Research Team Progressive material, technologies and their application in electronics

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Team members

prof. Ing. Alena Pietriková, CSc. (E-mail: <u>alena.pietrikova@tuke.sk</u>) – specializes on the microstructure and physical and electrical properties of advanced materials of electronics, Electronics Technology (LTCC and thickfilm technology, inkjet printing technology, assembly technology in electronics), multifunctional microsystems and hybrid sensors.

doc. Ing. Juraj Ďurišin, PhD. (E-mail: <u>juraj.durisin@tuke.sk</u>) – deals with the analysis of the microstructure of crystalline and amorphous material applied in electronics using light, electron microscopy and X-ray diffraction.

Ing. Ľubomír Livovský, PhD. (E-mail: <u>lubomir.livovsky@tuke.sk</u>) – address of microprocessor applications based on AVR and ARM microcontrollers, creating software with an emphasis on sensor, measuring systems and automation in the development environment, LabWindows / CVI as well as topology design of multilayer printed circuit boards (PCB) to Altium Designer and topology of PCB for "high-speed signals" using products from Mentor Graphics.

Ing. Igor Vehec, PhD. (E-mail: <u>igor.vehec.2@tuke.sk</u>) – is professionally focused on wire bonds in electronics, thick-film technology and multi-layer structures based on LTCC technology.

Ing. Pavol Cabúk, PhD. (E-mail: <u>pavol.cabuk@tuke.sk</u>) – is professionally focused on 3D flow and thermal transport simulation in electronic structures and measurements of real conditions in real structures.

Ing. Ondrej Kováč, PhD. (E-mail: <u>ondrej.kovac@tuke.sk</u>) – is professionally focused on InkJet printing technology, development of software solutions for mathematical analysis and data processing as well as on digital signal and image processing.

Research Direction

The research team focuses on film technology in electronics, rigid and flexible printed circuit boards, surface mount technology (SMT), multi-chip modules MCM-C, development and production of the most diverse elements of electronics and sensors, materials used in electrical engineering and last but not least, on the application of CAD systems and simulation software tools to analyze the flow of fluids and gases and heat transfer.

The importance and benefits of research

- Integrated research on the electrophysical properties of advanced materials used in electronics,
- research and development of multifunctional microsystems and hybrid sensors (multilayer ceramic modules based on LTCC),
- research activities in the field of materials research based on the use of modern experimental techniques and computer technology,
- applications software products for the design of printed circuit boards and for the development of hybrid and LTCC circuits, structures and sensor systems (flexible HYDE design system, Altium Designer to design printed circuit boards),
- applications software products for the analysis of temperature fields, the flow of liquid and gaseous media (Mentor Graphics Mechanical Analysis FloEFD),
- the quality and reliability of electronic systems.

Solving Current problems

• Application of modern experimental techniques and computer technology in materials.



The microstructure of solder volume 96.5Sn3Ag0.5Cu for HASL finish PCB solder pads.





The microstructure of solder volume 96.5Sn3Ag0.5Cu for ENIG finish PCB solder pads.



Pair distribution function G (z) of the molten Sn obtained at 240 °C.

• Electronics materials: Development of new rapid cooling base alloys of tin and its application in power electronics.



• Design tools: Design and production of multi-layer PCB with embedded resistors (Altium Designer).



• Analysis and simulation of signal parameters during and after the PCB design using Hyperlynx software products from Mentor Graphics.



• **Microjoining** technologies such as ribbon, ball and wedge bonding (Al, Au, Cu), reliability of microjoints from the point of view of electrical properties, strength and temperature.





• Materials and connections of power electronics: Analysis of connections for powerline applications, materials analysis pads, progressive cooling of power modules based on LTCC.



• Dielectric properties of substrates designed for the production of elements working in the GHz range.



• **Design and implementation of high-frequency component elements** using different materials and technologies based on LTCC (microstrip filters and resonators).



• **Multifunctional microsystems**: Development and implementation of IQ demodulator based on LTCC with integrated microstrip LP and BP filters based on various LTCC dielectric materials.



• Nanotechnology: Applications Inkjet Printing Technology in Electronics (antenna analysis of surface properties of polymeric substrates intended for Inkjet Printing Technology).



• Sensors: Analysis and development of inductive and capacitive sensors based layered technologies used for the construction of a proximity sensor.



- Analysis and processing of discrete signals.
- **Software analysis of images** from X-ray images, focusing on the evaluation of the quality of joints (cavities, voids, homogeneity).



Current Projects

- Effects of behaviour of multilayer modules based on LTCC in the high frequency environment. VEGA: 51/0218/13, prof. Ing. Alena Pietriková, CSc. 2012 2015
- Electrical properties of soldered and bonded joints in microelectronics. VEGA: 1/0776/14, Ing. Juraj Ďurišin, PhD. , 2014 2016
- Virtual and Practical Applications to Electronic Assembling Technology (VAPAEAT) VAPAEAT/2013-1-TR1-LEO05-47531), international project Leonardo da Vinci, prof. Ing. Alena Pietriková, CSc. , 2013 - 2015
- Development of New Generation Joints of Power Electronics Using Nonstandard Sn-based Alloys. APVV-14-0085, prof. Ing. Alena Pietriková, CSc. , 2015 - 2018
- Implementation of new research trends into education in the area of progressive materials and intelligent technologies of auto electronic. KEGA: 002TUKE-4/2014, prof. Ing. Alena Pietriková, CSc., 2014 2016

Cooperation with Academic Institutions and Industry

Cooperation with DESY, Hamburg and the ESRF, Grenoble in the field of materials research: Development of new types of materials prepared by flash cooling connections for power electronics.



View of the synchrotron experimental opinion P07 Peter and at DESY, Hamburg.





Aerial view of the experimental hall synchrotron PETRA I at DESY, Hamburg.

Aerial view of the experimental hall at synchrotron ESRF, Grenoble.

| Organization | Solved Tasks |
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| Institute of Material Research SAV Kosice | Development and analysis of new types of materials prepared by flash cooling connections for power electronics. |
| SEMIKRON, s.r.o | Development boards for powerline applications, analysis of materials applied in power electronics. Analysis of the temperature profile of the melting process of power electronics. |
| EVPÚ Nova Dubnica | Assessment of disorders of solder joints on printed circuit boards and microscopic analysis of faulty resistors void in joints and analysis of options for their elimination. |
| Magneti Marelli | Optimisation of nitrogen flow in "reflow". |
| | Universal graphic control panel for the dashboard of cars in LabVIEW. Comparison of Method Control for Devices after Surface Mounting by Automatic Optic |
| | Inspection. |
| | Analysis eliminate warping effect of BGA packages. Assessment of the effects of external factors on the quality of solder joints. |

| Samsung Electronics Slovakia, s.r.o. | Analyse and testing BGA errors, reduction of errors and false seeking improved testing process. |
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| SMK | The development of coils with ferrite. |
| Logomotion | Research, development, implementation and testing of miniaturized modules NFC. |

Selected Publication

- Surface analysis of polymeric substrates used for inkjet printing technology/ Alena Pietrikova, ... [et al.], Circuit World, Volume: 42 Issue: 1, 2016,
 - http://www.emeraldinsight.com/action/doSearch?AllField=Pietrikova&content=articlesChapters
- Impact analysis of LTCC materials on microstrip filters' behaviour up to 13 GHz / Alena Pietriková ... [et al.] 2015. In: Microelectronics International. Vol. 32, no. 3 (2015), p. 122-125. ISSN 1356-5362 Spôsob prístupu: http://www.emeraldinsight.com/doi/pdfplus/10.1108/MI-01-2015-0003...
- Atomic structure of Cu-Zr-Ti metallic glasses subjected to high temperature annealing / Juraj Ďurišin ... [et al.] 2014. In: Journal of Alloys and Compounds. Vol. 608 (2014), p. 241-246. ISSN 0925-8388 Spôsob prístupu: http://www.sciencedirect.com/science/article/pii/S0925838814009165...
- Reologické vlastnosti ne-newtonovských kvapalín / Alena Pietriková, Michal Kravčík 2011. In: Chemické listy.
 Vol. 105 (S), no. Symposia (2011), p. 630-632. ISSN 0009-2770
- Vplyv teploty na fázové transformácie spájkovacích zliatin / Juraj Ďurišin, Alena Pietriková, Jozef Bednarčík 2011. In: Chemické listy. Vol. 105, no. (S) (2011), p. 482-484. ISSN 0009-2770
- In situ investigation of the SnAgCu solder alloy microstructure / Alena Pietriková, Jozef Bednarčík, Juraj Ďurišin 2011. In: Journal of Alloys and Compounds. Vol. 509, no. 5 (2011), p. 1550–1553. ISSN 0925-8388 Spôsob prístupu:

http://www.sciencedirect.com/science?_ob=PublicationURL&_tockey=%23TOC%235575%232011%23994909994 %232...

- Microstructural analysis and transport properties of RuO2-based thick film resistors / S. Gabáni, K. Flachbart, V.
 Pavlík 2008. In: Acta Physica Polonica A. Vol. 113, no. 1 (2008), p. 625-628. ISSN 0587-4246
- **RuO2-based low temperature sensors with "tuned" resitivity dependences** / S. Gabáni ... [et al.] 2004. In: Czechoslovak Journal of Physics. Vol. 54, Suppl. D, Part 2 (2004), p. D663-D666. ISSN 0011-4626
- Production of very fine copper powder and control of its properties / Alena Pietriková, Edita Kapušanská 1991.
 In: Kovové materiály. Roč. 29, č. 4 (1991), s. 262-272
- Spôsob prípravy medeného prášku pre výrobu vodivých sieťotlačových pást : patentový spis č. 250050 / Miloš
 Somora, Alena Pietriková Praha : ÚPVaO, 1989. 7 s.
- Spôsob výroby oxidu kremičitého SiO2 zo serpentinitovej nerastnej suroviny : patent č. 283183 / Alena
 Pietriková, Milan Búgel, Michal Neubauer Banská Bystrica : ÚPV SR, 2003. 2 s.
- Spôsob výroby silikagélu s hladkým povrchom stien sférických častíc zo serpentinitu : patent č. 286560 / Michal Neubauer, Alena Pietriková, Milan Búgel - Banská Bystrica : ÚPV SR, - 2008. - S. 5.