CEITEC | Central European Institute of Technology
BRNO | CZECH REPUBLIC

VYSOKÉ UČENÍ TECHNICKÉ V BRNĚ

Nanotechnology for Electronics

EUROTRAINING

WHEN 24-25/03/2015

WHERE **CEITEC Brno University of Technology Core facility Nanofabrication and Nanocharacterization**
Technická 10, Brno, 616 00

COURSE CHAIR **Jaromír Hubálek** Smart Nanodevices

1st Day Program: 24th March, 2015

DAY 1

Course site: CEITEC BUT, Faculty of Electrical Engineering and Communication, building A8, room T8-215, Technická 10, Brno, Czech Republic

14:00 – 14:10 **Introduction**

14:10 – 15:00 **Prof. János Mizsei**

Electronics, microelectronics, nanoelectronics: applications and trends

Presentation of invited renowned scientists

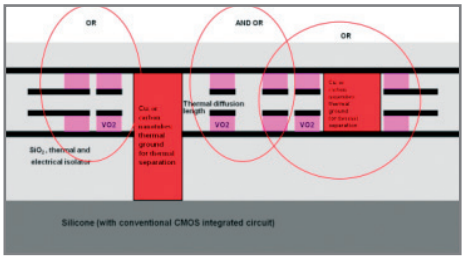
János Mizsei CSc, Ph.D., DSc. Professor

Head of the Semi-conductor Laboratory
Department of Electron Devices
Budapest University of Technology and Economics
www.eet.bme.hu/staff/run/en/id/mizsei

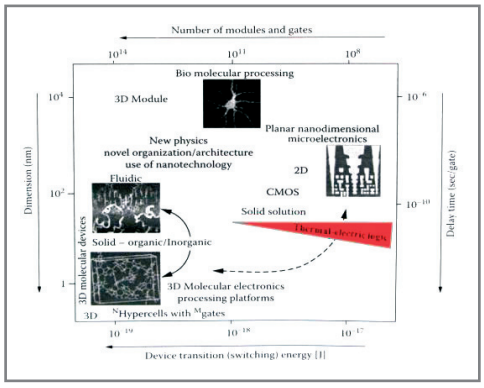
Abstract

Until now, the continuous development of electronics has been characterized by Moore's law. The scale down resulted in the nanosized CMOS integrated circuits, pushing the "red brick wall" towards the lower dimensions. On the other hand, there are many new ideas for building atomic or molecular scale devices for the information technology. However, there is still a gap between the up-to-date "top-down" CMOS technology and the "bottom-up" devices, i.e. molecular electronics, nanotubes, single electron transistors.

The new thermal-electric device, the phonsistor and the CMOS compatible thermal-electric logic circuit (TELC) may help to fill this gap.



Realization: a vertical (3D) thermal IC



Thermal electric logic circuit in the „gap"

15:00 – 15:50

Pavel Neužil, Ph.D.

MEMS technology and applications

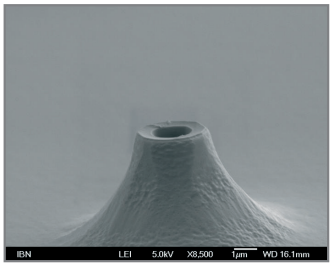
Presentation of invited renowned scientists

Pavel Neužil, Ph.D. Senior Researcher

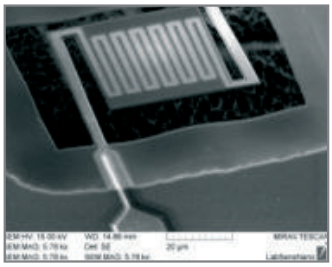
Research Group: Smart Nanodevices
Central European Institute of Technology
Brno University of Technology
http://www.ceitec.eu/pavel-neuzil-ph-d/u26730

Abstract

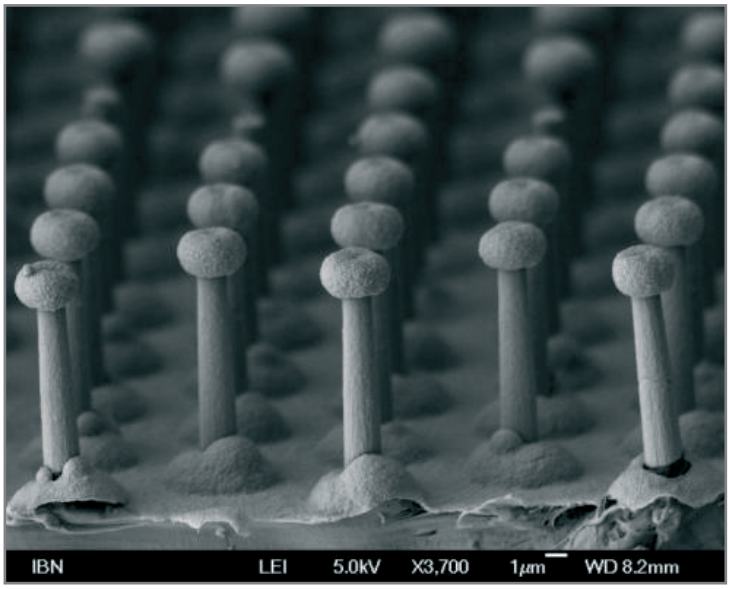
MEMS technology is derived from IC fabrication techniques started some 40 years ago. Originally it was mostly based on silicon for it mechanical, electrical and optical properties. Gradually other materials were used such as glass and polymers. An overview of MEMS fabrication techniques and MEMS devices. We will discuss standard devices such as pressure and inertial sensors. There are unique MEMS devices which cannot be replaces by other non-MEMS techniques probes for scanning probe microscopy, patch clamp systems and focal plane arrays for infrared imaging based on uncooled bolometers.



Patch Clamp nozzle



IR bolometer



Gecko lizard mimicking material

15:50 – 16:10 **Coffee break**

16:10 – 17:10 **Martin Kirchner**

Electron beam lithography – instrumentation and processing

Presentation of an industrial expert from Raith, Germany

Martin Kirchner Sales Director New Markets

Raith GmbH Dortmund/Germany

Abstract

Electron and ion beam lithography are enabling technologies for research and development in many fields of nano technology. The presentation reviews the basics of both technologies. Emphasis is given on instrumentation and processing which is useful in academic or industrial research and in small batch production. Application results from recent years are presented stemming from various disciplines including Electronics and Photonics.

The presenter is with Raith, a high tech company headquartered in Dortmund, Germany. Since two decades Raith instruments are extensively used within the nano fabrication and nano engineering community. Raith made conventional electron beam lithography accessible to a broad research community worldwide. In February 2013 Raith acquired Vistec Lithography who is known for more than 40 years of experience in the field of electron beam lithography under the brands of Philips, Cambridge Instruments and Leica.

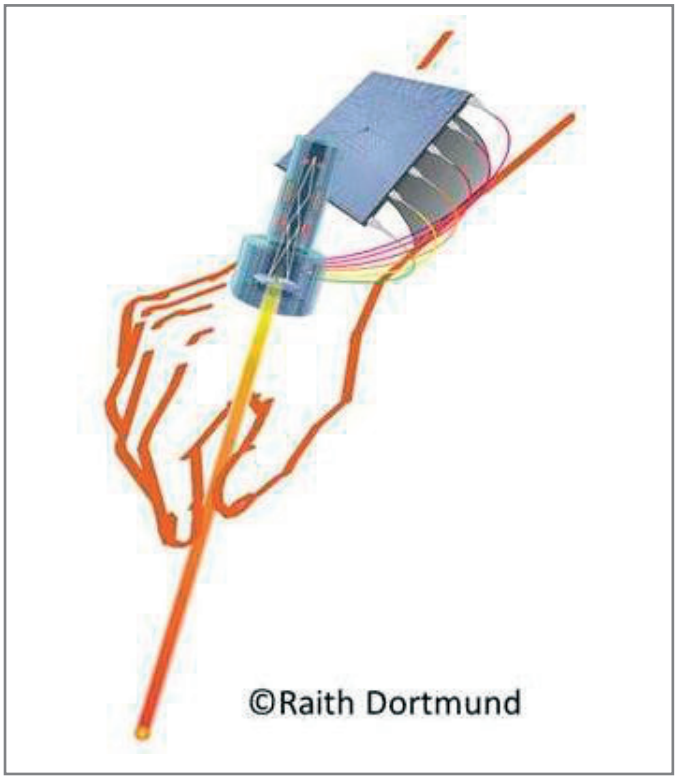


Figure symbolizes a focused charged particle beam structuring substrates at nano scale.

17:10 – 17:50

Attila Bonyár, Ph.D.

Enhancing Biosensors with Nanotechnology

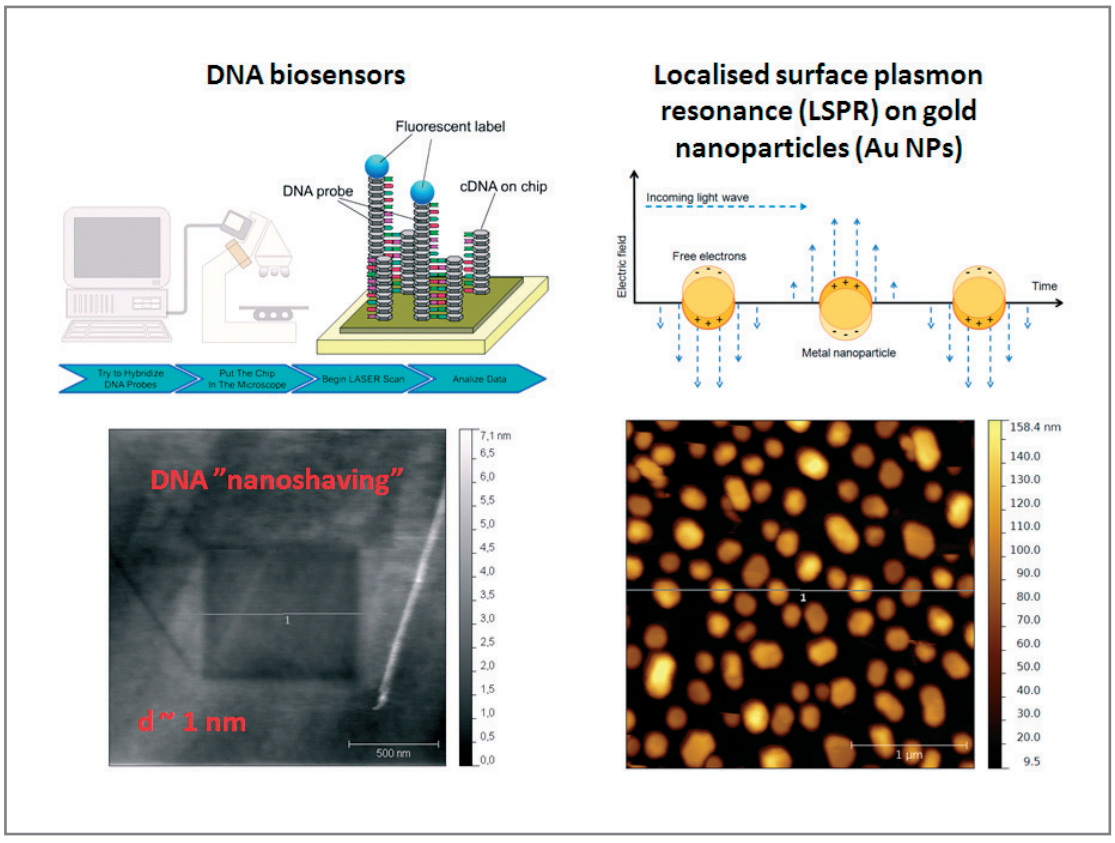
Presentation of a young East-European scientist

Attila Bonyár, Ph.D. Assistant Professor

Department of Electronics Technology
Budapest University of Technology and Economics

Abstract

Biosensors applying nanoscale biomaterials such as DNA molecules as sensing elements possess great potential in the fields of disease diagnostics, environment monitoring or in pathogen detection. The optimization of sensor properties (such as sensitivity or limit of detection) is a constant challenge in this multi-disciplinary field. Signal amplification methods, including the application of nano-materials or nano-patterned surfaces for surface plasmon resonance imaging (SPRi); and novel atomic force microscopy (AFM) based nanotechnology tools and investigation methods are in the focus of this presentation.



2nd Day Program: 25th March, 2015

DAY 2

Course site: CEITEC BUT, Faculty of Electrical Engineering and Communication, building A8, room T8-215, Technická 10, Brno, Czech Republic

09:00 – 09:40

Michal Urbánek, Ph.D.

Controlling spin vortex states in magnetic nanodisks by magnetic field pulses

Presentation of a local senior researcher

Michal Urbánek, Ph.D. Senior Researcher

Research Group: Fabrication and Characterisation of Nanostructures
Central European Institute of Technology
Brno University of Technology
http://www.ceitec.eu/michal-urbanek-ph-d/u17142

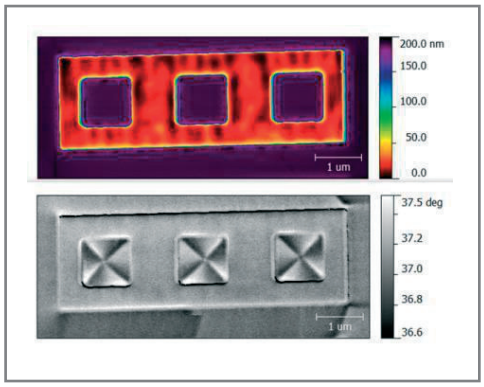
Abstract

Magnetic vortices are curling magnetization structures formed in micro- and nanosized magnetic disks and polygons. They are known for having four different magnetization configurations (vortex states) that can be used for a multibit memory cell. The vortex states are defined by the polarity of the vortex core, pointing either up or down perpendicular to the disk plane and by the circulation of the magnetization in the plane of the disk, curling either counterclockwise or clockwise. They can be controlled by applying static out-of-plane (polarity control) or in-plane (circulation control) magnetic fields, although the amplitude of these fields is relatively large. In 2006 Van Wayenberge et al. demonstrated [1] that the vortex polarity can be switched at much lower field amplitudes by using fast rising magnetic fields and we have recently demonstrated [2] that a similar approach can be used for the circulation switching.

In the talk I will describe static and dynamic magnetization reversal processes in magnetic vortices. Special emphasis will be given to the dynamic control of the magnetic vortex states and the use of magnetic vortices as multibit magnetic memory cells.

[1] Van Waeyenberge, B. et al., Magnetic vortex core reversal by excitation with short bursts of an alternating field. Nature 444, 461 (2006).

[2] Uhlíř, V. et al., Dynamic switching of the spin circulation in tapered magnetic nanodisks. Nature Nanotech. 8, 341 (2013).



Magnetic vortexes observation by Scanning Probe Microscope AutoProbe CP-R and Lithographic Scanning Probe Microscope Dimension Icon

09:40 – 10:20

Ass. prof. Martin Vala, Ph.D.

Organic Electronics and Photonics: Applications and Materials

Presentation of local senior scientist

Ass.Prof. Martin Vala, Ph.D. Senior Researcher

Research Group: Institute of Physical and Applied Chemistry
Faculty of Chemistry, Brno University of Technology
https://www.vutbr.cz/en/people/martin-vala-50351

Abstract

Organic electronics is a platform technology based on the combination of new materials and cost-effective, large area production processes that open up new fields of application. Organic electronics offers the potential to manufacture thin, light-weight, flexible and environmentally friendly products. It also enables a wide range of electrical components that can be produced and directly integrated in low cost reel-to-reel processes. Intelligent packaging, smart clothing, lightweight and flexible displays and solar cells, energy efficient lighting, disposable diagnostic devices or games, and printed batteries are just a few examples of promising fields of application for organic electronics based on new large scale processable electrically conductive and semi-conducting materials.

The lecture will focus on several example applications: organic photovoltaics, organic light emitting devices, organic field effect transistors and organic solid state lasers. The operation principle and materials requirements will be discussed. An advantage of the organic material to be used for these and similar applications will be demonstrated on molecular tailoring of promising group of materials: diketo-pyrrolo-pyrroles.

10:20 – 10:40

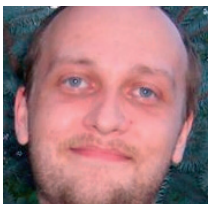
Coffee break

10:40 – 11:20

Ing. Jiří Šmarhák

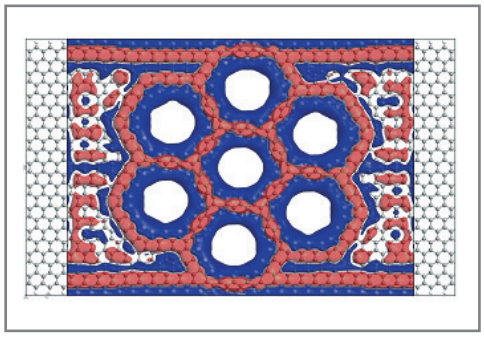
Computer simulation of nanostructures

Presentation of an invited young scientist



Ing. Jiří Šmarhák Ph.D. Student

Research Group: Electron Devices
Department of Microelectronics
Czech Technical University in Prague
http://micro.feld.cvut.cz/people/index.htm



Electron difference density isosurface for value -10^{-5} Å^{-3} of 22-ZGNR structure patterned with [42]annulene-like patches.

Abstract

In electronics it rises an immense need for computer simulation on a quantum level in recent years. There are many new makeable nanostructures which need to be simulated for better understanding of their properties as well as there are many potentially interesting nanostructures that are possible to be invented by means of computer simulation in the future. One of the high performance commercial simulation software available on the market called Atomistix ToolKit (ATK) presented by QuantumWise is a good choice for mentioned type of simulations.

11:20 – 12:00

Petr Klenovský, Ph.D.

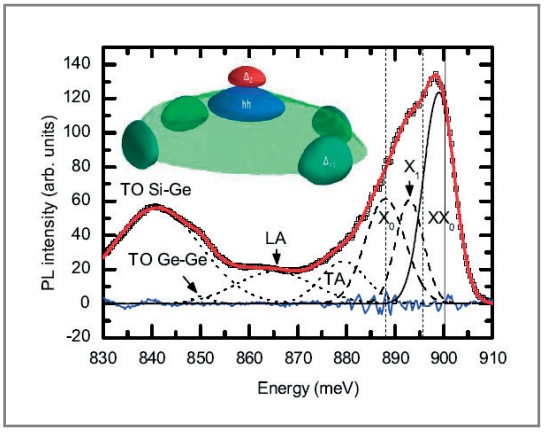
Controlling properties of the semiconductor quantum dots for their usage in the information technology

Presentation of a local young scientist

Petr Klenovský, Ph.D. PostDoc
Research Group: Functional Properties of Nanostructures
Central European Institute of Technology
Masaryk University CEITEC MU
http://www.ceitec.eu/petr-klenovsky/u17318

Abstract

Quantum dots (QDs) have intriguing properties similar to those of atoms, although they are much larger. This is mainly due to the spatial confinement of charge carriers present in them. Thus, compared to bulk semiconductors QDs have discrete energy spectrum and allow for the existence of exotic complexes of several mutually interacting excitons (electron-hole pairs). However, their most compelling feature is the possibility to tune these parameters by tailoring the composition of the materials they are fabricated from. This enables to utilize QDs in communication and information technologies, or even medicine. This lecture will provide a brief insight into the physics of QDs and overview of the current state of research of semiconductor QDs. Examples of the contribution of our research group will be given as well.



Photoluminescence spectra of SiGe QDs compared with theory.

12:00 – 12:10 **Problem solving discussion**

12:10 – 13:00 **Lunch break**

13:00 – 13:30

Introduction to the laboratory visit

David Skoda, Ph.D. Head of Core Facility and Centre of Laboratories
Central European Institute of Technology
Brno University of Technology
http://www.ceitec.eu/david-skoda-ph-d/u46833

Abstract

Core facility Nanofabrication and Nanocharacterization provides a complete set of methods for nanofabrication and nanocharacterization and carry out both complete fabrication process of nanodevices, and their characterization of down to the sub-nanometre level in a clean environment (ranging from the class 100 to 100 000). Almost all instruments available in the core facility can be directly operated by users (after a proper training led by the operators) who are as a rule highly motivated in reaching the best results.The infrastructure is strictly planned and run on the open access policy enabling the users both from academia (internal and external groups) and industry an access to highly specialized and sophisticated equipment and methods, very often quite unique in the Czech Republic or not available to the broader scientific community.

Equipment and contacts

Nanofabrication and Nanocharacterization

UV Direct Write Laser system
Heidelberg Instruments DWL 66 FS
Martin Buršík
martin.bursik@ceitec.vutbr.cz

Optical microscope
Olympus MX 51
Martin Buršík
martin.bursik@ceitec.vutbr.cz

Spectroscopic reflectometer
Ocean Optics NanoCalc 2000
David Škoda
david.skoda@ceitec.vutbr.cz

Scanning Electron Microscope/e-beam writer
Tescan Mira3
Eva Kolíbalová
eva.kolibalova@ceitec.vutbr.cz

Mechanical profilometer
Bruker Dektak XT
Dalibor Šulc
dalibor.sulc@ceitec.vutbr.cz

Resist stripper
Diener Nano Plasma cleaner
Marek Eliáš
marek.elias@ceitec.vutbr.cz

Atomic Layer Deposition System
Cambridge NanoTech Fiji 200
Marek Eliáš
marek.elias@ceitec.vutbr.cz

Wire bonder
TPT HB 16
Martin Buršík
martin.bursik@ceitec.vutbr.cz

NIR/VIS/UV S… Ellipsometers
J. A. Woollam IR-Vase, V-Vase
Alois Nebojsa
alois.nebojsa@ceitec.vutbr.cz

NIR/VIS/UV Optical Spectrometry
McPherson
Alois Nebojsa
alois.nebojsa@ceitec.vutbr.cz

mailto:martin.bursik@ceitec.vutbr.cz

SPM/microRaman/Photo Luminiscence system
NT-MDT NTegra Spectra, Solaris 3
Alois Nebojsa
alois.nebojsa@ceitec.vutbr.cz

Vacuum FTIR
Bruker Vertex80v + Hyperion 3000
Alois Nebojsa
alois.nebojsa@ceitec.vutbr.cz

Scanning Near-Field Optical Microscope
Nanonics MV 4000
Dalibor Šulc
dalibor.sulc@ceitec.vutbr.cz

…ised Ion Beam/Scanning Electron Microscope
Tescan Lyra 3 XMH
Eva Kolíbalová
eva.kolibalova@ceitec.vutbr.cz

Lithographic Scanning Probe Microscope
Bruker Dimension Icon
Dalibor Šulc
dalibor.sulc@ceitec.vutbr.cz

Structural Analysis Laboratory

X-ray powder diffractometer
Rigaku SmartLab 3kW
Pavla Roupcova
pavla.roupcova@ceitec.vutbr.cz

X-ray diffractometer
Rigaku SmartLab 9kW
Ondřej Caha
ondrej.caha@ceitec.muni.cz

Installed equipment in a fully operational state

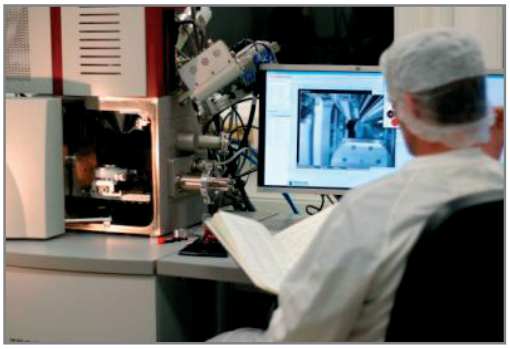
13:30 – 16:00 **Visit to the CEITEC BUT core facilities**

Practical demonstration and laboratory visit

Location of core facility

Core facility Nanofabrication and Nanocharacterization is a part of research infrastructure CEITEC Nano.
CEITEC Nano has been operated as a single-sited national research infrastructure "under construction" which is expected toreach the fully operational state in 2016 in new complex of laboratories at Campus of Brno University ofTechnology „Pod Palackého vrchem". Since 2012 a part ofthe planned equipment (approximately 1/3 of the total amount) has been already purchased and temporarily installed into small clean room labs available at Brno University of Technology and Masaryk University.

Photos of the Core Facility CEITEC BUT



Organization of visits:

Clean room at Faculty of Mechanical Engineering

Brno University of Technology
Technická 2, 616 00 Brno
Distance: 5 minutes walk from the lecture room
Group size: 5 people + 1 guide, possibility to guide two groups parallel.
Timing: first round starts at 13.40, last round starts at 15.15
Length of visit: 30 minutes

Clean room and laboratories at Faculty of Science

Masaryk University
Kotlářská 9, 602 00 Brno
Distance: 15 minutes by car from the lecture room (2 cars with drivers will be available)
Group size: 5 people + 1 guide, possibility to guide two groups parallel
Timing: first round starts at 13.50, last round starts at 15.15
Length of visit: 40 minutes

Laboratory of research group Smart Nanodevices

Faculty of Electrical Engineering and Communication, Brno University of Technology
Distance: 5 minutes walk from the lecture room
Group size: 5 people + 1 guide
Timing: first round starts at 13.40, last round starts at 15.15
Length of visit: 20 minutes

16:00 – 16:30 **Farewell coffee with discussion and course evaluation**

The lecture room will be opened from 15.30. The attendance can use it up to their arrival from the laboratory visits.

16:30 – **Disperse**

Further information / contact persons:

Dr. Olivér Krammer, krammer@ett.bme.hu, tel: +36 1 4632755)
Dr. Zsolt Illyefalvi-Vitez, illye@ett.bme.hu, tel: +36 1 4632753)

Budapest University of Technology and Economics,
Department of Electronics Technology, Hungary

Kateřina Švidrnochová, katerina.svidrnochova@ceitec.vutbr.cz, tel: +420 54114 9114)
Ass. Prof. Jaromír Hubálek, jaromir.hubalek@ceitec.vutbr.cz, tel: +420 54114 6195)

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