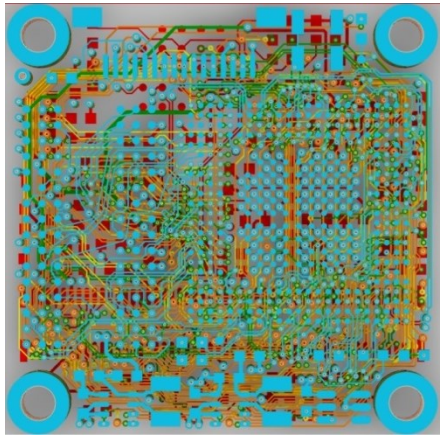
Space related activities at Department of Microelectronics



Pavel Hazdra et al.

Department of Microelectronics

Faculty of Electrical Engineering

Czech Technical University in Prague

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Department's Research Activities Related to SPACE

Nanotechnologies

Optoelectronics

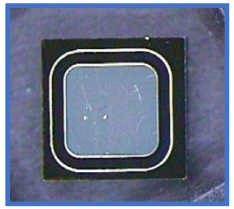
- **Radiation Resistance of Semiconductor Devices**
- **WBG Devices for Harsh Environment**
- **Radiation Resistance of Optoelectronic Components**
- **Thermo-Mechanical Simulation and Reliability Engineering**

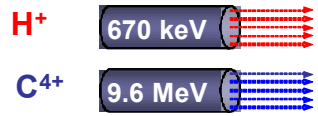
Advanced Semiconductor Technologies

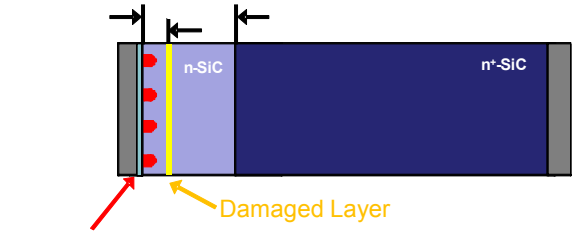
Design, Test and Application of Integrated Electronic Systems

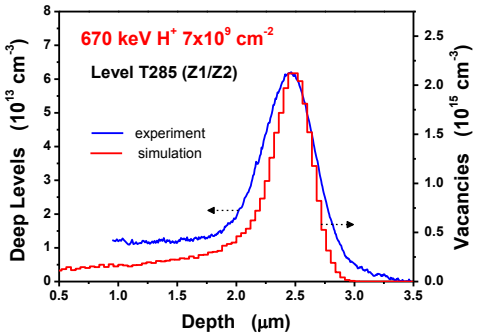
Radiation Resistance of Semiconductor Devices and Systems

Effect of Radiation (electrons, protons, neutrons, etc.) on Semiconductor (Si, SiC, GaN, diamond) Device Performance

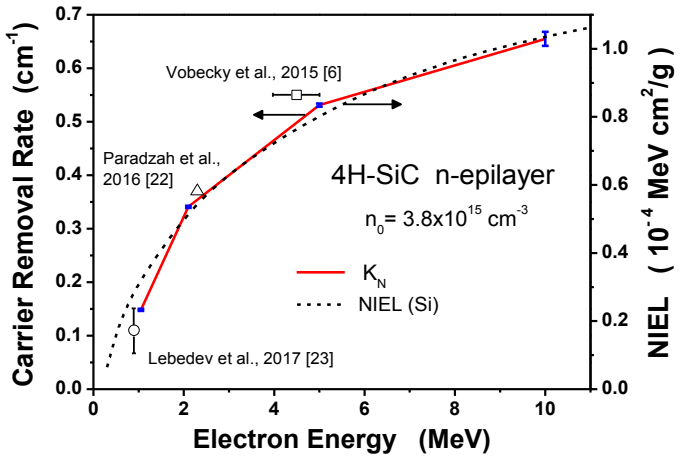




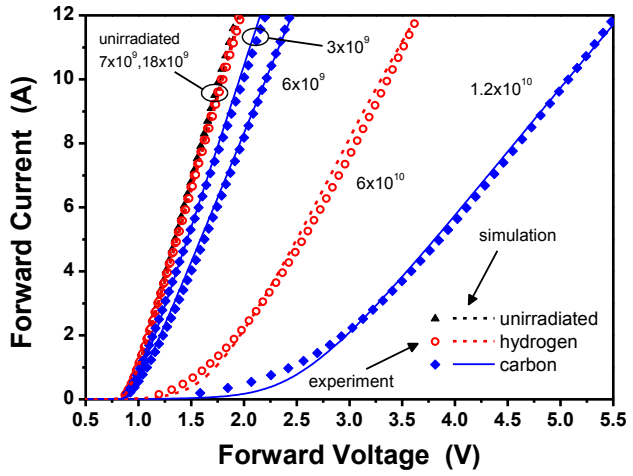




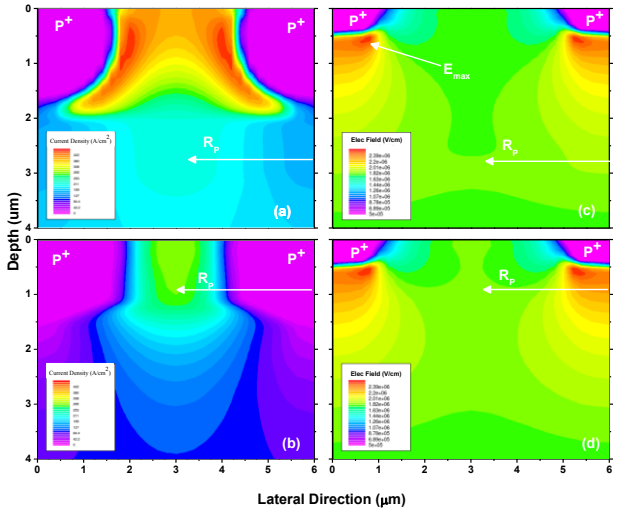
Carrier Removal/NIEL



Modification of IV Characteristics



Analysis of Underlying Effects



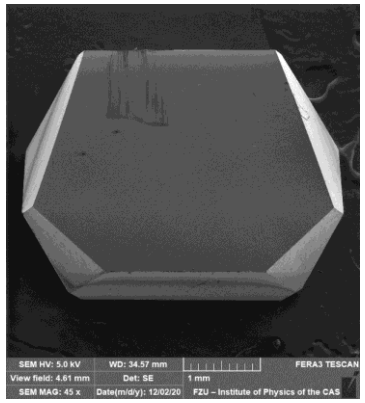
Hazdra, P., Smrkovský, P., Vobecký, J., and Mihaila, A.; Radiation Resistance of High-Voltage Silicon and 4H-SiC Power p-i-n Diodes. *IEEE Transactions on Electron Devices*, *68* (2021) 202–207.

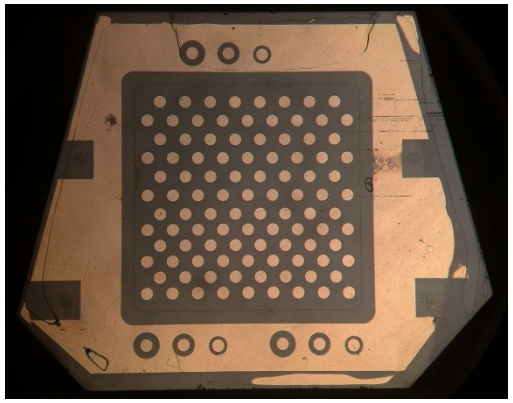
Hazdra, P., Smrkovský, P., and Popelka, S.; Radiation Defects and Carrier Lifetime in 4H-SiC Bipolar Devices. *Physica Status Solidi (a)*, (2021) 2100218.

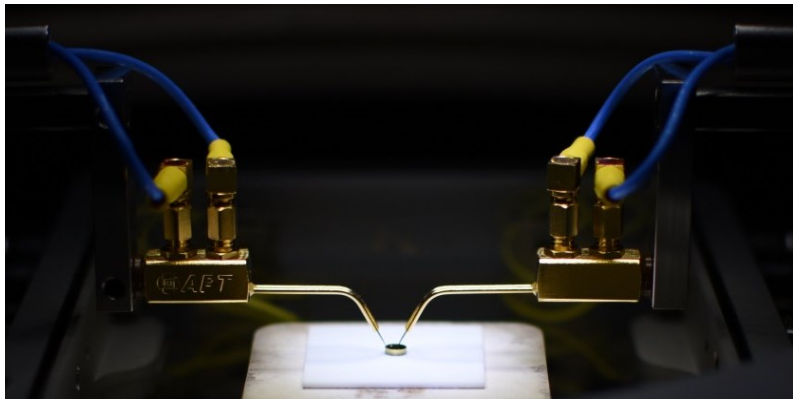
WBG devices for Harsh Environment

Development of Power Devices on HPHT grown diamond

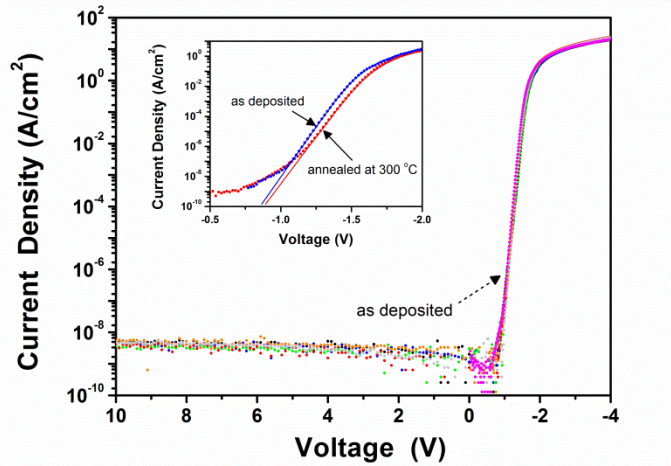
FZU Institute of Physics of the Czech Academy of Sciences

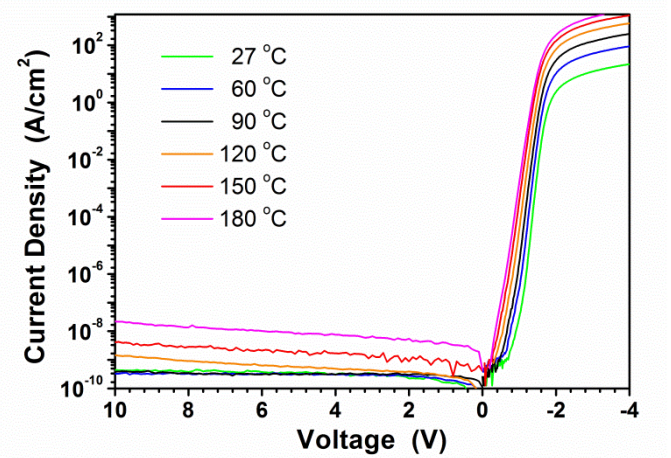






Extreme Current Densities > 10^3 A/cm^2
Extreme I_{ON}/I_{OFF} Ratio ~ 10^{11}
Operation at temperature > 150 degC





HAZDRA, P. et al. Pseudo-vertical Mo/Au Schottky diodes on {113} oriented boron doped homoepitaxial diamond layers. *Diamond and Related Materials*; 126 (2022) 109088.

HAZDRA, P. et al. Low-resistance ohmic contacts on boron-doped {113} oriented homoepitaxial diamond layers. *Diamond and Related Materials* 121 (2022) 108797.

Radiation Resistance of Optoelectronic Components

- Effects of gamma rays on optical materials and waveguides
- The effect of gamma-ray irradiation on bulk optical plastic materials
- Effects of gamma rays on elastomer multimode optical channel waveguides
- Effects of gamma rays on optical fibers and cables

workplace Nuclear Research Institute Rez
irradiation facilities ROZA, PRAZDROJ and PANOZA

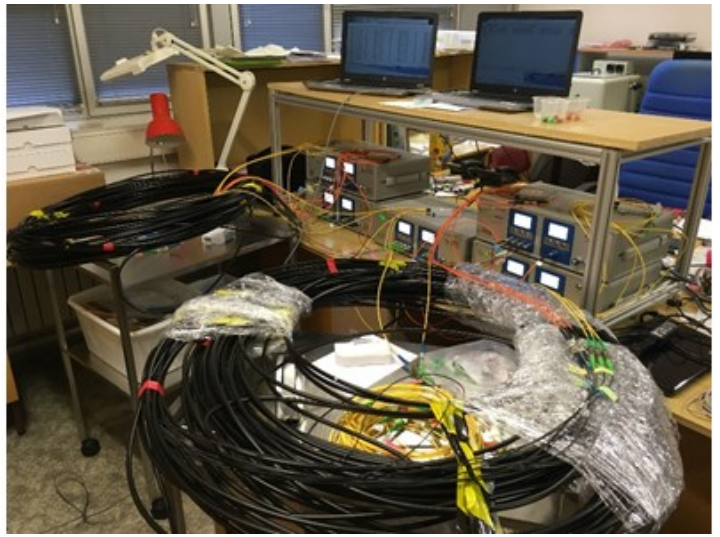
CTU labs for measurements properties of optical waveguides (PLANIO laboratotry)

PANOZA

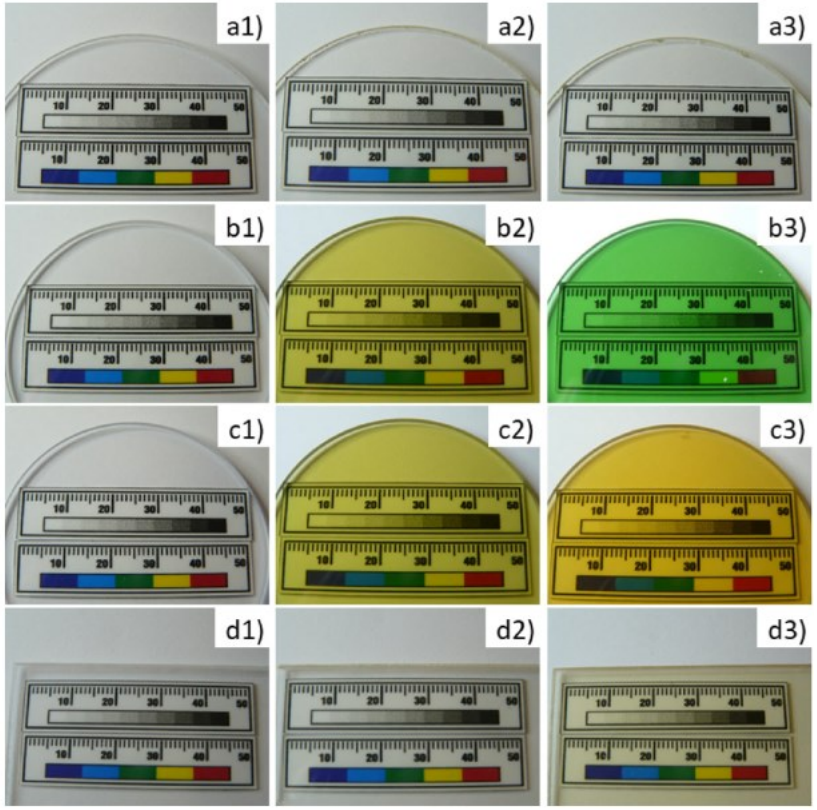
gamma radiation source - ^{60}Co

- ROZA : ≈ 1 kGy/hod
- PRAZDROJ : ≈ 1 kGy/hod
- PANOZA : ≈ 80 Gy/hod

https://micro.fel.cvut.cz/cs/planio/



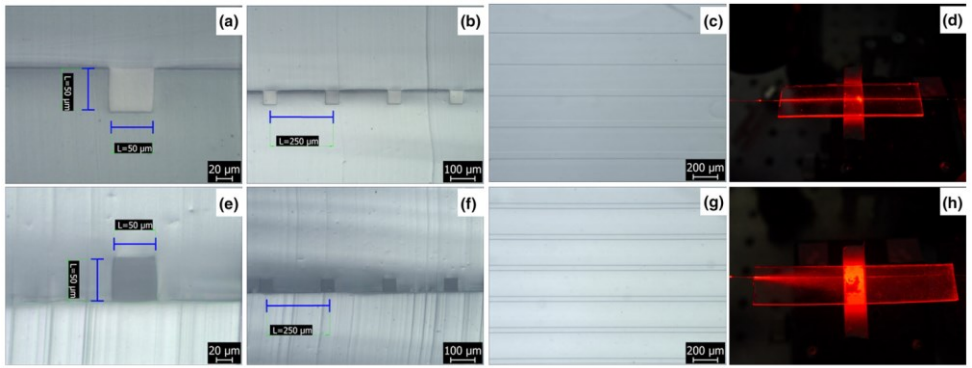
Radiation Resistance of Optoelectronic Components



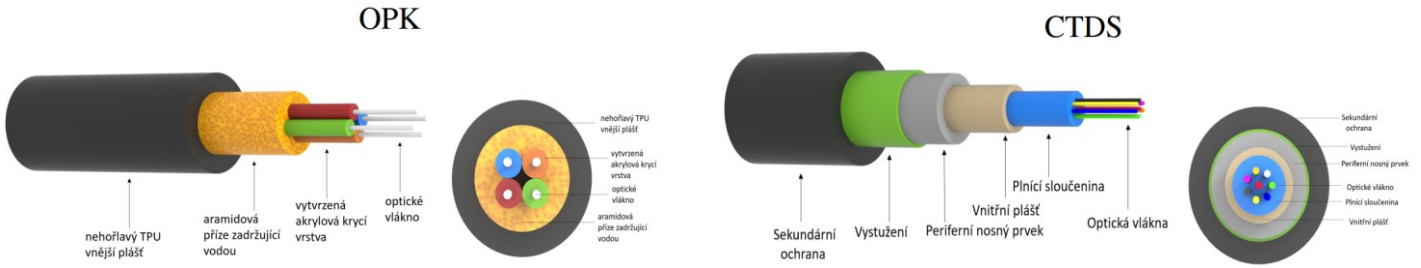
Bulk plastic materials where (1)s are always the reference sample, (2)s and (3)s are the samples irradiated with lower (14.6 kGy) and higher doses (54.2 kGy), a) CR-39, b) MR-8, c) Trivex, d) ZEONEX E48R

V. Prajzler, V, Chlupaty, Z. Sarsounova: The effect of gamma-ray irradiation on bulk optical plastic materials, J Mater Sci: Mater Electron (2020) 31:22599–22615.

V. Prajzler, V, Chlupaty, Z. Sarsounova: The effect of gamma-ray irradiation on polycarbonate sheets, Radiation Physics and Chemistry 196 (2022) 110100.



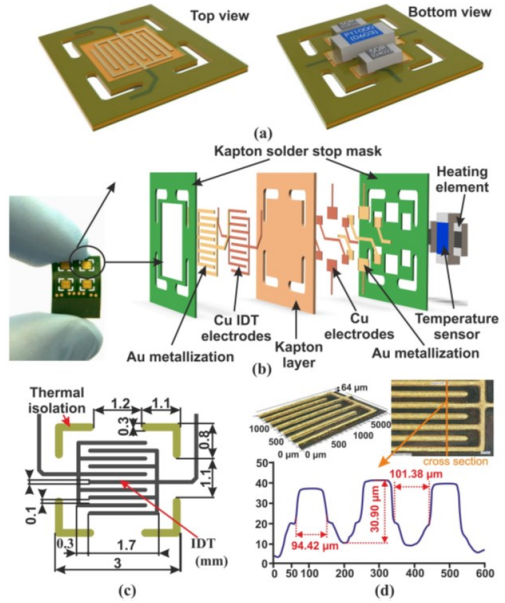
V. Prajzler, M. Neruda, M. Kveton: Effects of gamma rays on elastomer multimode optical channel waveguides, J Mater Sci: Mater Electron (2020) 31:17202–17211.

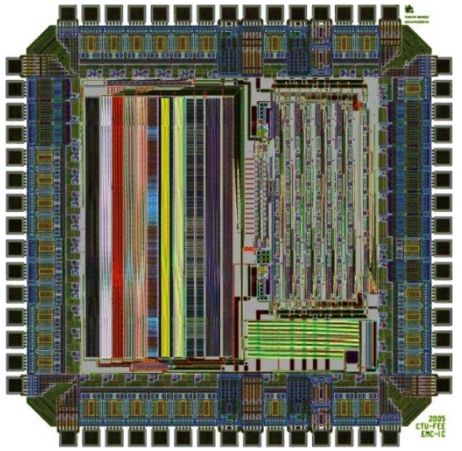


Z. Sarsounova, V. Placek, V. Prajzler, K. Masopustova, P. Havránek: Influence of Optic Cable Construction Parts on Recovery Process after Gamma Irradiation, Energies 2022, 15, 599.

Thermo-Mechanical Simulation and Reliability Engineering

- Thermo-mechanical properties of components modeling, analysis, design
- Reliability engineering of electronic components electro-mech-heat phenomena
- EMC and interference in electronic and microelectronic circuits
- Energy harvesting for additional power supply
- Printed layer technology (printed layers, components and antennas on flexible substrates, flexible printed oxygen-free gas sensors, vital signs sensors, radiation detectors).
- Modeling of physical phenomena in semiconductor structures and components
- Diagnostics of electronic components
- Characterization in an adjustable atmosphere of pure nitrogen or technical air with gas admixtures



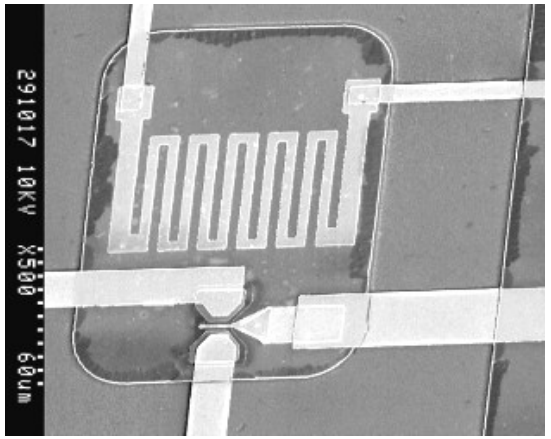


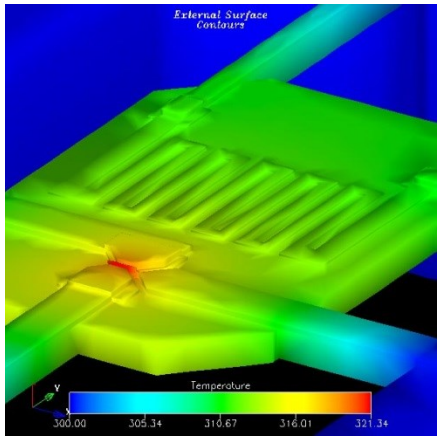
LAPOSA, A. et al. Inkjet Seeded CVD-Grown Hydrogenated Diamond Gas Sensor Under UV-LED Illumination. *IEEE Sensors Journal*. 2020, **20**(3), 1158-1165.

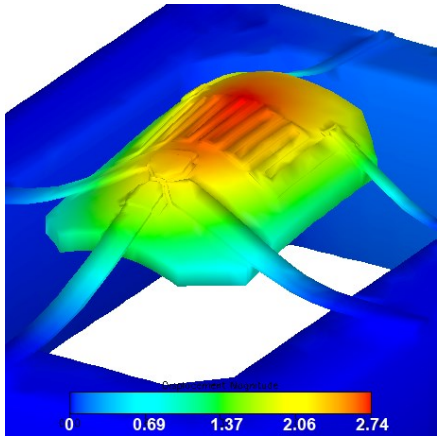
KROUTIL, J. et al. A chemiresistive sensor array based on polyaniline nanocomposites and machine learning classification. *Beilstein Journal of Nanotechnology*. 2022, **13** 411-423.

Thermo-mechanical simulation and reliability engineering

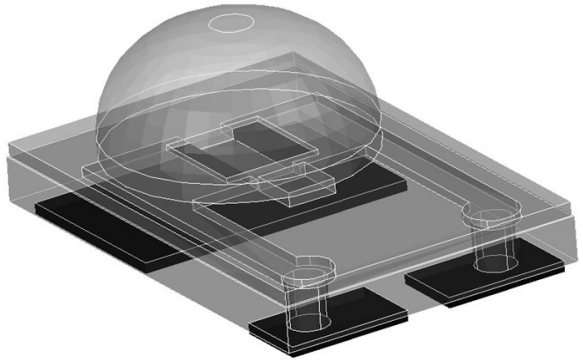
Design and thermo-mechanical evaluation of MEMS

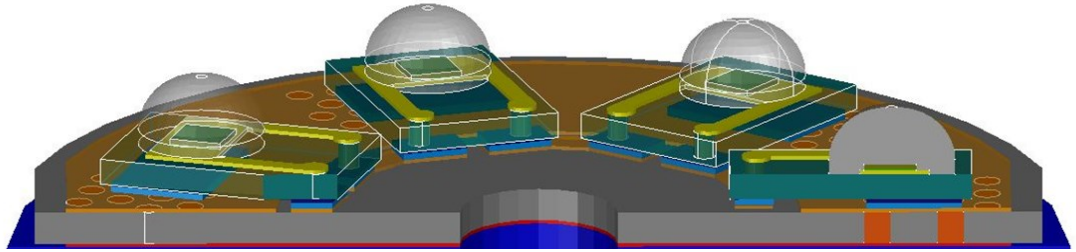






Thermo-mechanical evaluation of the LED boards





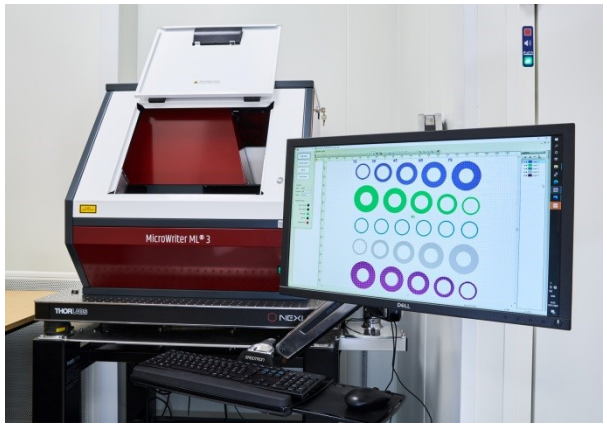
PERPINA, X.P., JAKOVENKO, J. et al. Thermal Management Strategies for Low- and High-Voltage Retrofit LED Lamp Drivers. *IEEE Transactions on Power Electronics, 34* (2019) 3677-3688.

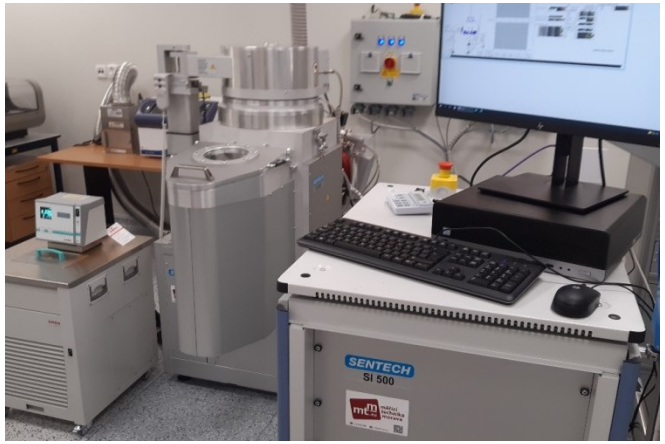
Department Facilities

NanoLab Cleanrooms

Direct Write Photolithograph

Durham MicroWriter ML3



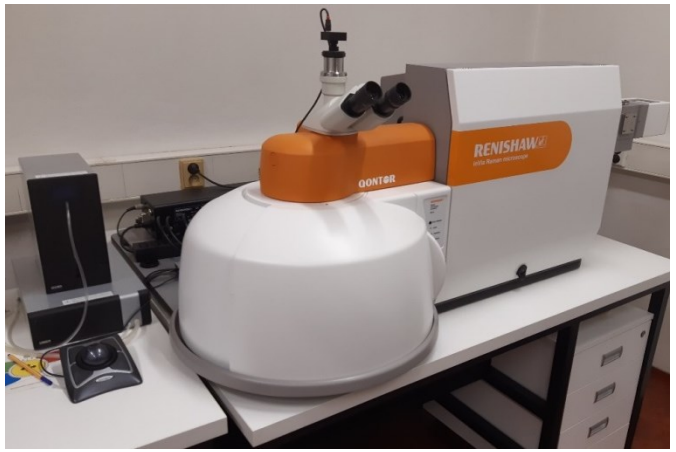


Deep Reactive Ion Etching

Sentech SI 500

Atomic Layer Deposition

Sentech LL ALD



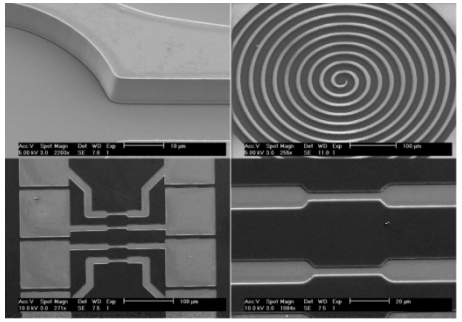
Raman Spectrometer

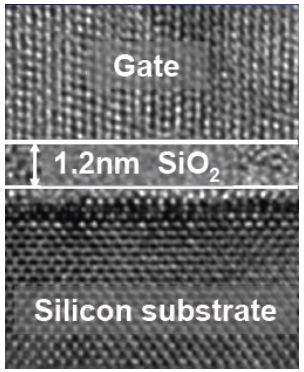
Renishaw InVia Qontor

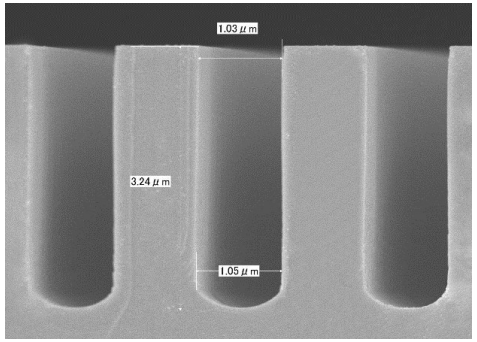
https://micro.fel.cvut.cz/cs/nanolab/

Microelectronic Technologies

- **Atomic Layer Deposition** – deposition of very thin layers of SiO_2, Al_2O_3, TiO_2, HfO_2 and ZnO with good coverage of the vertical edges and perfect homogeneity.
- **Deep Reactive Ion Etching** – etching of deep trenches and holes with high aspect ratio. Shallow silicon, SiO2, Al2O3 TiO2, HfO2, ZnO etching. Photoresist etching and surface activation.
- **Direct-Write Optical Lithography** – photoresist exposition without the need of mask with 600 nm resolution. Layout definition of the electronic devices, optical waveguides and sensors.
- **Inkjet Priting Technique** – selective deposition of conductors (Ag nanoparticle, PEDOT:PSS based inks), dielectrics (SU8, PVP based inks), semiconductors (ZnO, PANI based inks) and seed layers (eg. diamond and ZnO)
- **Spin Coating**
- **Metal Evaporation**
- **High Energy Pulsed Light Curing**, sintering or annealing – delivering up to 2500 J/pulse, radiant pulse energy up to 7 J.cm-2, pulse range from 100 to 6000 µs
- **UV Ozone Cleaning** – up to 150 °C
- **High Temperature Annealing**

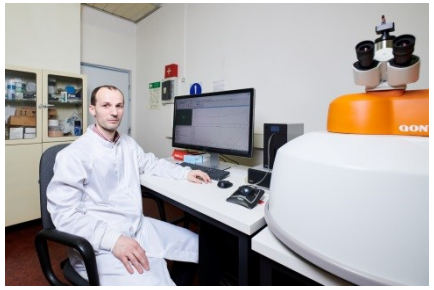


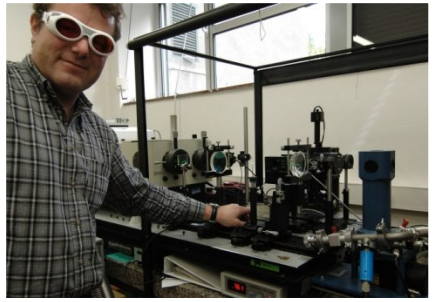


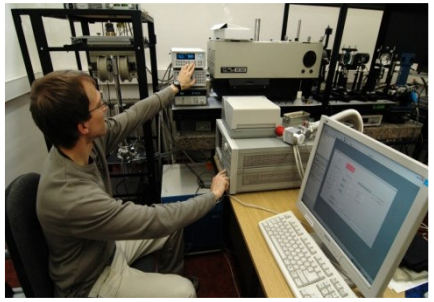


Characterization Methods

- **AC and DC electrical on chip characterization** I-V, C-V, impedance (Cascade Microtech M150 + Linkam LTSE420-P , Keysight B1500A, Agilent 4156C, Agilent 4194A, etc.)
- **Thin film resistivity measurement** van der Pauw (VDP) method, four point probe (4PP) method
- **Deep Level Transient Spectroscopy (DLTS)** up to 690 K (Semilab DLS-83E)
- **Hall-effect measurements**
- **Standard electrical and magneto-electrical transport measurements** temperature range 10- 350K
- **Optical characterization** photoluminescence, photoconductance and photoreflectance in the UV/VIS range
- **Gas sensor measurements** response/recovery time, stability, reproducibility, repeatability, reversibility, selectivity etc.
- **Optical power measurement**
- **m-line spectroscopy**
- **Raman spectroscopy characterization** surface characterization using three different laser wavelengths. Analysis of the chemical composition Surface 2D mapping and depth profiling. Lasers 532 nm, 633 nm and 830 nm, temperatures from 78 to 690 K (Renishaw inVia Qontor)
- **AFM/SPM characterization of thin films** (NT-MDT Ntegra Prima)

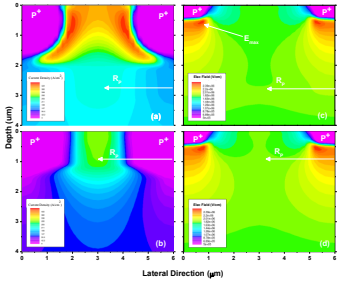


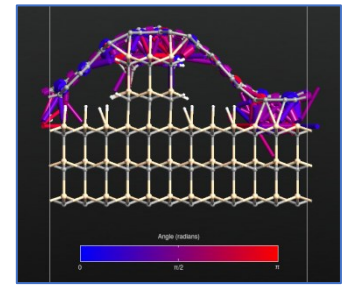


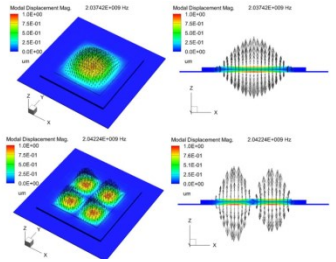


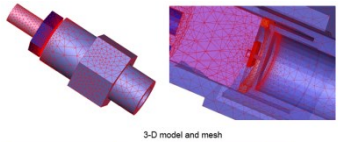
Simulation Activities and Software Packages

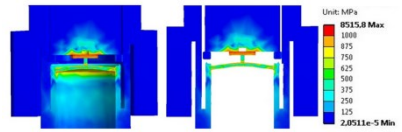
Silvaco TCAD	Process, Device, and MixedMode Circuit Simulation
Synopsys/QuantumWise ATK	Virtual NanoLab, Quantum Atomistic Solver
CoventorWare	MEMS design and simulation including the MEMS-specific multi-physics, such as electrostatics, coupled electro-mechanics, piezoelectric, piezoresistive, and damping effects
ANSYS Workbench	Structural, thermal, and electromagnetic analysis
Rsoft	Photonic Component Design Suite for design and simulation of passive photonic devices
OPTICAD	Layout and analysis of 3D optical systems











Šmarhák, J.; Voves, J.; Electronic transport properties of compressed and stretched helicene-graphene nanostructures, a theoretical study; Physica E, 141 (2022) 115111.

Reggiani, S., Balestra, L., Gnudi, A., Gnani, E., Baccarani, G., Dobrzynska, J., Vobecky, J., and Tosi, C. ; TCAD Investigation of Differently Doped DLC Passivation for Large-Area High-Power Diodes. *IEEE Journal of Emerging and Selected Topics in Power Electronics*, *9* (2021) 2155–2162.

Collaboration Offer and Contacts

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RadHard Optoelectronics	Václav Prajzler	xprajzlv@fel.cvut.cz
Reliable Systems and Sensors	Miroslav Husák	husak@fel.cvut.cz
NanoLab	Jan Voves	voves@fel.cvut.cz

https://micro.fel.cvut.cz