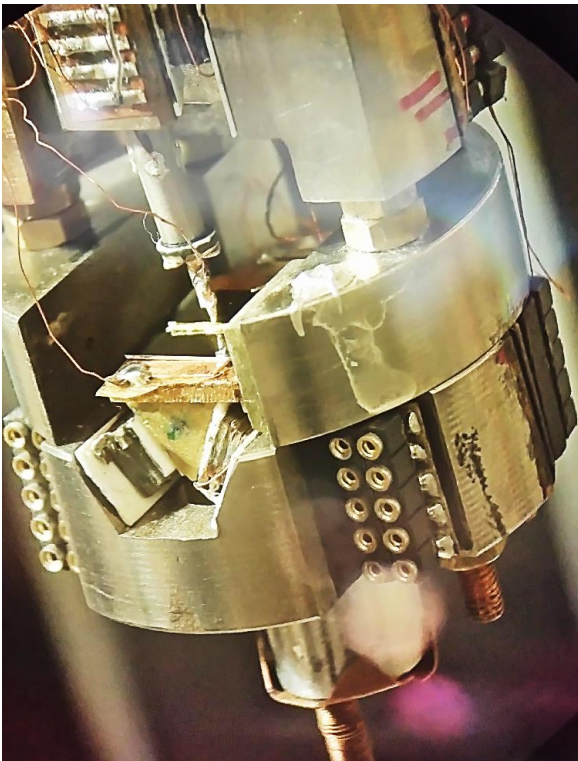


L. J. VAN DER PAUW, PRR 13, 1 (1958)

# My research

(MoN)

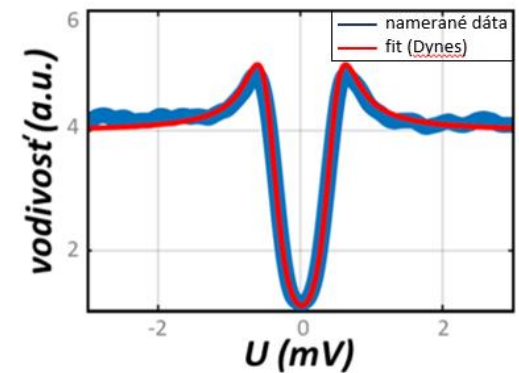
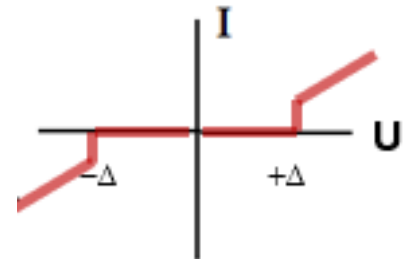
## STM



## STS

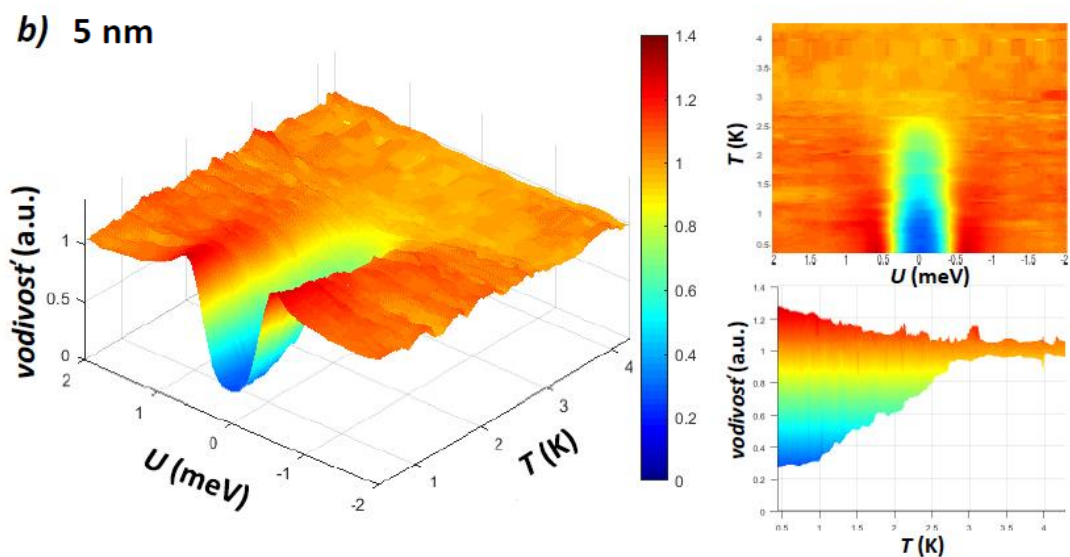
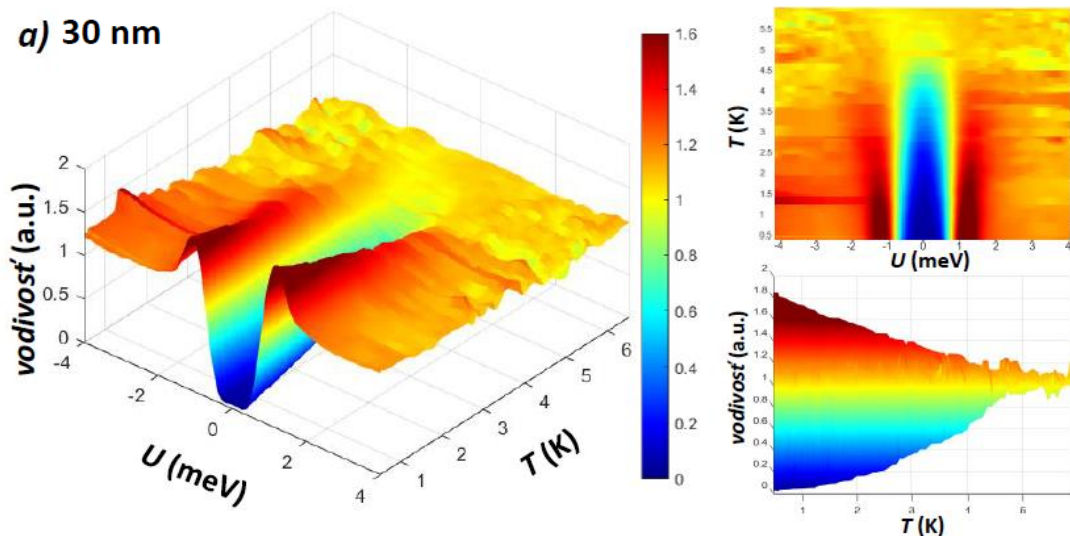
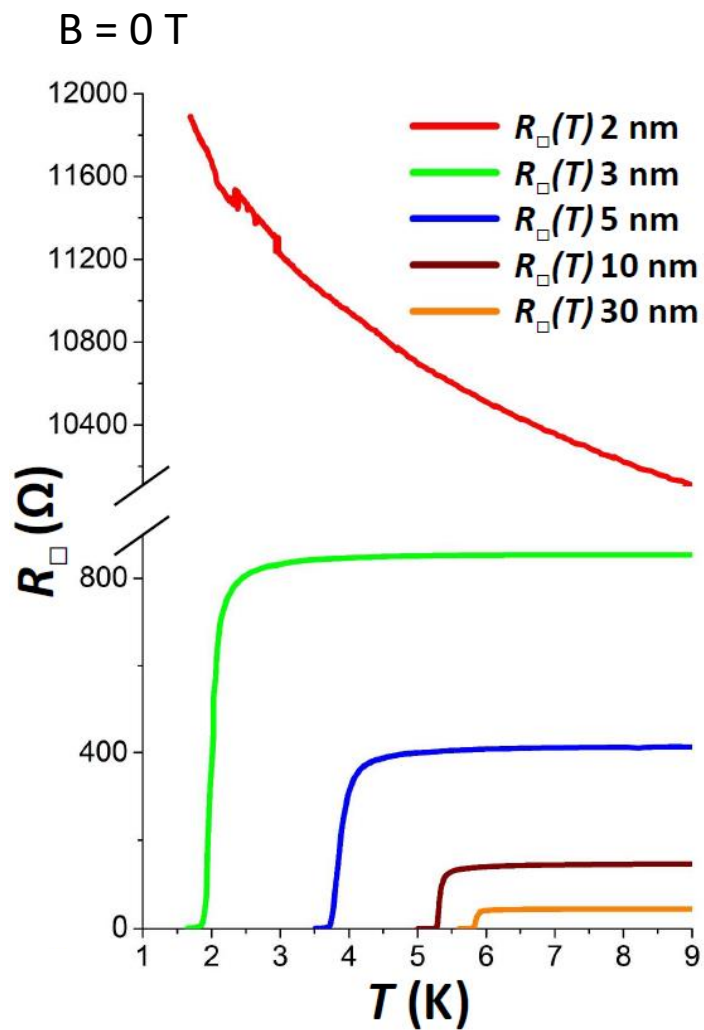
$$N_S(E) = \text{Re} \left\{ \frac{E}{\sqrt{E^2 - \Delta^2}} \right\}$$

$$N_S(E, \Gamma) = \text{Re} \left\{ \frac{(E - i\Gamma)}{\sqrt{(E - i\Gamma)^2 - \Delta^2}} \right\}$$



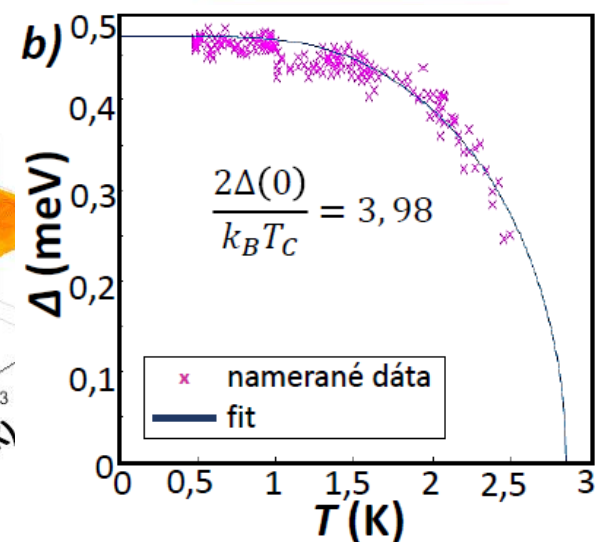
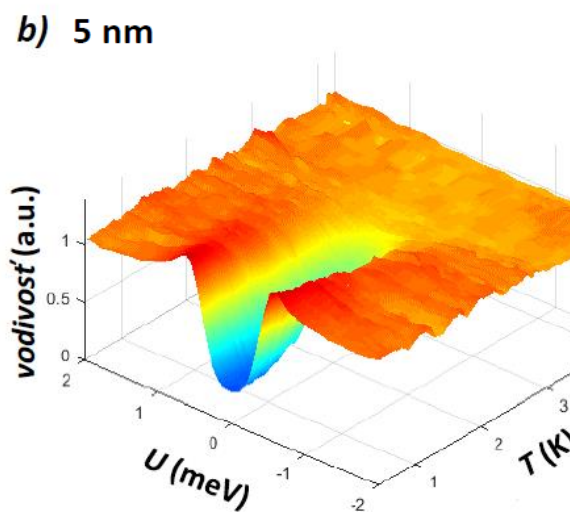
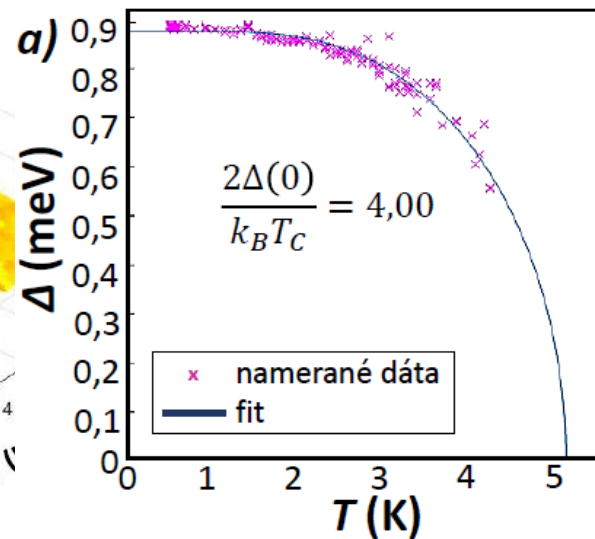
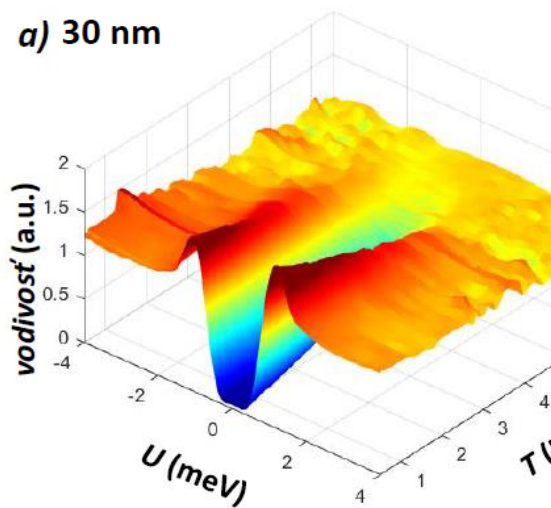
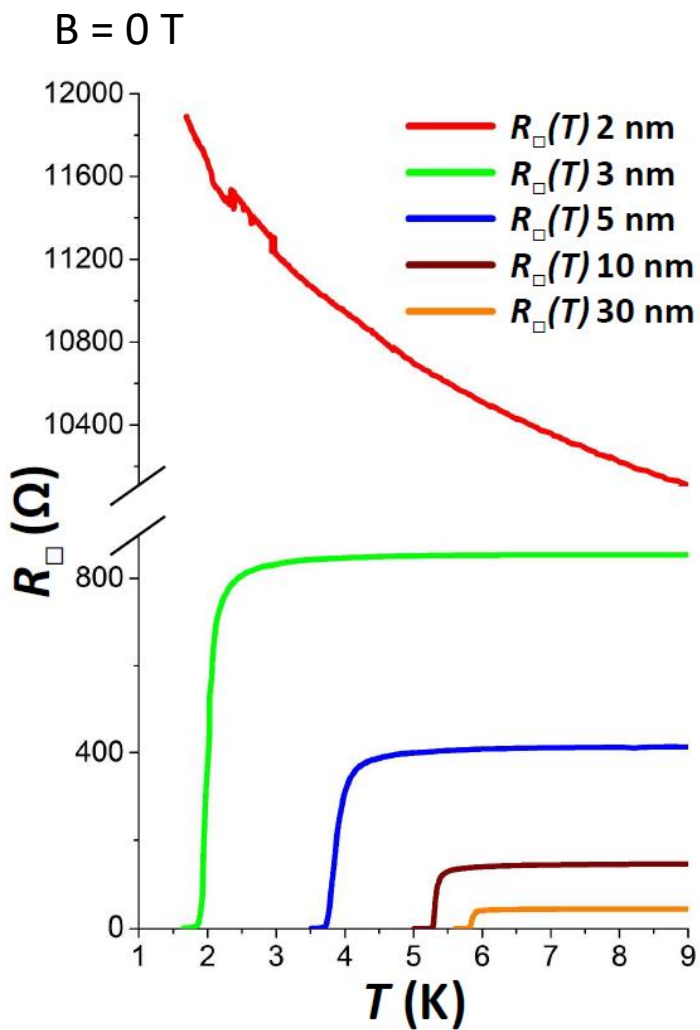
# My research

(MoN)



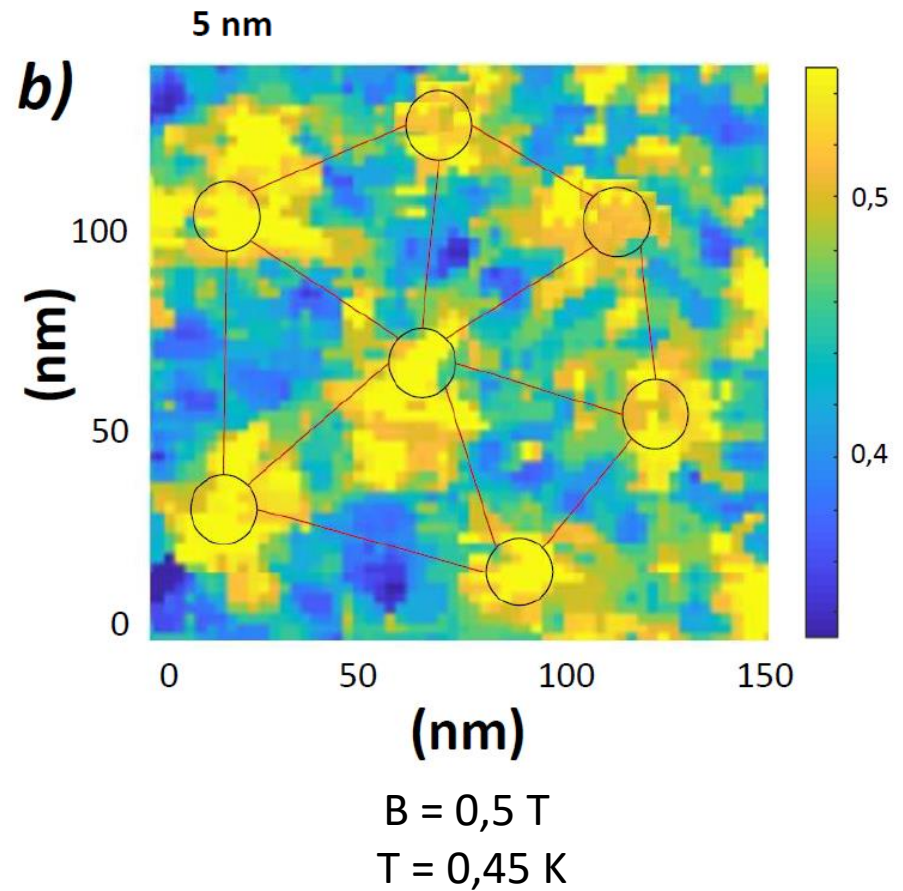
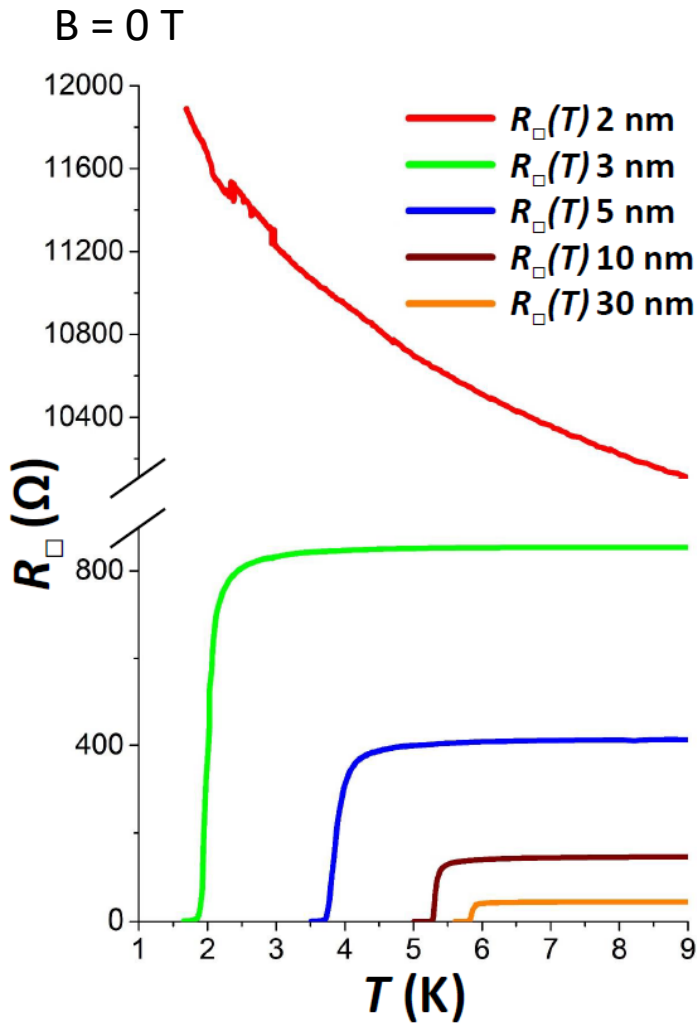
# My research

(MoN)



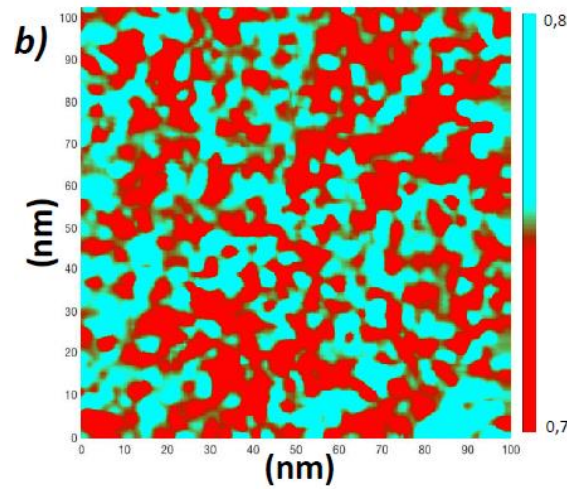
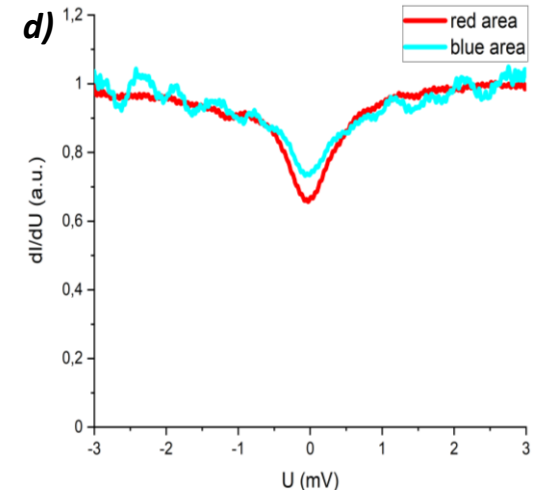
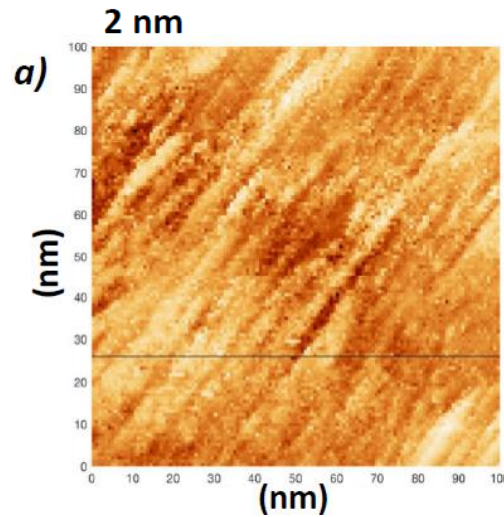
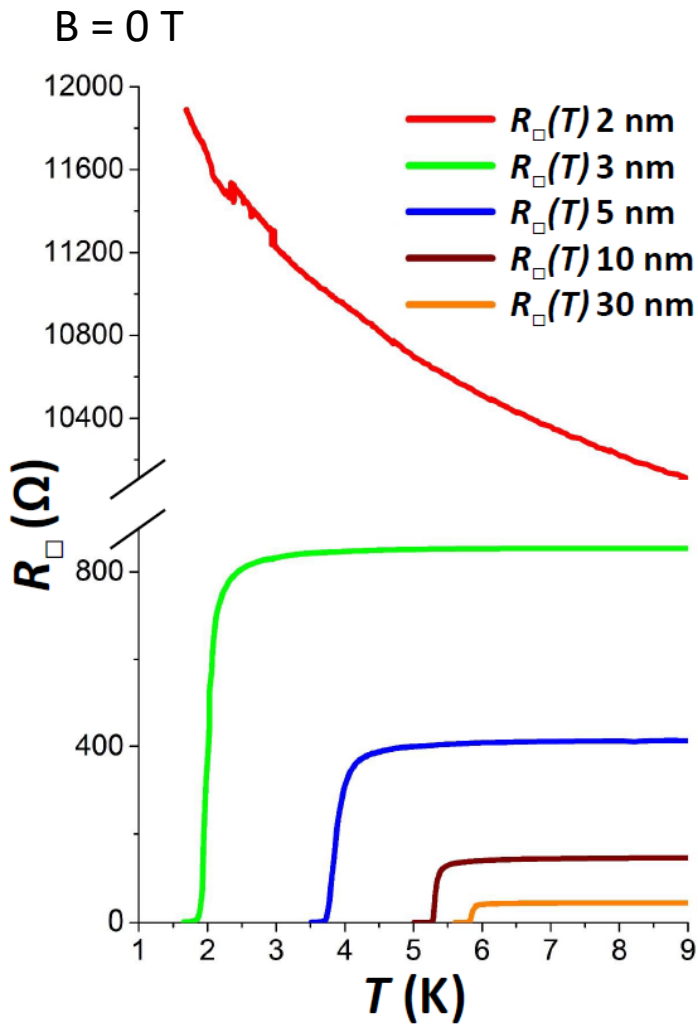
# My research

(MoN)

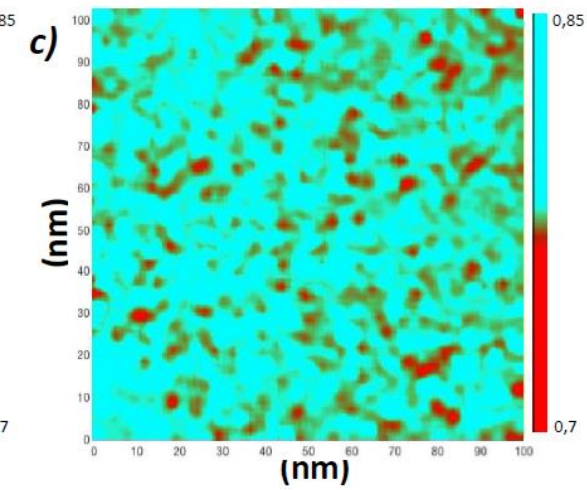


# My research

(MoN)



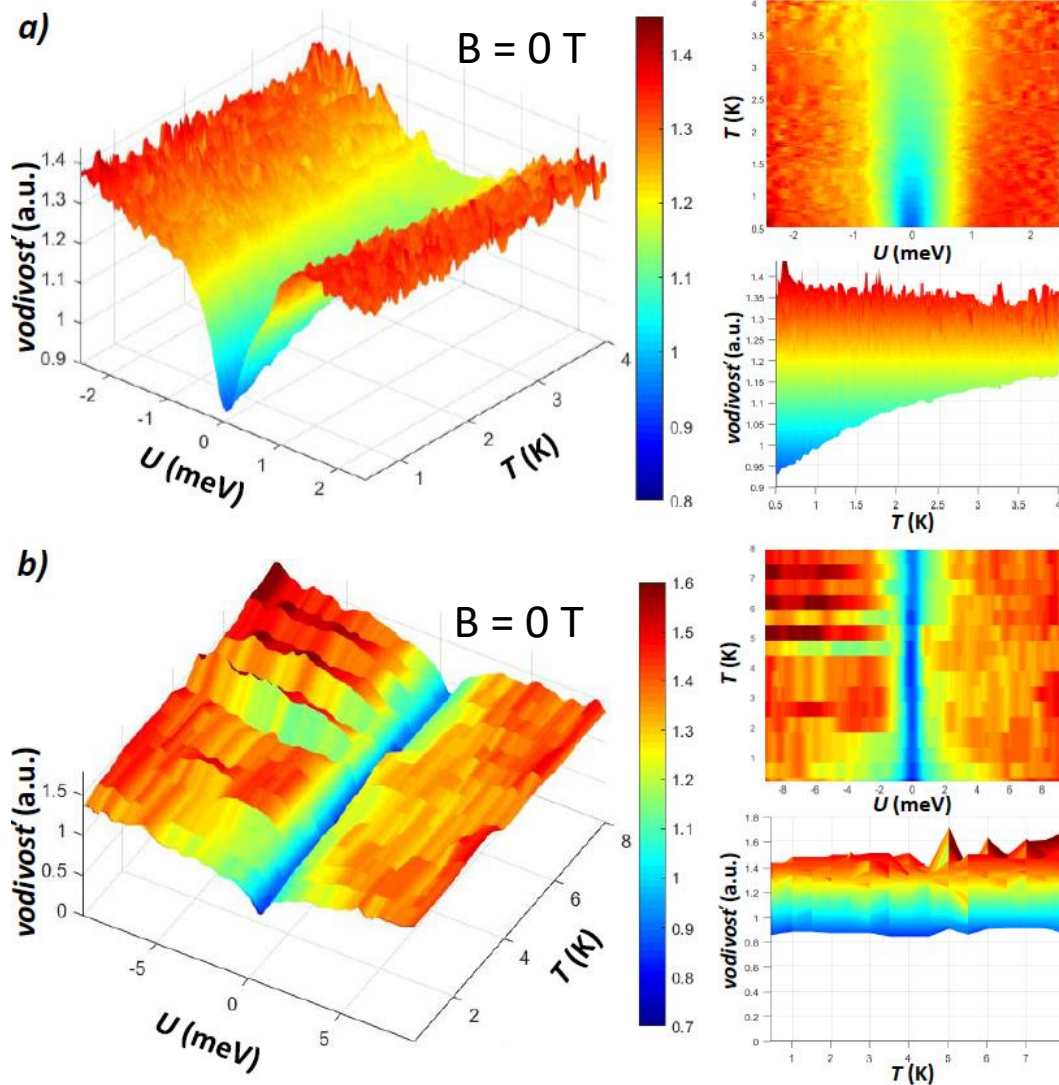
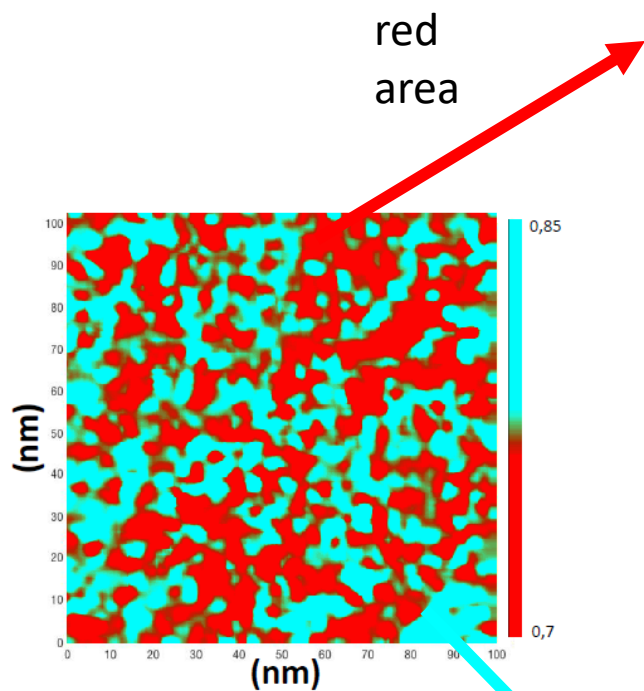
$B = 0 \text{ T}$



$B = 5 \text{ T}$

# My research

(MoN)





Thank you for your attention!