DIAGNOSTICS AND MATERIAL RESEARCH

SERVICES OFFER

FACULTY OF ELECTRICAL
ENGINEERING
UNIVERSITY OF WEST BOHEMIA

RICE

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CONTENT

OFFER

Diagnostics and Material science group offers cooperation, consultancy, advisory, and devices for measurement in expert fields of:

- Electrical insulation testing and on-line monitoring
- High voltage insulation tests
- Thermal analyses (thermomechanical analysis, dynamical-mechanical analysis, differential scanning calorimetry, simultaneous thermal analysis)
- Infrared spectrometry FTIR
- Analyses of solids, liquids and gasses
- Determination of glass transition temperature, melting temperature, measurement of thermal and weight stability, analysis of evolved gasses during temperature decomposition, measurement of coefficient of thermal expansion
- Quality control
- Microscopy (laser confocal, fluorescence, optical, electron), measurement in 3D
- Materialography and image analysis
- Climatic testing
- Diagnostics Tests of Electronic Structures, PCBs and Components
- Disturbance withstand testing
- Acoustic noise measurement
- Electroacoustic diagnostics
- Room acoustics analysis
- Acoustic devices testing
- Design of measurement and diagnostics methods
- Accredited tests of EMC and environment withstand testing

The diagnostics and Material science group offers services to companies, research organizations, and even to the students of master and doctoral programs. The cooperation is based on expert consultancy, business cooperation, grant cooperation and master and doctoral thesis cooperation, etc.

THERMAL ANALYSES AND FTIR

Thermal analyses are practical tools in material diagnostics that help to determine the properties and behavior of substances and materials. The laboratory is equipped with several instruments for materials characterization.

Examples of measurements

Phase transitions: measurement of glass transition temperature (Tg), crystallization temperature (Tc), melting temperature (Tm), measurement of oxidation stability, etc.

Measurement of enthalpy of chemical reactions (curing, crosslinking, melting, decomposition...)

Analysis of degree of curing/crosslinking of thermosets and thermoplastics

Reaction kinetics (determination of activation energy, preexponential factor, rate constant)

Measurement of coefficient of thermal expansion (CTE)

Measurement of mechanical properties using dynamic mechanical analysis (DMA)

Measurement of thermal and weight stability of materials

Determination of amount of organic and inorganic fillers

Analysis of gases evolved during thermal decomposition of the material

Analysis of oxidation and nitration products in insulating liquids

Qualitative analysis of solids and liquids

Quality control of materials, contamination analysis

◀ Differential scanning calorimetry (DSC)

TA Instruments DSC Q2000

Temperature range: **-90 up to 550 °C**

The instrument also provides measurement in modulated mode (MDSC) or under UV light.

◀ Simultaneous Thermal Analysis (STA)

TA Instruments SDT Q600 and SDT Q650

Temperature range : **ambient up to 1500 °C**

The instrument allows simultaneous recording of weight change and heat flux evolution during sample heating (i.e., simultaneous TGA + DSC analysis). An infrared spectrometer can also be easily connected to the instrument to analyze the composition of the decomposition gases throughout the test. Modulated TGA (MTGA, for kinetics studies).

Thermomechanical analysis (TMA)

TA Instruments TMA Q400EM

Temperature range: **-150 up to 1000 °C**

The instrument also provides measurement in dynamic mode (DTMA), in which reversing and non-reversing components of dimension change are available.

Dynamic mechanical analysis (DMA)

TA Instruments DMA Q800

Temperature range : **-150 up to 600 °C**

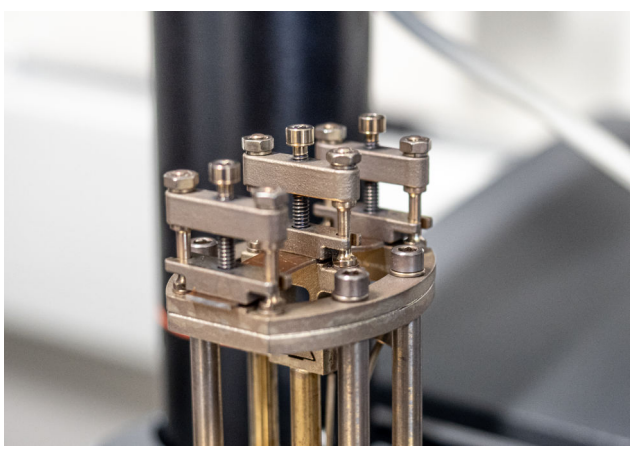
Available clamps: dual/single cantilever, 3-point bend, shear, tension (film, fiber), and compression.

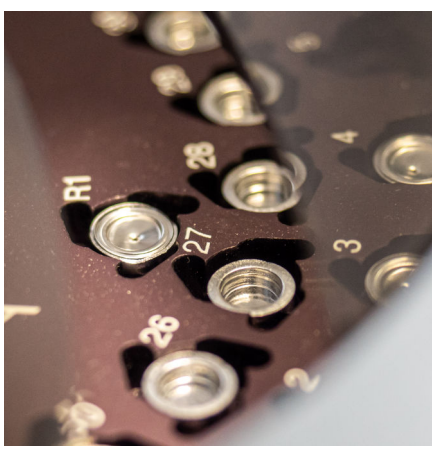
Fourier transform infrared spectrometer (FT-IR)

Thermo Scientific Nicolet 380

Spectral range: **400 up to 4000 cm^{-1}**

Modes of measurement and analysis: Attenuated Total Reflectance (ATR), transmission mode, Evolved Gas Analysis (TGA-FTIR).





DIAGNOSTIC TESTS OF ELECTRONIC STRUCTURES, PCBS AND COMPONENTS

The most frequently used methods for electronic structures, PCBs, and component diagnostics are optical, fluorescent, and laser methods and AFM microscopy. One of the most used methods in the lab is the materialographic microsections analysis prepared with a diamond saw, grinder, and polisher.

- Assessment of IPC-A-610 Acceptability of Electronics Assemblies Criteria
- Assessment of IPC-A-600 Acceptability of Printed Boards Criteria
- Diagnostics of active and passive components
- Integrated Circuit Decapsulation
- Diagnostics of solder joints
- Diagnostics tests of mechanical defects (fractures, cracks)

MICROSCOPY AND MATERIALOGRAPHY

Detailed imaging of object surfaces in high resolution is a frequent requirement in material diagnostics, an inspection of manufactured components, or when studying defects. The microscopy laboratory is equipped with an optical microscope, an electron microscope, a laser confocal microscope, and an AFM microscope. We offer methods and resources for visual object investigation magnified in the range from 5 to 150 000 times.

- Precise measurement of dimensions magnified in the range from 5 to 150 000 times
- Non-contact surface roughness measurement magnified in the range from 150 to 150 000 times
- Colour 3D surface reconstruction
- Materialographic cross section preparation
- EDS elemental analysis

Laser confocal microscopy

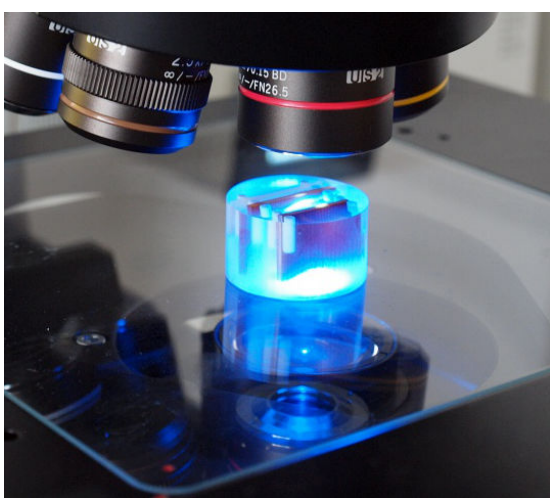
Olympus LEXT OLS5000

Max. Magnification **17280x**

Resolution on X, Y axes – **120 nm**, on Z axis – **0,5 nm**

Colour 3D surface reconstruction

Allows to measure surface roughness



Electron microscopy

Max. magnification **100 000x**

Resolution **17 nm**

Elemental analysis (EDS)

Elemental mapping and line scan

AFM Microscopy

Max. magnification **150 000x**

Resolution down to **1 nm**

Max. area **20 µm x 20 µm x 3 µm**

Contact and non-contact modes

Allows 3D surface reconstruction

Fluorescent microscopy

Max. magnification **3 200x**

fully 3-axis motorized table

High-sensitivity microscope camera

COMPUTED TOMOGRAPHY

The v|tome|x computed tomography is a versatile tool suitable for the rapid inspection of samples in two-dimensional space. In addition, the tomograph can be used to create a 3D model of the supplied example and perform precise measurements and analyses on it.

The following analyses can be performed on the provided samples

Analysis of pores and inclusions within the sample. Including determination of their size, position, statistical and graphical evaluation. The analysis can also be performed according to P201/202 standards.

Measurement of geometric dimensions. The analysis can be performed even in places inaccessible to conventional measuring tools.

Comparison of nominal and real model. This analysis can detect deviations between the part design (CAD data) and the reconstructed data from the real sample. In the result, the deviations of the individual locations are graphically displayed.

Measurement of the wall thickness of the sample. The wall thickness of the entire sample can be analyzed and then displayed graphically.

Analysis of fiber-reinforced composites. It is possible to determine the local and global orientation of fibres, their volume in the material. The results can be statistically processed and graphically displayed.

◀ Computed tomograph

GE phoenix v|tome|x s 240

240 kV/320 W and 180 kV/15 W RTG tubes

max. sample diameter **250 mm**,

max. sample height **400 mm**,

max. sample weight **10 Kg**

CLIMATE AND THERMAL TESTS

Equipment of the environmental testing laboratory is used to simulate the environment that is used to verify the functionality of electrical equipment in the circumstances or to determine the influence of climate on the properties and durability of materials and equipment according to standardized tests. For these tests, the laboratory is accredited by the Czech Accreditation Institute. It has calibrated climatic chamber, which allows for simulated environments with ambient temperatures from -70 to 180 °C and relative humidity from 10 to 98 % RH. Environmental tests can be used in developing electrical equipment to verify their functionality in different climates or to assess the tested sample durability using accredited tests.

Chambers options

Damp heat in the range **10 – 98 %RH.**

Dry heat up to **350 °C.**

Cold test down to **-70 °C.**

Climate and vibration combined.

Salt Mist.

Harmful emissions (Cl_2, SO_2, NOX, H_2S)

Fast temperature changes **-80 °C and 220 °C**

Muffle furnace up to **1350 °C.**

Condensation chamber **100 % RH.**

Combined aging of insulators by AC (**24 kV**), pulse (±5 kV) voltage and temperature up to **300 °C**.

Materials durability testing.

Functional testing of equipment.

Accredited environmental tests.

Long-term aging of insulation materials by the means of temperature and/or alternating or pulse voltage.

Environment simulation.

SOLDERABILITY TESTING OF PCBS AND COMPONENTS

A solderability tester MUST is used in this laboratory to verify the compatibility of lead and lead-free solder alloys and surface finishes of component terminals and printed circuit boards. To evaluate the solderability under the same conditions as in real life, the tester is equipped with a nitrogen cover to ensure an inert atmosphere.

Dip and Look Test

Wetting Balance Test

Area of Spread Test – equipment for vapour phase soldering

Lead-free solder SAC305, testing in protective nitrogen atmosphere

ACOUSTIC LABORATORIES

Anechoic chamber

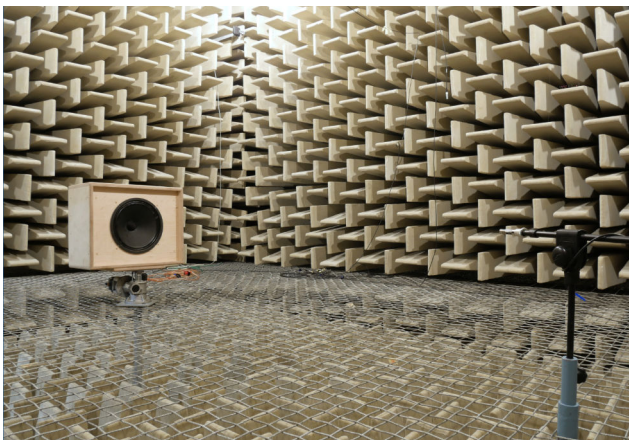
According to: **ČSN EN ISO 3745**

Low frequency limit: **90 Hz**

Volume: **128,3 m^3**

Dimensions: **5,0 x 4,1 x 6,4 m**

Temperature setting: **20 - 30 °C**



Reverberation room

According to: **ČSN EN ISO 354**

Dimensions: **6,8 x 5,3 x 6,1 m**

Volume: **214,9 m^3**

Noise level measurement.
Frequency analysis of sound (FFT analysis and 1/n-octave band filters).
Sound power measurement (free field, sound intensity).
Sound intensity measurement.
Sound source identification, sound intensity mapping.
Measurement of electro-acoustic transducers.
Directional pattern of sound sources measurement.
Vibration measurement.
Measurement of sound absorption coefficient of acoustic materials.
Measurement of room acoustic parameters (reverberation time, STI-PA).
Design of room acoustic treatment.
Multichannel sound recording.
Most of equipment is portable, due to outdoor measurement is possible.

Equipment of acoustic laboratories

Analyser Brüel & Kjaer PULSE 3560C, up to 9 channels (software FFT & CPB Analysis, Noise Source Indentification, Sound Quality, Datarecorder, Order Analysis)

Measurement microphones Brüel & Kjaer 4190 for free field, Brüel & Kjaer 4943 for diffusion field, Low noise measurement microphone Brüel & Kjaer 4955

1-axis and 3-axis charge and voltage accelerometers

Probe for measurement of acoustic intensity Brüel & Kjaer 3599

Handheld sound level meters Brüel & Kjaer 2260, 2231, NTI XL2

Remote controlled turntable for directional patterns of sound source measurement

Power amplifiers, multichannel audio signal processors, equalizers, AD/DA converters (Sabine, Rane, RME)

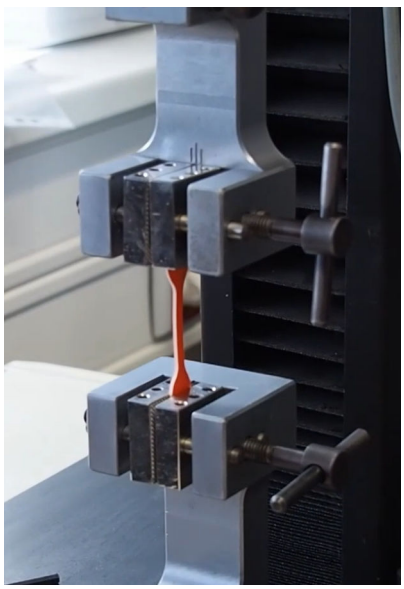
Sound sources (point source, omnidirectional, loudspeaker boxes)

Portable 24 channel hard disk sound recorder Alesis HD24

2 channel handheld sound recorders Sony, Marantz, Tascam

MECHANICAL TESTS

The devices for mechanical properties testing are located at the laboratories. The apparatus allows for the provision of tensile, compressive, impact, and bending tests of metal and composite materials at ambient or increased temperature. The laboratory analyses the hardness of the plastic according to Shore A and Shore D (ISO 868, ASTM D2240).



Two devices for accurate measuring of mechanical properties up to 100 kN and 3 kN

Temperature dependence of measured parameters up to 250 °C and 10 kN.

Universal test device for tensile, compressive and bending strength.

Impact strength (Charpy) 50 J.

IONIC CONTAMINATION

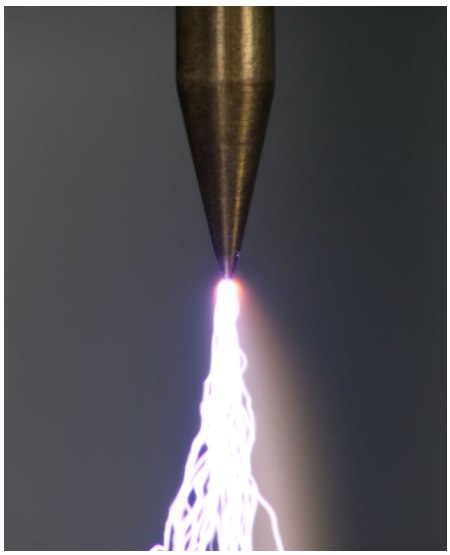
Measurement of ionic contamination is an essential method for determination of the purity of the assembled components or functional units, where impurities can cause a significant deterioration of operational parameters. The laboratory is equipped with a contaminometer (ionograph) which can carry out such accurate measurements.

Measurement of ionic contamination on bare board PCBs.
Measurement of ionic contamination on components
Measurement of ionic contamination on assembled PCBs

Contaminometer Concoat CM11

Measuring range: **0,01 - 30** µg **NaCl/cm²**
Maximum board dimension: **300 x 250 x 30 mm**
Minimum PCB surface: **100 cm²**

HIGH VOLTAGE APPLICATIONS



The laboratory provides expertise in physical-chemical phenomena in electrical insulating materials, design, and optimization of insulation systems of electric equipment. It carries out diagnostic tests on insulation systems and electric power engineering systems.

Complex testing of electrical insulation materials, material application and evaluation with regard to electric and other parameters.

Material and application research.

High voltage source of 200 kV AC and 130 kV DC.

Electromagnetically shielded chamber equipped with a 50 kV source.

High frequency pulse voltage accelerated aging

±5 kV, 0 - 10 kHz

Combined with thermal aging up to **300 °C**

AC voltage accelerated aging

24 kV

Combined with thermal aging up to **300 °C**

DIELECTRIC SPECTROSCOPY

Dielectric spectroscopy belongs to the diagnostics method at the edge of physics, chemistry, electrical engineering, and material science. The method can be used for studying the behavior of liquids and solids such as polymers, glass, ceramics, etc.

Permittivity measurement

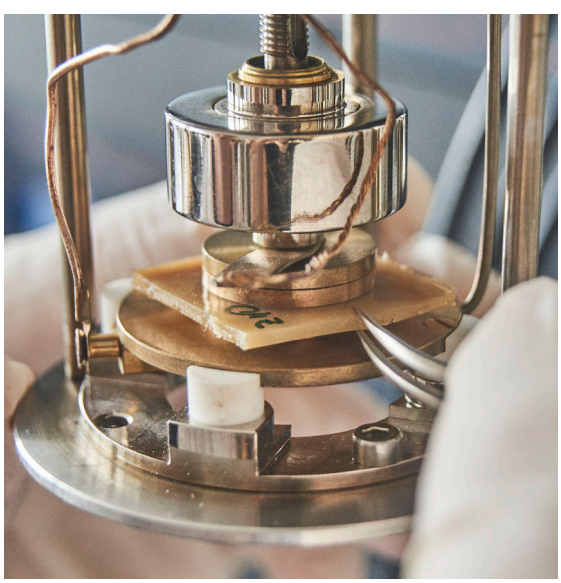
Loss factor tan δ measurement

Measurement in frequency and temperature domain

Frequency spectrum: from 3 mHz up to 40 MHz

Temperature : from –160 °C up to +400 °C

Analysis using special software WinFIT



ELECTRICAL PROPERTIES TESTING

Laboratory equipped with devices to evaluate the permittivity, dielectric strength, partial discharges, insulation resistance, volume, and surface resistivity of all kinds of electrical insulations.

These values can be measured at different frequencies, voltages and temperatures.

Dissipation Factor, permittivity, dielectric strength, partial discharges, insulation resistance, internal and surface resistivity, leakage currents.

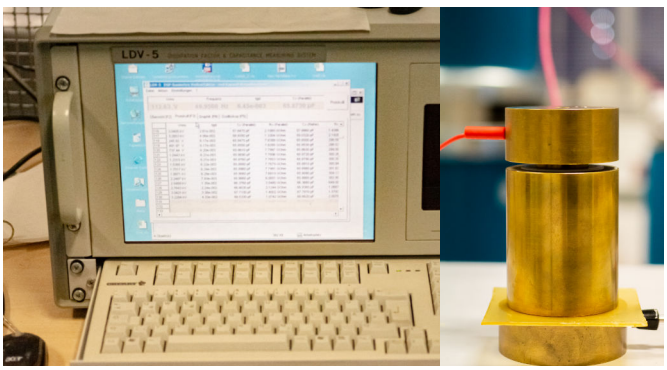
Frequency, voltage and temperature dependencies of the measured quantities.

Bridges for measurement of tan δ: LDV5 - automatic recordings of measurement, VKB semiautomatic at 30 Hz - 300 kHz.

Keithley 6517A for measurement of polarization and depolarization current with automatic recording.

Volume and surface resistivity measurement.

CTI comparative tracking index according to IEC 60112.



Global method for partial discharge measuring according to IEC 60270

Lemke probe for detection and localization of partial discharges - portable device

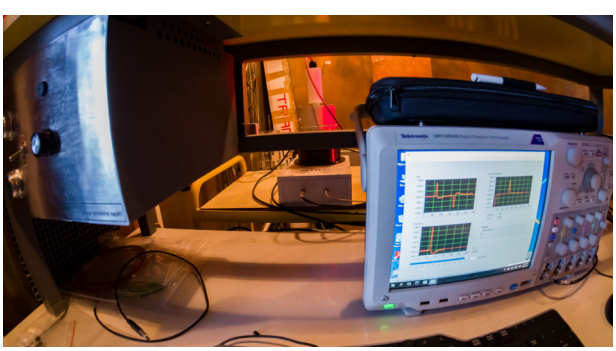
Doble PD SMART - digital method for Partial discharge phenomena analysis

Research in the field of partial discharges under DC voltage

Partial discharge localization - UV CAMERA for laboratory PD localization

SPACE CHARGE

The space charge measuring system is based on the pulse electroacoustic method - PEA (by TECHIMP). It is used to image the distribution, accumulation, and evaluation of the overall behavior of space charge within polymeric insulating materials.



LIQUID DIELECTRICS

We perform research and development in the field of liquid dielectrics. Emphasis is placed on biodegradable materials. For the analysis of chemical and physical properties, we use and offer.

Diram Coulometer WTD a KOH

Determination of water content: in organic acids, alcohols, esters, ethers, hydrocarbons, and other organic solvents

Moisture measurement: in medicines, sugars, various tablets, powder extracts and cereals (1ppm to 5% H2O)

Determination of the acid number in oil: measurement range from 2 µg KOH / g test substance

CALIBRATION LABORATORY

The calibration laboratory includes a stand for measuring fundamental electric quantities and a stand for accurate frequency measurement.

Workplace for measuring basic electric quantities

Workplace is equipped with Fluke 5500A and with multimeter Agilent 3458A.

	source	measurement
dc voltage	0 to 1000 V ±0,006 %	0 to 1000 V ±0,001 %
dc current	0 to 11 A ±0,06 %	0 to 0,1 A ±0,004 %
ac voltage	1 mV to 1000 V up to 500 kHz	0 to 1000 V up to 300 kHz
ac current	0,02 μA to 11 A up to 10 kHz	1 μA to 1 A up to 100 kHz
resistance	0,1 Ω to 10 MΩ ±0,02 %	0,01 Ω až 10 MΩ ±0,005 %

Workplace for accurate frequency measurement

The workstation can measure frequencies up to 2GHz and generate up to 1GHz with 10-digit resolution and 10^{-10} accuracy. Time, statistical and frequency analysis can be performed in the frequency domain. The generated frequencies have very low phase noise and excellent spectral purity. The accuracy of the counters and the frequency accuracy of the generators are checked.

GPS synchronized frequency standard – NanoSync 2, Fei-Zyfer

Frequency & time interval analyzer – HP5372A, Opt. 040, Opt. 090

Low phase noise generators – HP8662A and Agilent 33522B

OPTOELECTRONIC MEASUREMENT

A dedicated optical multimeter can be used to verify the performance, wavelength, and stability of visual sources operating in standard transmission bands of the infrared spectrum. The device can also measure sources coupled to an optical fiber, where the thread can be terminated with an optical connector.

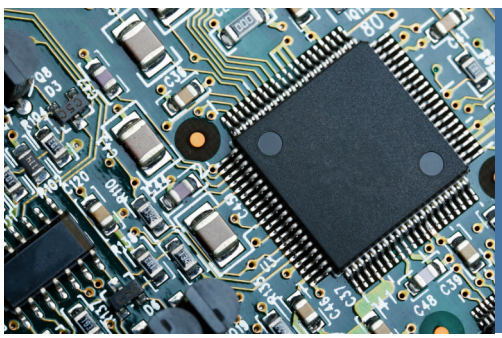
Measurement of optical power and wavelength of optical sources in the infrared band (including LEDs and lasers with fibre optic output)

Power range: - 40 dBm to +30 dBm

Wavelength range: 900 nm to 1650 nm

COMPUTER-AIDED DESIGN OF ELECTRONIC CIRCUITS, SIMULATION AND PREPARATION OF TECHNOLOGICAL DATA

The development of every electronic device starts with circuit design, which is done exclusively with CAD software. Each design includes circuit simulations not only in terms of the components used but also in terms of the PCB design and materials used, including subsequent post-processing.



- Circuit design using CAD software
- Computer simulation of circuits
- Printed circuit board design
- Production of precision film matrices on photoplotter
- Preparation of process data (Gerber, Excellon, HPGL)
- PCB manufacturing

Photoplotter MIVA 1624E T3

Resolution **24000 dpi**

Minimum line width **20 µm**

Maximum film size **410 x 550 mm**

Software

Ansoft Designer, PADS, HyperLynx, Formica, Eagle, CAM 350

HF MEASUREMENT AND SIMULATION

The software equipment of our workplace allows us to perform designs and simulations of planar components and circuits. An integral part of this is also the analysis of signal transmission on the PCB, including the evaluation of the results and subsequent optimization of the designed transmission paths.

- Design and simulation of planar components and circuits
- Analysis of signal transmission on a printed circuit
- Optimization of transmission paths
- Measurement of RLC parameters of components
- Spectral analysis of components and circuits
- Measurement of S-parameters of the circuit

Simulation tools

Ansoft Designer - simulation of parameters of conductive connections, materials and technological modifications of printed circuit boards, parametric analysis.

HyperLynx - detection of critical points in the use of specific components and board parameters, including design of solutions, LineSim and BoardSim module, EMC design.

Measuring equipment

RLC meter Agilent - frequency range 1 MHz - 3 GHz, measuring bench for measuring pin and SMD components

Agilent Spectrum Analyzer with Tracking Generator - frequency range 9 kHz - 3 GHz, -148 dBm DANL, tracking generator output level - 30 dBm to 0 dBm

Agilent High Frequency Generator - frequency range 9 kHz - 3 GHz, output signal level -127 dBm to +13 dBm, amplitude, frequency, phase and pulse modulation

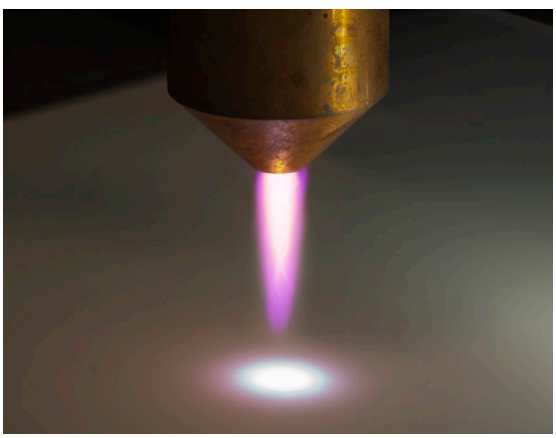
Function generator - frequency range up to 120 MHz, 2 channels, custom waveform programming

Signal Integrity Analyzer - frequency range DC to 30 GHz, 2 channels, S-parameters, TDR system

PLASMATIC SURFACE TREATMENT

The workplace is equipped with a Plasma Brush PB3 from Relyon plasma designed for industrial plasma surface treatment.

Reduction of surface tension of surfaces before deposition of layers
Precision cleaning of surfaces
Removal of oxide layers
Functionalization and activation of surfaces
Disinfection of surfaces from microorganisms



Plasma Brush

High process speed and efficiency

Low thermal stress on substrates

Process gas: compressed air, N_2, Ar_2, forming gas N_2+H_2

Movement speed up to **200 mm/s**

Wide range of usable substrates: Thermoplastics PP, ABS, PE, PET, POM, Elastomers, Epoxies, Polyesters, CFK, GFK, textiles, paper, metals, glass and ceramics, natural materials

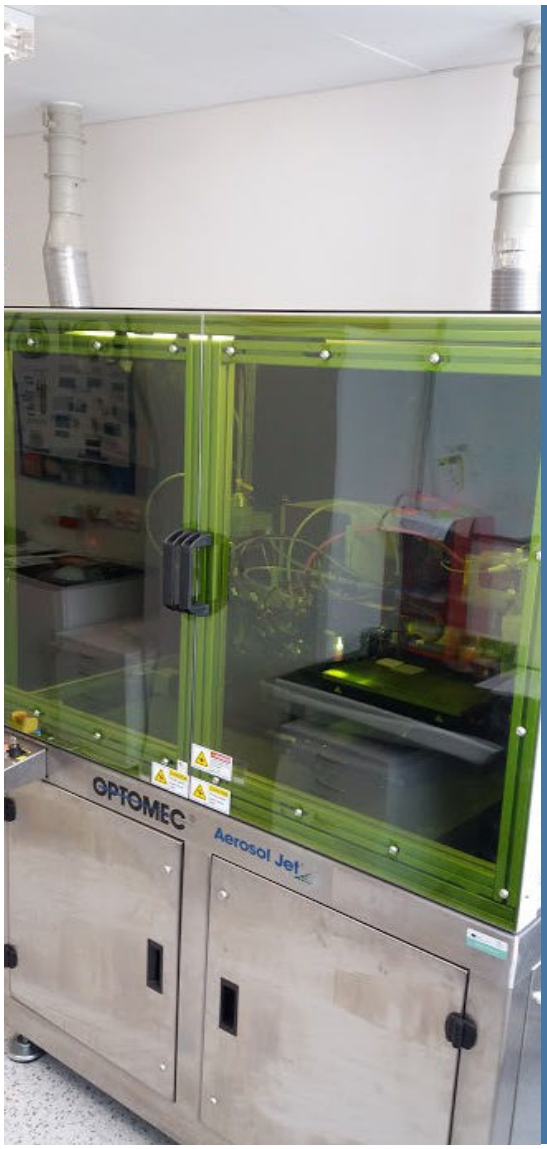
MATERIAL DEPOSITION

In the field of deposition of materials, the department is equipped with industrial deposition equipment "Aerosol Jet Printing", screen printing machine and equipment for vacuum deposition of materials in addition to standard laboratory techniques "spin coating" and "dip coating".

Aerosol Jet Printing – AJP

It is a unique patented technology used for selective deposition of materials using the Aerosol Jet Printing method. The Aerosol Jet Printing (AJP) method is an additive particular deposition technique that enables the miniaturization of electronic systems, the realization of delicate conductive motifs, and the integration of passive components without the need to prepare masks and film templates. The patented selective deposition solution, utterly different from the inkjet printer principle, uses an aerodynamic carrier gas stream to concentrate an aerosol of deposited material onto a precisely defined area of the substrate. It is the only device of this type in the Czech Republic and Eastern Europe.

Parameters Aerosol Jet Printing



Non-contact deposition of a wide range of organic and inorganic materials, nanocarbon structures and bioactive substances.

Direct printing of motifs without the need to prepare film matrices or templates.

Direct design of motifs in AutoCAD environment.

Printing on a wide range of substrates (Thermoplastics PP, ABS, PE, PET, PEN, PI, PA, Elastomers, Epoxies, Polyesters, textiles, paper, metals, glass and ceramics, natural materials).

Printing on uneven and textured substrates with a height of unevenness up to 10 mm.

Minimum line widths up to 10 µm.

Minimum deposited layer thickness from 100 nm

Range of ink viscosities:

- Pneumatic atomizer: 1 - 1000 cP
- Ultrasonic atomizer: 1 - 5 cP

Minimum ink quantity

- Pneumatic atomizer: 10 ml
- Ultrasonic atomizer: 1 ml

Low thermal stress on the substrates and printing materials used during the deposition process.

Possibility of direct laser selective sintering, 700mW 830nm IR laser.

Accuracy +/- 10 µm in X, Y axis with repeatability +/- 1 µm.

Screen printing machine

The workplace is equipped with an industrial screen printing machine EKRA E2. The screen printing machine enables selective deposition of functional materials by screen printing and stencil printing methods. Thanks to a wide range of accessories and a variable table system, the screen printing machine enables the deposition of materials in the form of total homogeneous layers as well as in the form of delicate motifs on almost any rigid, flexible and textile substrates.

Screen and template printing

MOPS camera system with variable illumination for precise print alignment

Maximum printable area: 370 x 450 mm

Maximum substrate thickness: 75 mm

Print accuracy: ± 10 µm

Squeegee speed: 10 to 170 mm/s

Squeegee pressure: 10 to 250 N

Screen breakage: -1.5 to 5 mm

Vacuum or mechanical fixation of substrates

Adjustable squeegee angle

Equipment for vacuum deposition

The department is equipped with laboratory equipment from Polaron Instruments for the deposition of thin films by vacuum evaporation and magnetron sputtering. The main applications include sample preparation for electron microscopy, thin film conductive layer deposition, and electrode structures.

Deposition chamber size: 155 mm

Materials to be deposited: carbon, gold, aluminium

Dispenser

The workplace is equipped with an automatic microdispensing Nordson EFD PROPlus4L/A with pneumatic deposition. Microdispenser is equipped with a contact print head and enables selective deposition of functional materials based only on the drawing, making it suitable for prototyping. Servomotor drive ensures precise printing with high repeatability. Electrically conductive, dielectric, and resistive materials in a wide range of viscosities can be applied to almost any substrate, from rigid to flexible to elastomeric.

Fully digital printing without the need for a template.

Process camera for precise assembly.

Wide range of needle accessories for any application.

Maximum printable area: 300 x 300 mm

Maximum substrate height: 100 mm

Print speed: up to 10 mm/s

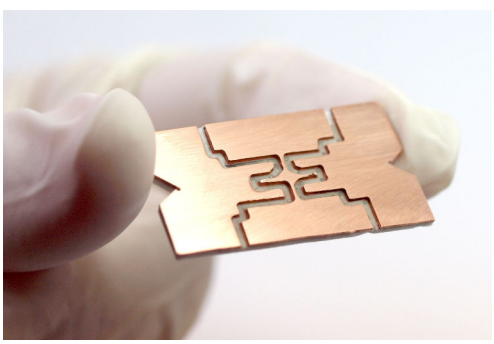
Printing accuracy: ± 3 µm

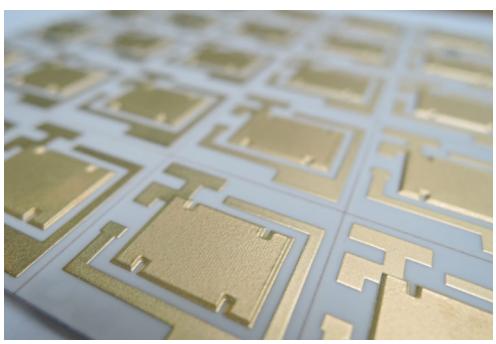
Minimum printed line width: 300 µm

Maximum pressure: 7 bar

SUBSTRATES FOR POWER APPLICATIONS

The department is equipped with a muffle furnace with a gas-tight retort where the firing of materials and pastes in a nitrogen atmosphere can be carried out up to temperatures 1100 °C. The laboratory specializes in manufacturing and testing ceramic-based substrates with a thick copper film layer. It is mainly used for DBC, and thick film printed Cu technology. The thickness of the conductive layers can reach up to several hundreds of micrometers.





UV-VIS SPECTROSCOPY

The method is suitable for the measurement of absorption spectra in solutions of test substances in any solvent, for the measurement of concentrations of dyes and organic substances, or the measurement of spectra of different types of light sources. The instrument also allows measurements of time-dependent reactions and processes (kinetic measurements) or at selected wave frequencies.

Spectrometer Ocean Optics QE65 Pro

Single beam spectrophotometer

Wavelength range 200 - 1100 nm

Radiation source - tungsten (visible region) and deuterium (ultraviolet region) lamp

TESTING AND DIAGNOSTICS OF GAS SENSORS

The apparatus for mixing gas mixtures consisting of 7 mass flow controllers from Sierra Instruments and two test chambers allows testing of different types of gas sensors under defined conditions. The sensors can be tested in environments with humidity variations ranging from 20 - 80%, temperature ranging from 0 - 100 °C, analyte flow rates ranging from 0.2 - 1.5 l/min, analyte concentrations ranging from hundreds of ppb to hundreds of ppm (specific values are related to the type and nature of the gas being tested).

PRINTED ELECTRONICS

In printed electronics, we have long-term experience in applied research. In this area, we cooperate with several research and industrial partners in the Czech Republic and abroad. We are currently involved in international and national projects.

Printed flexible sensors - vapour and gas sensors, resin curing sensors, temperature sensors

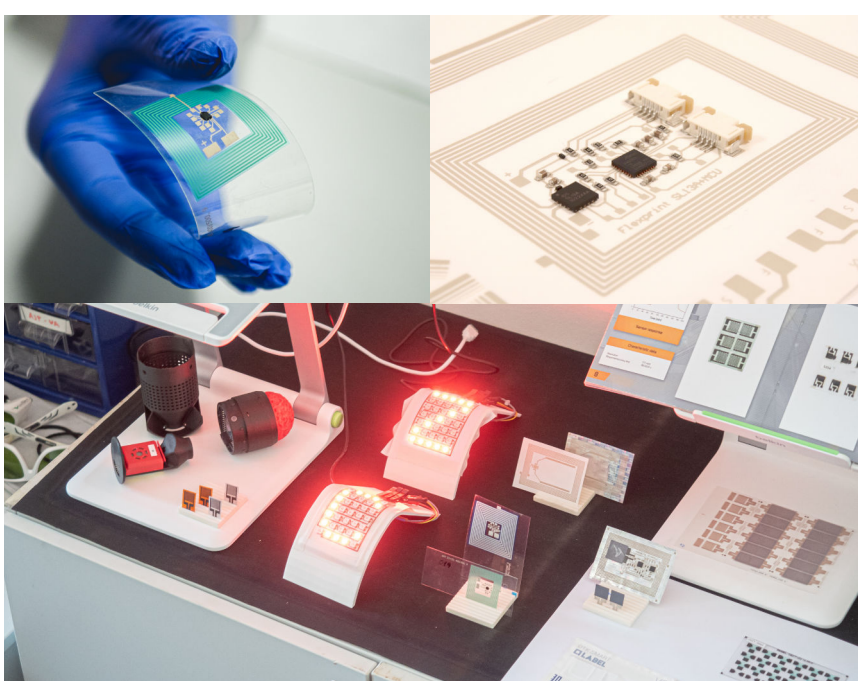
Printed semiconductor components - OFET (organic unipolar transistor), OECT (electrochemical transistor), resistors, capacitors, inductances, antennas

Hybrid functional circuits on flexible substrate

Smart packages and labels - RFID, integrated sensors, data recording, evaluation and transmission

Flexible function blocks for Smart Textiles.

Security and anti-counterfeiting systems



SMART TEXTILES

In the field of Smart Textiles, we have long-term experience in applied research focused on protective clothing and textile products for patients, convalescents, the elderly, and people requiring special care. In this area, we cooperate with several research and industrial partners in the Czech Republic and abroad. Within this area, we participate in international and national projects.

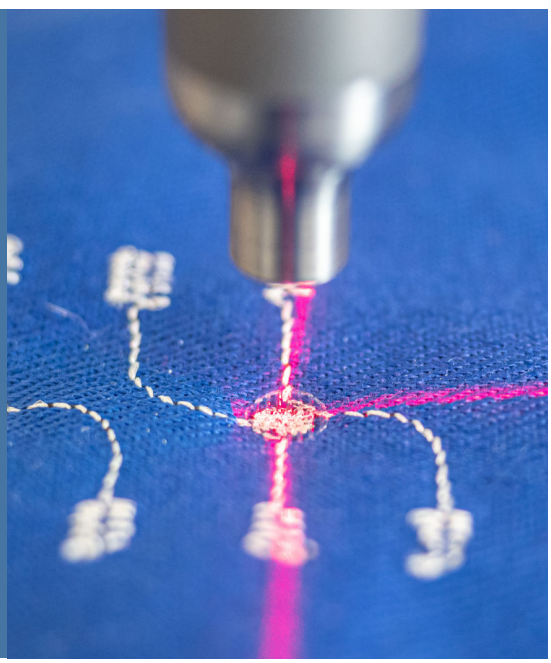
Sewn-in flexible sensors - humidity sensors, temperature sensors, occupancy sensors, strain and pressure sensors

Interconnection structures - printed interconnection structures, textile bus interconnection structures

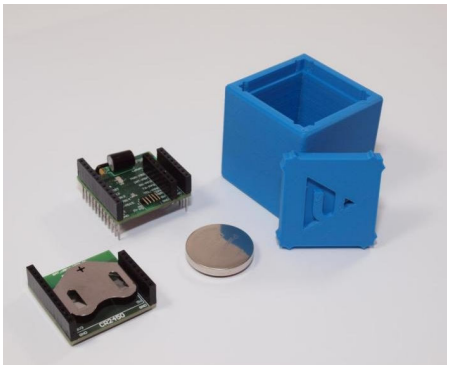
Integration of functional blocks into textiles - housing, flexible connectors, textile electrodes (ECG, breathing and heart rate sensing)

Printed and/or embroidered electronic components on textiles - antennas, batteries, supercapacitors, passive electronic elements

Design and integration of microsystems into textile structures



INTERNET OF THINGS AND SMART TECHNOLOGIES



The Internet of Things, in its general definition, is the interconnection of numerous devices (called Nodes) through low-power, long-range wireless networks (called LPWANs - Low Power Wide Area Networks). In the Czech Republic, three solutions for these networks can be found: Sigfox, LoRaWAN, and NB-IoT technologies. The ZČU campus is covered by its own LPWAN network LoRaWAN. It is also possible to connect several dozens of nodes to the commercial Sigfox network free of charge through the SimpleCell operator.

Colleagues from our department have initiated the involvement of all other entities of the university (faculties, research centers, informatization, and computing centers) in this area, as the Internet of Things and SMART technologies have substantial interdisciplinary overlap. This issue is being addressed under the umbrella of the university-wide group SmartCity ZČU, which includes representatives of all university faculties and some other specialized departments.

The first joint project of this group was the so-called SmartCAMPUS ZČU (www.smartcampus.cz), which our department again initiated. The idea of the SmartCAMPUS project is a scaled-down model of a city, a living testbed, enabling testing of state-of-the-art SMART and IoT technologies on a smaller scale for thorough testing of "pre-pilot" operation for final deployment in larger units such as cities, regions, etc. In the project, we cooperate with the following entities: the Technology Centre Písek, ČD Telematika, the City of Pilsen, RVTECH, SimpleCell, and IndustryLight. We are members of the Czech Smart City Cluster, IQRF Alliance, and the Smart Pilsen Region initiative. SmartCAMPUS allows students' involvement in the projects and thus gives rise to unique interdisciplinary teams across the university.

There is an excellent opportunity for companies to test their technologies and integrate them with other technologies on campus. Municipal representatives will gain access to the knowledge base, and we are willing to provide expert consultation. As part of the SmartCAMPUS project, we have developed our open-source prototyping platform for the Internet of Things called KETCube. It is a modular demo platform consisting of a main board, a battery board, and an extension board. The heart of the base module is a combined ARM microcontroller with a radio module for LoRaWAN. The individual modules are connected via a developed socket, and the base module is also compatible with the microBUS™ standard. The project is publicly available at https://github.com/SmartCAMPUSZCU.

smart CAMPUS

ELECTROMAGNETIC COMPATIBILITY (EMC)

In the field of EMC, the laboratory provides tests, preparation of the declaration of conformity, EC declaration according to NV No. 616/2006 Coll., and documents for compliance with the requirements of the European Directive No. 2004/108/EC for CE declaration. The Electrotechnical Laboratory has modern instrumentation, including a shock-free chamber.

- Measurement of interference in conductors in the 9 kHz to 30 MHz band
- Tests for immunity to groups of transient pulses
- Measurement of radiated interference in the 9 kHz to 6 GHz band
- Shock wave immunity tests
- Tests for immunity to radio frequency interference propagating over wires
- Tests for immunity to high-frequency electromagnetic fields with different types of modulation
- Tests for immunity to power supply voltage fluctuations and disturbances
- Magnetic field immunity tests
- Tests for resistance to static electricity discharges
- Magnetic field pulse immunity tests

In the field of EMC, the laboratory offers the following tests:

Electrostatic discharge resistance test	ČSN EN 61000-4-2 ed.2	Electrical equipment
Resistance test by fast electrical transients (pulse groups)	ČSN EN 61000-4-4 ed.3	Electrical equipment
Impact impulse resistance test	ČSN EN 61000-4-5 ed.3	Electrical equipment
Resistance test by magnetic field of mains frequency	ČSN EN 61000-4-8 ed.2	Electrical equipment
Pulsed magnetic field resistance test	ČSN EN 61000-4-9	Electrical equipment
Test for resistance to short-term dips, short interruptions and slow voltage changes	ČSN EN 61000-4-11 ed.2 +A1	Electrical equipment
Measurement of radio interference characteristics from industrial, scientific and medical equipment	ČSN EN 55011 ed.3 +A1	Electrical equipment
Measurement of electromagnetic interference characteristics caused by household appliances, power tools and similar devices	ČSN EN 55014-1 ed.3 +A1+A2	Electrical equipment
Damped sine wave resistance test	ČSN EN 61000-4-12 ed.2	Electrical equipment
Measurement of radio interference characteristics caused by information technology equipment	ČSN EN 55032 ed.2	Electrical equipment
Electromagnetic compatibility test, railway vehicles - train and overall vehicle	ČSN EN 50121-3-1 ed.3	Railway vehicles
Electromagnetic compatibility test, railway vehicles - equipment	ČSN EN 50121-3-1 ed.3	Railway vehicle components
Immunity test - Radiated high frequency electromagnetic field	ČSN EN 61000-4-3 ed.3 +A1+A2	Electrical equipment
Immunity test - Resistance to line disturbances induced by radio frequency fields	ČSN EN 61000-4-6 ed.4	Electrical equipment

PROCESS MANAGEMENT

In the area of process management, we provide services and activities related to process analysis, modeling, and optimization. We focus on improving the efficiency of electrical and electronic manufacturing by introducing process control and other modern process management tools. We also focus on risk management, risk analysis, and information security systems. We can offer companies and companies cooperation in this area based on training, consulting, or solving specific projects.

Performing process analysis - workflow analysis in organizations
Process mapping and analysis for process digitalization
Risk management - risk analysis
Modeling and optimization of technological and diagnostic processes.
Measurement of process performance evaluation.
Production control and process design.
Quality and information security management systems
Statistical data analysis