



15 - 19 May 2024 Prague, Czech Republic

International Spring Seminar on Electronics Technology

*Trends in Electronics Manufacturing, Interconnection
Technology, and Microelectronics Packaging*

CONFERENCE PROGRAM & EXTENDED ABSTRACTS



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Genetics of the Czech Academy of Sciences

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ISSE 2024

47th International Spring Seminar on Electronics Technology

*"Trends in Electronics Manufacturing, Interconnection
Technology and Microelectronics Packaging"*

May 15 – 19, 2024, Congress Center of the Institute of Molecular Genetics, Prague,
Czech Republic

Conference Program
&
Extended Abstracts

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1st Edition 2024

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Preface

The organizers of the 47th International Spring Seminar on Electronics Technology welcome all attendees of the ISSE 2024, in Prague. The conference event begins on Wednesday, May 15th, with a welcome reception in the afternoon and includes three full conference days with six oral sessions and five poster sessions in the traditional in-person format. The plenary sessions will take place at the Institute of Molecular Genetics of the Czech Academy of Sciences, and the social program will provide a Prague city guided tour, Strahov Monastery and Library guided tour.

The International Spring Seminar on Electronics Technology (ISSE) is the premier European forum for exchanging information between senior and young scientists from academic communities and electronic industries worldwide. Topics include experimental and theoretical work in a widespread field of electronics and micro/nanoelectronics technology, electronics manufacturing, electronics packaging, advanced research, and teaching. Based on a combination of oral and poster presentations and individual meetings, professors, industrial participants, students, senior and junior researchers come together in a unique forum to discuss scientific and educational topics and organize international cooperation in a convenient atmosphere during the conference days.

This Book of Abstracts is meant to provide an overview of the whole technical scope of the conference and to support orientation during the conference. For this reason, the abstracts are ordered according to the sequence of the conference topic.

The local organizer, Department of Electrotechnology, Faculty of Electrical Engineering, Czech Technical University in Prague, was supported in conference organization by companies: Continental Automotive Czech Republic (main sponsor), Rohde & Schwarz (main sponsor), Infineon Technology Austria AG, Valeo, Vyrtych and IBG Czech.

The organizers would like to take the opportunity to express their particular gratitude to

- all participants for their valuable scientific contributions and presentations
- all reviewers for their help to achieve an internationally recognized scientific level
- all sponsors for supporting the organization of the conference
- and the IEEE EPS for its technical co-sponsorship

Acknowledgements are also directed to all colleagues, friends and ISSE members who helped with the conference organization.

The organizers wish all attendees a pleasant and successful conference!



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Publication Chair of ISSE



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History of ISSE

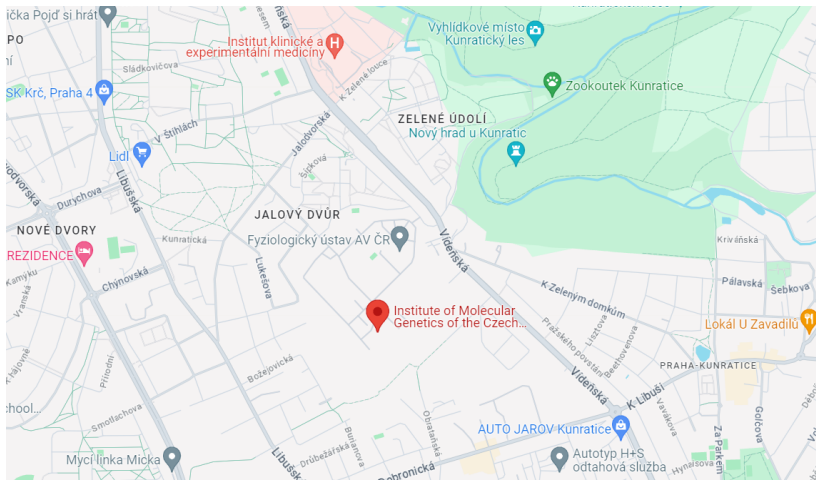
ISSE is a series of annual conferences on electronics packaging that was founded in 1977 to provide a European forum senior and junior scientists as well as electronic industries around the world.

- 1st 1977 Application of Mathematics in Electronics Technology, Weissig, Germany
- 2nd 1978 Reliability in Electronics, Prenet, Czechoslovakia
- 3rd 1979 Measurements in Electronics Technology, Balatonfüred, Hungary
- 4th 1980 Hybrid Technology, Manebach, Germany
- 5th 1982 Physical Measuring Methods, Prenet, Czechoslovakia
- 6th 1983 Research and Education in Microelectronics, Balatonfüred, Hungary
- 7th 1984 Applications of Microprocessors in Technology, Geising, Germany
- 8th 1985 Power Semiconductors, Hybrid Devices, Prenet, Czechoslovakia
- 9th 1986 Progress in Physical Measuring Methods on Electronics Technology, Balatonfüred, Hungary
- 10th 1987 Progress in Education in Hybrid Microelectronics, Sozopol, Bulgaria
- 11th 1988 Progress in Surface Mount Technology, Karsdorf, Germany
- 12th 1989 Thermal Problems in Electronics Technology, Prenet, Czechoslovakia
- 13th 1990 Computer Aided Electronics Technology, Göd, Hungary
- 14th 1991 Total Quality Control in Hybrid Production, Sozopol, Bulgaria
- 15th 1992 Higher Education in Electronic Technology, Herlany, Slovak Republic
- 16th 1993 Thick and Thin Film Sensors, Szklarska Poreba, Poland
- 17th 1994 Process Technology of Electronics, Weissig, Germany
- 18th 1995 Advanced Electronics Technology, Temesvár, Czech Republic
- 19th 1996 Advanced Electronics Technology, Göd, Hungary
- 20th 1997 Education and Research in Microelectronics, Szklarska Poreba, Poland
- 21st 1998 Advanced Electronics Technology, Neusiedl am See, Austria
- 22nd 1999 Driving Forces in Electronics Technology, Freital, Germany
- 23rd 2000 Networking Electronics Packaging Education, Balatonfüred, Hungary
- 24th 2001 Concurrent Engineering in Electronic Packaging, Calimanesti-Caciulata, Romania
- 25th 2002 Quality Management and Diagnostics in Electronics Packaging, Prague, Czech Republic
- 26th 2003 Integrated Management of Electronic Materials Production, High Tatras, Slovak Republic
- 27th 2004 Meeting the Challenges of Electronics Technology Progress, Bankia / Sofia, Bulgaria
- 28th 2005 European Electronic Packaging Network, Wiener Neustadt, Austria
- 29th 2006 Nano-Technologies for Electronics Packaging, St. Marienthal/Dresden, Germany
- 30th 2007 Emerging Technologies for Electronics Packaging, Cluj-Napoca, Romania
- 31st 2008 Reliability and Life-time Prediction, Budapest, Hungary
- 32nd 2009 Technology Integration, the path to New Solutions in the Modern Electronics, Brno, Czech Republic
- 33rd 2010 Polymer Electronics and Nanotechnologies: Towards System Integration, Warsaw, Poland
- 34th 2011 New Trends in Micro/Nanotechnology, Tatranská Lomnica, Slovak Republic
- 35th 2012 Power Electronics, Bad Aussee, Austria
- 36th 2013 Automotive Electronics, Alba Iulia, Romania
- 37th 2014 Advances in Electronic System Integration, Dresden, Germany
- 38th 2015 Novel Trends in Electronics Manufacturing, Eger, Hungary
- 39th 2016 Printed electronics and smart textiles, Pilsen, Czech Republic
- 40th 2017 High-Tech Electronics for a Better Tomorrow - Theoretical and Practical Aspects, Sofia, Bulgaria
- 41st 2018 Research and Development Tendencies in Advanced Electronics Technologies, Zlatibor, Serbia
- 42nd 2019 Advances in Printed and Ceramic Microsystems, Wroclaw, Poland
- 43rd 2020 Trends in Microelectronics Packaging and Interconnection Technology, Kosice, Slovakia
- 44th 2021 Advancements in Microelectronics Packaging for Harsh Environment, Dresden, Germany
- 45th 2022 Electronics Technology Innovations towards Green Electronics, Vienna, Austria
- 46th 2023 Revolutionizing the Electronics Ecosystems – Chiplet and Heterogeneous Integration, Timișoara, Romania

Conference Venue



Institute of Molecular Genetics of the Czech Academy of Sciences, address: Videnska 1083, 142 20 Prague 4, Czech Republic.



Conference Program

Wednesday, 15th of May

15:00	Arrival, registration, accommodation	Location: Residence Emmy Hotel
19:00	Welcome Party	Location: Conference Venue
21:00	Steering Committee meeting	Location: Auditorium 0.195

Thursday, 16th of May

08:30	Opening session of ISSE 2024	Location: Milan Hasek Auditorium
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Welcome speech

Oliver Krammer and Karel Dusek

08:45	Oral session I chaired by: O. Krammer and K. Dusek	Location: Milan Hasek Auditorium
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KN01 **10 Golden Rules of Chip- Package- Board Interactions**

Evelyn Napetschnig (Infineon Technologies AG)

KN02 **Technological Status Quo for High-end RF Printed Circuit Board Development at**

Rohde&Schwarz

Franz Röhrli (Rohde&Schwarz)

D32 **Electrochemical Migration: Evaluating the Effect of Fe2O3 Nanoparticle Incorporation on the Reliability of SAC Alloys**

Ali Gharaibeh (Budapest University of Technology and Economics)

D53 **Assessing Impact of Creep and Random Vibration on BGA Solder Interconnects Through Finite Element Analysis (FEA)**

Sabuj Mallik (Buckinghamshire New University)

D102 **Adhesion measurements of polyimide to SixNy for semiconductor component applications**

Moritz Hartleb (KAI Kompetenzzentrum Automobil- und Industrieelektronik GmbH)

10:45 **Coffee break**

11:00	Oral session II chaired by: P. Mach and J. Nicolics	Location: Milan Hasek Auditorium
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KN03 **Chiplet Design and Heterogeneous Integration Packaging**

John H Lau (Unimicron Technology Corporation)

B37 **Thermal Diffusivity of a Multilayer Structure**

Corina Ruxandra Mitulescu (National University of Science and Technology Politehnica Bucharest)

C46 **Experimental Study of a Novel Printed Circuit Board Interconnection Technology**

Karamat Adavi (Huber Automotive AG)

12:30	Lunch	Location: Conference Venue
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13:30	Poster session I chaired by: R. Kisiel and H. Wohlrabe	Location: Milan Hasek Auditorium, Exhibition Hall
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D01 **Power Cycling Lifetime Improvement in Aluminum Wire Bonding Process**

Hyeon Min Jeong (Infineon)

D03 **How Different Cleaning Procedures Affect Reliability of Conductive Joints on E-Textiles**

Martin Hirman (University of West Bohemia)

D04 **Moisture Resistance Enhancing of E-Textiles**

Martin Hirman (University of West Bohemia)

Conference Program

D07	Electrochemical Migration Resistance of Gold Surface Finishes Marketa Klimtova (Czech Technical University in Prague)
D17	Development of Sensor Emulators for Testing the Safety Mechanisms of Sensor Interfaces in Automotive Electronics Nicolae Gross (University Politehnica of Bucharest)
D21	Analysis of Electronic Modules for Construction Machines and Development of a Reliability Test Method Max Häusler (Technical University of Dresden)
D23	Design of a Flat Coil Electrothermal Vaporization Device for Inductively Coupled Plasma Optical Emission Spectrometry Petr Vesely (Czech Technical University in Prague)
F12	3D Printed Circuit Boards from Recycled Plastics: Interconnection Properties Jakub Zdrahal (Czech Technical University in Prague)
F18	Hydrogen in Automotive: LCA Study Michael Fridrich (Czech Technical University in Prague)
F28	Towards Sustainable Electronics: Unveiling the Nexus of Circular Economy, Global Policies and Industry Impacts Andrea Benesova (University of West Bohemia)
F47	Soil Degradation of Sustainable PLA/Flax Substrates and Printed Circuit Board Assemblies Csaba Farkas (Budapest University of Technology and Economics)
F74	Biodegradable Comb Sensor Based on 3D Printed Conductive Polylactic Acid Peter Lukacs (Technical University of Kosice)
F92	Sustainability in Electronics - Testing Sensors with Polycarbonate Housing (PC) vs Poly Lactic Acid Housing (PLA) Ioan Szabo (University Politehnica of Bucharest)
F99	Increasing productivity in vapour phase soldering using stack-mode Gergo Havellant (Budapest University of Technology and Informatics)
F108	Sustainability Challenges: The Circular Economy Dilemma in Lithium-Ion Battery Cell Electrochemical Discharging Processes Anna Prazanova (Czech Technical University in Prague)
15:00	Coffee break
15:15	Oral session III chaired by: S. Stoyanov and E. Ceuca Location: Milan Hasek Auditorium
KN04	Soldering defects and their arduous solution in PCB assembly at Rohde & Schwarz Vaclav Wirth (Rohde&Schwarz)
E43	Distributed System Using Synthetic Data of Lithium-ion Battery Digital Twin for Battery Diagnosis Eliza M Olariu (Technical University of Cluj Napoca)
E95	Study of Thermal Loading of Ceramic Capacitors during Reflow Soldering Steffen Wiese (Saarland University)
E98	Knowledge Mining using Generative AI for Causal Discovery in Electronics Production Sven Meier (Friedrich-Alexander-University Erlangen-Nürnberg)
16:45	Coffee break
17:00	Poster session II chaired by: K. Nieweglowski and B. Mihailescu Location: Milan Hasek Auditorium, Exhibition Hall
A02	Towards Additively Manufactured Alumina Substrates for Printed Electronics Applications Martin Janda (University of West Bohemia)

A19	3D printing Conductive Pastes Based on Polystyrene/Graphite Composite Iva Kralova (Czech Technical University in Prague)
A22	Development and Application of a Wireless, in Body Data Acquisition System for Observation of Experimental Rabbit's Bone Healing Jonas Uricar (Czech Technical University in Prague)
A36	The Effect of Oxide Reduction Using Formic Acid Vapours on The Thickness of The Conductive Layer David Michal (University of West Bohemia)
A44	NTC Thermistor Ferrite Composite for Temperature Sensing with Reduced Humidity Influence Maria Nikolic (University of Belgrade)
A45	Effect of electro(less) plating on mechanical and geometric properties of polymer-metal structures based on 3D printed models Radek Tucek (Czech Technical University in Prague)
A48	Stretchability of Printed Conductive Structures for Thermoformable Structural Electronics Adam Urban (University of West Bohemia)
A49	Design of a Flat Coil Electrothermal Vaporization Device for Inductively Coupled Plasma Optical Emission Spectrometry Patarau Toma (Tehcnical University of Cluj Napoca)
A87	Printed Piezoelectric Harvester for Integration in a Wearable Energy Storage Device Mariya Aleksandrova (Technical University of Sofia)
A118	Thick-film CuNi-Ag and CuNi-Cu Thermocouples and Thermoelectric Microgenerators Andrzej Dzedzic (Wroclaw University of Science and Technology)
A119	Thick_Film Thermoelectric Structures Based on Ca3Co4O9-Ag and Ca2.7Bi0.3Co4O9-Ag Thermopiles Andrzej Dzedzic (Wroclaw University of Science and Technology)
H14	A Dual-Band Wilkinson Power Divider Using Compact Lowpass Filter with Wide Suppression Band Saeedeh Lotfi (University of West Bohemia)
H15	Design of a Quadrature Hybrid Coupler with Triple Tapered Resonators Saeedeh Lotfi (University of West Bohemia)
H16	Design of Ultra-wide Stopband Lowpass Filter based on Compact Microstrip Resonator Cells Saeedeh Lotfi (University of West Bohemia)
H85	Textile-Based Flexible Coaxial Cable Jan Handrejch (University of West Bohemia)
19:00	Dinner Location: Conference Venue

Friday, 17 th of May	
08:30	Oral session IV chaired by: A. Geczy and J. Morris Location: Milan Hasek Auditorium
KN05	Contrasting Reliable Systems – Automotives and Mobiles Nihal Sinnadurai (Advanced Technology Transfer Associates)
KN06	Component packages and their influence on the climatic reliability of assemblies Vladimir Sitko (PBT Works)
A58	Additively Printed Heating Structure for Radome De-icing Application Kok Siang Siah (Institute for Factory Automation and Production Systems at Friedrich-Alexander-Universität Erlangen-Nürnberg)
A71	Laser powder bed fusion of titanium alloyed copper powder for power electronic substrates Christoph Hecht (Friedrich-Alexander-Universität Erlangen-Nürnberg)
10:30	Coffee break

Conference Program

10:45	Poster session III chaired by: A. Dziedzic and M. Kisic	Location: Milan Hasek Auditorium, Exhibition Hall
I05	Development an Ultra-Low Power “Coin” Size Sensor Elitsa E Gieva (Technical University of Sofia)	
I26	Design and Implementation of an Electronic Encryption System based on PCA algorithm Petre Anghelescu (National University of Science and Technology Politehnica Bucharest)	
I29	Thermal Junction of NTC Chip Thermistors Milan Bodic (Faculty of Technical Sciences Novi Sad)	
I30	Differential thermal voltammetry for states-of-health (SOH) estimation of Li-ion batteries Miroslav Mikolasek (Slovak University of Technology)	
I31	Evaluation of semipermeable membranes for encapsulating gas sensors in human intestinal environments Felix Stadermann (Institute for electronics packaging - TU Dresden)	
I38	Realization of Cost-Effective Supercapacitors Utilising Substitutable Materials Irina Madalina Burcea (National University of Science and Technology Politehnica Bucharest)	
I40	Highly Elastic Textile Conductive Ribbons as Frequency Resonators for Wearable Strain Monitoring Michaela Radouchova (University of West Bohemia)	
I42	Modelling and Simulation of a Two-Stage Grid-Connected MPPT Inverter Patarau Toma (Tehcnical University of Cluj Napoca)	
I56	Evaluating the Performance of Measurements Systems Using Data Processing Methods Based on Kalman Filter Alexandru F Flutur (Technical University of Cluj-Napoca)	
I63	Multifunctional Inkjet-Printed Silver Structures for Wearable Biosensors Rade Tomov (Technical University of Sofia)	
I70	A TeraRanger One based LiDAR Pena D Madalina (1 Decembrie 1918 University Alba Iulia)	
I80	Design of navigation system with wireless connectivity Rosen Miletiev (Technical University of Sofia)	
I82	3-axis Accelerometer IMU in Various Degrees of Freedom Multi-switch Button Array Slavomir Kardos (Technical University of Kosice)	
I83	Nitrogen Dioxide Sensor based on Organic Electrochemical Transistor Josef Slauf (University of West Bohemia)	
I89	Noise Measurement System Based on Cross-Correlation Method Ana Cristina Davidas (Technical University of Cluj-Napoca)	
I96	Electronic Nose Based on AI-capable Sensor Module for Beverages Identification Attila Géczy (Budapest University of Technology and Informatics)	
I111	Stretchable Strain Sensor using Interdigitated Capacitor on Fabric Milica Kisic (University of Novi Sad)	
I112	Influence of Number of Turns on Common-Mode Choke’s Characteristics Mirjana Damnjanovic (University of Novi Sad)	
I122	Master-Slave BMS Architecture with CAN-bus for Inter-Cell Communication Lucian Perisoara (University Politehnica of Bucharest)	
12:30	Lunch	Location: Conference Venue
13:30	Oral session V chaired by: P. Lukacs and A. Tulbure	Location: Milan Hasek Auditorium
KN07	AI in production – Magic AOI Jakub Altman (Continental)	
A104	Flexible Frequency Selective Surfaces Olga Rac-Rumijowska (Wrocław University of Science and Technology)	
A113	Influences on the Mechanical Strength of Inkjet-Printed, Ag-Nanoparticle-Based Interconnects of Ni-Ag Finished Fine-Pitch Components Christian Voigt (Friedrich-Alexander-University Erlangen-Nürnberg)	
H10	Propagation Delay Analysis by Employing Various PCB Manufacturing Process Jae-Ho Choi (Samsung Electronics)	

16:00	Social program	
19:00	Dinner	Location: Strahov Monastery
21:00	Social program	

Saturday, 18 th of May		
09:00	Poster session IV chaired by: T. Blecha and F. Steiner	Location: Milan Hasek Auditorium, Exhibition Hall
D24	Development of Computationally Efficient Numerical Models for Assessing the Reliability of Electronic Components under Vibration Loads Chengzhe Lyu (Technical University of Dresden)	
D33	Effect of New Types of PCB Surface Finishes on Fractographic Morphology of Solder Joints Daniel Dzivy (Technical University of Kosice)	
D41	Effect of TiO₂ Nanoparticles Addition on the Electrochemical Migration of Lead-Free Sn-Bi Alloys Ali Dayoub (Budapest University of Technology and Economics)	
D50	Occurrence of Voids in Soldered Joints for Electrical Engineering Tomas Chvosta (Czech Technical University in Prague)	
D59	The Use of Scatter Plot Charts for the Study of Changes in the Electrical Parameters of Conductive Adhesive Joints Pavel Mach (Czech Technical University in Prague)	
D60	Effect of Post-Annealing on Electrical Parameters of Joints Formed from Conductive Adhesive Pavel Mach (Czech Technical University in Prague)	
D61	Influence of Reflow Temperature Profile on the Intermetallic Layers Thickness at Different Surface Finishes Karel Dusek (Czech Technical University in Prague)	
D64	Effect of Manufacturing Technology on Polymer Thick-film Resistors in 3D Printed Structures Igor Vehec (Technical University of Kosice)	
D66	Lithium-Ion Cell and Battery Testing by Spectral Analysis Krasimir Kishkin (Technical University of Sofia)	
D67	Effects of Thermal Cycling and PCB Substrate Type on Reliability of Solder Joints Daniel Fros (Czech Technical University in Prague)	
D68	Board Level Underfill - Moisture Related Voids Zbynek Plachy (Czech Technical University in Prague)	
D76	Electrical Properties' Stability of Flexible Carbon-Based Conductive Layers Peter Lukacs (Technical University of Kosice)	
D79	Utilization of microextraction-gas chromatography coupled to mass spectrometry for characterization of electrotechnology materials Dominik Pilnaj (Czech Technical University in Prague)	
D81	Stability of OhmegaPly Resistors with Different Shapes Tomas Lenger (Technical University of Kosice)	
D88	Analyzing the Impact of Surface Treatment on Solder Joint Voids Pavel Rous (University of West Bohemia)	
D94	The Use of Bending Experiments for the Efficient Characterization of the Mechanical Functionality of Component Interconnections Erik Wiss (Saarland University)	
D105	Variations in Open Circuit Voltage of Cycle-Aged Lithium-Ion Batteries due to Silicon-Enhanced Anodes Michele Galasso (Czech Technical University in Prague)	
D117	The set-up for Seebeck coefficient characterisation of film materials Piotr M Markowski (Wrocław University of Science and Technology)	
D123	An Expired Solder Paste vs Fresh Solder Paste: Reliability and Sustainability in Electronics Manufacturing David Busek (Czech Technical University in Prague)	

Conference Program

10:30	Coffee break	
10:45	Poster session V chaired by: E. Gieva and M. V. Nikolic	Location: Milan Hasek Auditorium, Exhibition Hall
E06	Intra-Day Optimal Dispatching of an Islanded Microgrid under Solar Power Uncertainty Nicolae A Sarbu (Technical University of Cluj-Napoca)	
E09	Modelling the Effect of Laser-Trimming on the Electrical Properties of Thick-film Resistors Oliver Krammer (Budapest University of Technology and Economics)	
E27	Active balancing of Li-ion battery cells using the DC2100B-C and DC2100B-D module Mirela Olteanu (Technical University of Cluj-Napoca)	
E39	Investigation of Sn grain growth in solder joints by numerical simulations István Bozsóki (Budapest University of Technology and Economics)	
E54	Reliability Meta-modelling of Power Components Stoyan Stoyanov (University of Greenwich)	
E57	Optimal Resource Scheduling for a Greenhouse Powered by an Islanded Microgrid Nicoleta Stroia (Technical University of Cluj-Napoca)	
E97	Modelling of Battery Management System based on Switching Capacitors Dimitar Arnaudov (Technical University of Sofia)	
E103	FCCSP Warpage Scope Evaluation for 5G Product with Advanced Wafer Node TzuChi Zeng (Siliconware Precision Industries)	
E107	State-of-Charge Estimation Based on Open-Circuit Voltage Model Considering Hysteresis Vaclav Knap (Czech Technical University in Prague)	
E116	Simulation of Electrochemical Heating in Li-Ion Batteries Jan Zemen (Czech Technical University in Prague)	
B55	A Simple and Cost-Efficient Method for Lithium-ion Battery Thermal Parameter Identification Faisal Rehman (Czech Technical University in Prague)	
C11	Low Temperature Adhesive Die Bonding for Sensitive MEMS Dies Lukas Lorenz (Fraunhofer Institute for Photonic Microsystems)	
C110	Silver Sintering Application in Packaging Al Metallized Chip onto Au Metallized Substrates Marcin Mysliwiec (Warsaw University of Technology)	
G25	Iron Nanoparticle-Doped Flux: Wetting Characteristics of Flux and SAC305 Solder and Effects on Flux Viscosity Irina Wodak (TU Wien)	
G73	TCAD model of GAA Nanowire Transistor with silicon oxide/nitride/oxide dielectric Rostislav Rusev (Technical University of Sofia)	
G75	Investigation of In-Situ Polymerization in Nanocomposites Alexandra Borok (Budapest University of Technology and Economics)	
G84	Detection of Nucleotides Using Gold Nanoprisms Immobilized on Glass Nora Tarpataki (Budapest University of Technology and Economics)	
G86	Modeling the Optical Response of a Periodic Nanoparticle Arrangement with the Finite Element Method Rebeka Kovacs (Budapest University of Technology and Economics)	
G121	Investigation of Polymer Nanocomposites Doped with Gold Nanorods and Alexa Fluor Indicator Molecules with Raman Spectroscopy Shereen Zangana (Budapest University of Technology and Economics)	
J90	Training Cost Analysis on a Large Computer Vision Ceramic Defect Detection Model Adrian V Tulbure ("1 Decembrie 1918" University of Alba Iulia)	
12:30	Lunch	Location: Conference Venue
13:30	Oral session VI chaired by: P. Markowski and D. Busek	Location: Milan Hasek Auditorium
I62	Portable Device for In-Situ Cyclic Voltammetry Measurements Mitar Simic (University of Novi Sad)	
F65	Unlocking Insights: A Systematic Survey of Material Composition in Lithium-Ion Battery Cells for Recycling Solutions Jan Koci (Czech Technical University in Prague)	

14:15	Closing ceremony - invitation to ISSE 2025	Location: Milan Hasek Auditorium
14:45	Social program	
18:00	Steering committee meeting	Location: Milan Hasek Auditorium
19:00	Awarding ceremony	Location: Conference Venue
19:30	Dinner	Location: Conference Venue
Sunday, 19th of May		
09:00	Farewell; End of conference	

Contents

Keynote presentations	9
KN1 Evelyn Napetschnig 10 Golden Rules of Chip- Package- Board Interactions	9
KN2 Franz Röhrli Technological Status Quo for High-end RF Printed Circuit Board Development at Rohde & Schwarz	10
KN3 John H. Lau Chiplet Design and Heterogeneous Integration Packaging	11
KN4 Vaclav Wirth Soldering defects and their arduous solution in PCB assembly at Rohde & Schwarz	12
KN5 Nihal Sinnaduraj Contrasting Reliable Systems – Automotives and Mobiles	13
KN6 Vladimir Sitko Component packages and their influence on the climatic reliability of assemblies	14
KN7 Jakub Altmann AI in production – Magic AOI	15
A - New Materials, Components and Processes	16
A2 Martin Janda, David Kalas, Karel Sima Towards Additively Manufactured Alumina Substrates for Printed Electronics Applications	16
A19 Iva Králová, Vasyľ Babets, Jonáš Uricár Analysis of Composite BiSn Solder Paste Doped by Titanium Dioxide Nanoparticles	18
A22 Jonáš Uricár, Dominik Pilnaj, Josef Sedláček 3D printing Conductive Pastes Based on Polystyrene/Graphite Composite	20
A36 David Michal, Jan Reboun The Effect of Oxide Reduction Using Formic Acid Vapours on The Thickness of The Conductive Layer	22
A44 Maria Vesna Nikolic, Zorka Z. Vasiljevic, Milena P. Dojcinovic NTC Thermistor Ferrite Composite for Temperature Sensing with Reduced Humidity Influence	24
A45 Radek Tucek, Lukáš Vojtech Effect of electro(less) plating on mechanical and geometric properties of polymer-metal structures based on 3D printed models	26

A48	Adam Urban, Silvan Pretl, Martin Janda Stretchability of Printed Conductive Structures for Thermoformable Structural Electronics	28
A49	Sergiu Cadar, Dorin Petreus, Toma Patarau Design of a Flat Coil Electrothermal Vaporization Device for Inductively Coupled Plasma Optical Emission Spectrometry	30
A58	Kok Siong Siah, Umang Bharatkumar Ramaiya, Felix Häußler, Hüseyin Erdogan, Jörg Franke Additively Printed Heating Structure for Radome De-icing Application	32
A71	Christoph Hecht, Mario Sprenger, Jörg Franke Laser powder bed fusion of titanium alloyed copper powder for power electronic substrates	34
A87	Rebeka Kovács, Attila Bonyár Printed Piezoelectric Harvester for Integration in a Wearable Energy Storage Device	36
A104	Olga Rac-Rumijowska, Piotr Pokryszka, Patrycja Suchorska-Wozniak, Katarzyna Kaczkowska, Iwona Karbownik, Tomasz Rybicki Flexible Frequency Selective Surfaces	38
A113	Christian Voigt, Johannes Dornheim, Alexander Muth, Nils Thielen, Jörg Franke Influences on the Mechanical Strength of Inkjet-Printed, Ag-Nanoparticle-Based Interconnects of Ni-Ag Finished Fine-Pitch Components	40
A118	Szymon Wójcik, Mirosław Gierczak, Kathrin Reinhardt, Andrzej Dziedzic Thick-film CuNi-Ag and CuNi-Cu thermocouples and Thermoelectric microgenerators	42
A119	Szymon Wójcik, Mirosław Gierczak, Nana Brguljan, Andrzej Dziedzic Thick-Film Thermoelectric Structures Based on Ca₃Co₄O₉-Ag and Ca_{2.7}Bi_{0.3}Co₄O₉-Ag Thermopiles	44
B - Thermal Management		46
B37	Corina Ruxandra Mitulescu, Mihai Branzei, Bogdan Mihailescu Thermal Diffusivity Determination of a Semiconductor Device	46
B55	Faisal Rehman, Dominika Dusíková, Jan Zemen A Simple and Cost-Efficient Method for Lithium-ion Battery Thermal Parameter Identification	48
C - Advanced Packaging and Interconnection Technologies		50
C11	Nithin Anujan Beena, Lukas Lorenz, Thomas Ludewig, Volker Bock Low Temperature Adhesive Die Bonding for Sensitive MEMS Dies .	50
C46	Karamat Adavi, Sebastian Quednau, Xaver Müller, Karsten Meier, Hanno Platz Experimental Study of a Novel Printed Circuit Board Interconnection Technology	52
C110	Marcin Mysliwiec, Krystian Pavlov, Ryszard Kisiel Silver Sintering Application in Packaging Al Metallized Chip onto Au Metallized Substrates	54
D - Testing, Reliability and Quality Management		56

D1	HyeonMin Jeong, KyoungMin Song, KilSu Lee, Dexter Inciong Reynoso, Rabie Djemour Power Cycling Lifetime Improvement in Aluminum Wire Bonding Process	56
D3	Martin Hirman, Jiri Navratil, Tomáš Blecha, Renata Nemcokova, Viera Glombikova, Frantisek Steiner How Different Cleaning Procedures Affect Reliability of Conductive Joints on E Textiles?	58
D4	Martin Hirman, Jiri Navratil, Tomáš Blecha, Renata Nemcokova, Viera Glombikova, Frantisek Steiner Moisture Resistance Enhancing of E-Textiles	60
D7	Markéta Klimtová, Petr Veselý, Iva Králová Electrochemical Migration Resistance of Gold Surface Finishes	62
D17	Nicolae Ioan Gross, Paul Svasta Development of Sensor Emulators for Testing the Safety Mechanisms of Sensor Interfaces in Automotive Electronics	64
D21	Max Häusler, Karsten Meier, Karlheinz Bock Analysis of Electronic Modules for Construction Machines and Development of a Reliability Test Method	66
D23	Petr Veselý, Jaroslav Šenkýr, Markéta Klimtová Electrochemical Migration: What Happens If You Pour Coke into Computer	68
D24	Chengzhe Lyu, Karsten Meier, Karlheinz Bock Development of Computationally Efficient Numerical Models for Assessing the Reliability of Electronic Components under Vibration Loads	70
D32	Ali Gharaibeh, Dániel Rigler, Bálint Medgyes Electrochemical Migration: Evaluating the Effect of Fe₂O₃ Nanoparticle Incorporation on the Reliability of SAC Alloys	72
D33	Daniel Dzivy, Alena Pietrikova, Peter Hornak Effect of New Types of PCB Surface Finishes on Fractographic Morphology of Solder Joints	74
D41	Ali Dayoub, Ali Gharaibeh, Patrik Tamási, Markéta Klimtová, Iva Králová, Karel Dušek, Bálint Medgyes Effect of TiO₂ Nanoparticles Addition on the Electrochemical Migration of Lead-Free Sn-Bi Alloys	76
D50	Tomáš Chvosta, Karel Dušek, Tomáš Gurcík Occurrence of Voids in Soldered Joints for Electrical Engineering	78
D53	Joshua Depiver, Sabuj Mallik, Emeka H. Amalu Assessing Impact of Creep and Random Vibration on BGA Solder Interconnects Through Finite Element Analysis (FEA)	80
D59	Pavel Mach, Ivana Pelikánová The Use of Scatter Plot Charts for the Study of Changes in the Electrical Parameters of Conductive Adhesive Joints	82
D60	Pavel Mach, Ivana Pelikánová, Jaroslav Rohlena Effect of Post-Annealing on Electrical Parameters of Joints Formed from Conductive Adhesive	84

D61	Karel Dušek, Petr Veselý, David Bušek, Iva Králová, Markéta Klimtová, Dominik Pilnaj, Jonáš Uricár, Zbynek Plachý, Kristina Sorokina, Jan Hintermüller, Ali Dayoub Influence of Reflow Temperature Profile on the Intermetallic Layers Thickness at Different Surface Finishes	86
D64	Igor Vehec, Peter Lukacs, Tomas Lenger, Lukas Garnek Effect of Manufacturing Technology on Polymer Thick-film Resistors in 3D Printed Structures	88
D66	Krasimir Y. Kishkin, Dimitar D. Arnaudov, Venelin Todorov Lithium-Ion Cell and Battery Testing by Spectral Analysis	90
D67	Denis Froš, Markéta Klimtová, Iva Králová Effects of Thermal Cycling and PCB Substrate Type on Reliability of Solder Joints	92
D68	Zbynek Plachý, Attila Géczy, Karel Dušek Board Level Underfill – Moisture Related Voids	94
D76	Peter Lukacs, Tomas Lenger, Igor Vehec Electrical Properties’ Stability of Flexible Carbon-Based Conductive Layers	96
D79	Dominik Pilnaj, Jonáš Uricár, Petr Veselý, Karel Dušek Utilization of microextraction-gas chromatography coupled to mass spectrometry for characterization of electrotechnology materials . . .	98
D81	Tomas Lenger, Alena Pietrikova, Peter Lukacs, Martin Jarkovsky Stability of OhmegaPly Resistors with Different Shapes	100
D88	Pavel Rous, František Steiner Analyzing the Impact of Surface Treatment on Solder Joint Voids . .	102
D94	Erik Wiss, Shiva Goud Anthati, Vlad Serea The use of bending experiments for the efficient characterization of the mechanical functionality of component interconnections	104
D102	Moritz Hartleb, Peter Imrich, Johannes Zechner, Golta Khatibi Adhesion measurements of polyimide to SixNy for semiconductor component applications	106
D105	Michele Galasso, Simon Schwunk, Václav Knap Variations in Open Circuit Voltage of Cycle-Aged Lithium-Ion Batteries due to Silicon-Enhanced Anodes	108
D117	Piotr Marek Markowski The set-up for Seebeck coefficient characterisation of film materials .	110
D123	David Busek, Jonáš Uricár An Expired Solder Paste vs Fresh Solder Paste: Reliability and Sustainability in Electronics Manufacturing	112
E	- Process Modelling and Simulation	114
E6	Nicolae Alexandru Sárbu, Dorin Petreus Intra-Day Optimal Dispatching of an Islanded Microgrid under Solar Power Uncertainty	114
E9	Oliver Krammer, Patrik Kovács Modelling the Effect of Laser-Trimming on the Electrical Properties of Thick-film Resistors	116

E27	Mirela Olteanu, Dorin Petreus, Ana-Maria Petri Active balancing of Li-ion battery cells using the DC2100B-C and DC2100B-D module	118
E39	István Bozsóki, Attila Géczy, Balázs Illés Investigation of Sn grain growth in solder joints by numerical simulations	120
E43	Eliza Maria Olariu, Adelina Ioana Ilies, Horia Hedesiu Distributed System Using Synthetic Data of Lithium-ion Battery Digital Twin for Battery Diagnosis	122
E54	Stoyan Stoyanov, Tim Tilford, Yaochun Shen Reliability Meta-modelling of Power Components	124
E57	Nicoleta Stroia, Daniel Moga, Dorin Petreus, Eniko Lazar, Alexandru Lodin Optimal resource scheduling for a greenhouse powered by an islanded microgrid	126
E95	Adam Yuile, Erik Wiss, David Barth Study of Thermal Loading of Ceramic Capacitors during Reflow Soldering	128
E97	Dimitar D. Arnaudov, Krasimir Y. Kishkin, George Angelov Modelling of Battery Management System based on Switching Capacitors	130
E98	Sven Meier, Florian Töper, Jonas Gebele, Nils Thielen, Steffen Klarmann, Jörg Franke Knowledge Mining using Generative AI for Causal Discovery in Electronics Production	132
E103	Tzu-Chi Zeng, Vito Lin, Teny Shih FCCSP Warpage Scope Evaluation for 5G Product with Advanced Wafer Node	134
E107	Václav Knap, Anna Pražanová, Jan Kasper, Pavel Hrzina State-of-Charge Estimation Based on Open-Circuit Voltage Model Considering Hysteresis	136
E116	Dominika Dusíková, Jan Zemen Simulation of Electrochemical Heating in Li-Ion Batteries	138
F	- Environmental and Ecological Effects in Electronics Technology	140
F12	Jakub Zdráhal, Markéta Klimtová, Iva Králová 3D Printed Circuit Boards from Recycled Plastics: Interconnection Properties	140
F18	Michael Fridrich, Anna Pražanová, Václav Knap Hydrogen in Automotive: LCA Study	142
F28	Andrea Benešová, Martin Hirman, František Steiner Towards Sustainable Electronics: Unveiling the Nexus of Circular Economy, Global Policies and Industry Impacts	144
F47	Csaba Farkas, András Csiszár, László Gál, Attila Géczy Soil Degradation of Sustainable PLA/Flax Substrates and Printed Circuit Board Assemblies	146
F65	Jan Kocí, Anna Pražanová, Václav Knap Unlocking Insights: A Systematic Survey of Material Composition in Lithium-Ion Battery Cells for Recycling Solutions	148

F74	Peter Lukacs, Tomas Lenger, Igor Vehec Biodegradable Comb Sensor Based on 3D Printed Conductive Polylactic Acid	150
F92	Ioan Szabo, Andrei Tulbure, Cristian Farcas Sustainability in Electronics - Testing Sensors with Polycarbonate Housing (PC) vs Poly Lactic Acid Housing (PLA)	152
F99	Gergo Havellant, Attila Géczy Increasing productivity in vapour phase soldering using stack-mode	154
F108	Anna Pražanová, Zbynek Plachý, Jonáš Uricár, Václav Knap Sustainability Challenges: The Circular Economy Dilemma in Lithium-Ion Battery Cell Electrochemical Discharging Processes . .	156
G - Nanotechnology, Nanomaterials and Nanoelectronics		158
G25	Irina Wodak, Golta Khatibi, Andriy Yakymovych, Attila Géczy Iron Nanoparticle-Doped Flux: Wetting Characteristics of Flux and SAC305 Solder and Effects on Flux Viscosity	158
G73	Rostislav Rusev, Ivelina Ruskova, George Angelov, Elitsa Gieva, Rossen Radonov, Dorian Minkov TCAD model of GAA Nanowire Transistor with silicon oxide/nitride/oxide dielectric	160
G75	Alexandra Borók, Attila Bonyár Investigation of In-Situ Polymerization in Nanocomposites	162
G84	Nóra Tarpataki, Alexandra Borók, Attila Bonyár Detection of Nucleotides Using Gold Nanoprisms Immobilized on Glass	164
G86	Rebeka Kovács, Attila Bonyár Modeling the Optical Response of a Periodic Nanoparticle Arrangement with the Finite Element Method	166
G121	Shireen Zangana, Melinda Szalóki, Miklós Veres Investigation of Polymer Nanocomposites Doped with Gold Nanorods and Alexa Fluor Indicator Molecules with Raman Spectroscopy . . .	168
H - Signal Integrity and Electromagnetic Compatibility		170
H10	Jae-Ho Choi, Dong-Yoon Seo, Se-Woong Choi, Do-Hyung Kim, Jeong-hyeon Cho, Ji-Won Kim, Lee Won-Seop Propagation Delay Analysis by Employing Various PCB Manufacturing Process	170
H14	Saeedeh Lotfi, Golshan Mohamadpour, Tomáš Blecha A Dual-Band Wilkinson Power Divider Using Compact Lowpass Filter with Wide Suppression Band	172
H15	Saeedeh Lotfi, Golshan Mohamadpour, Tomáš Blecha Design of a Quadrature Hybrid Coupler with Triple Tapered Resonators	174
H16	Sobhan Roshani, Saeed Roshani, Saeedeh Lotfi, Martin Janda Design of Ultra-wide Stopband Lowpass Filter based on Compact Microstrip Resonator Cells	176
H85	Jan Handrejch, Tomáš Blecha Textile-Based Flexible Coaxial Cable	178

I - Sensors, Actuators and Microsystems	180
15 Stoyan G. Bogdanov, Nina R. Bogdanova, Elitsa Gieva Development an Ultra-Low Power “Coin” Size Sensor	180
126 Petre Anghelescu Design and Implementation of an Electronic Encryption System based on PCA algorithm	182
129 Milan Z. Bodic, Stanko O. Aleksic, Vladimir M. Rajs, Milica G. Kisic Thermal Junction of NTC Chip Thermistors	184
130 Miroslav Mikolasek, Martin Kemeny, Martin Brazda, Erik Baga, Jakub Gavenda, Lukas Gardian, Matej Novak Differential thermal voltammetry for states-of-health (SOH) estimation of Li-ion batteries	186
131 Felix Stadermann, Victoria Constance Köst, Krzysztof Niewegłowski, Karlheinz Bock Evaluation of semipermeable membranes for encapsulating gas sensors in human intestinal environments	188
138 Irina Madalina Burcea, Rodica Cristina Negroiu, Bogdan Mihailescu, Madalin Vasile Moise, Ciprian Ionescu Realization of Cost-Effective Supercapacitors Utilising Substitutable Materials	190
140 Michaela Radouchova, Tomáš Blecha Highly Elastic Textile Conductive Ribbons as Frequency Resonators for Wearable Strain Monitoring	192
142 Dorin Petreus, Toma Patarau, Petre Dorel Teodosescu Modelling and Simulation of a Two-Stage Grid-Connected MPPT Inverter	194
156 Alexandru-Florin Flutur, Septimiu Sever Pop, Vlad Bande Evaluating the Performance of Measurements Systems Using Data Processing Methods Based on Kalman Filter	196
162 Mitar Simic Portable Device for In-Situ Cyclic Voltammetry Measurements . . .	198
163 Rade Tomov, Mariya Aleksandrova, Georgi Nikolov, Ivo Iliev Multifunctional Inkjet-Printed Silver Structures for Wearable Biosensors	200
170 Madalina Pena, Gombos Andreea, Emilian Ceuca A TeraRanger One based LiDAR	202
180 Rosen Miletiev, Rumen Yordanov, Emil Iontchev Design of navigation system with wireless connectivity	204
182 Slavomir Kardos, Igor Vehec 3-axis Accelerometer IMU in Various Degrees of Freedom Multi-switch Button Array	206
183 Josef Slauf, Jan Reboun Nitrogen Dioxide Sensor based on Organic Electrochemical Transistor 208	208
189 Ana Cristina Davidas, Ovidiu A. Pop, Liviu Viman, Traian Petrisor Jr. Noise Measurement System Based on Cross-Correlation Method . .	210
196 Barbara Molnár, Attila Géczy Electronic Nose Based on AI-capable Sensor Module for Beverages Identification	212

NTC Thermistor Ferrite Composite for Temperature Sensing with Reduced Humidity Influence

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Summary: Negative temperature coefficient (NTC) thermistor semiconducting oxides, such as ferrites used as resistance-based temperature sensors, remain in research focus, as they are basic building blocks of many electronic systems. In this work we have investigated NTC thermistor properties of a ferrite composite ($\text{MnFe}_2\text{O}_4/\text{Fe}_2\text{O}_3$) ceramics obtained by solid-state sintering in the form of a bulk sample with a diameter of 8.7 mm and thickness of 1.8 mm. We obtained a thermal (material) constant ($B_{10,90}$) of 4390 K from measured impedance at 100 Hz in the temperature range 10 - 90 °C and temperature sensitivity (α) of -4.87 %/K at 25 °C, that was within the range required for a commercial NTC thermistor material (B between 2000 and 5000, α between -2 and 6% K at room temperature -25 °C). The influence of relative humidity (RH) in the range 30-90% at 25 and 50 °C on impedance in the frequency range 50 Hz – 1 MHz was monitored. The obtained results showed that at 100 Hz the change in impedance was from 8.15 to 3.56 M Ω at 25 °C and 2.81 to 1.65 M Ω for RH from 30 to 90%, indicating that the humidity influence was reduced compared to other NTC thermistor materials. Future work will focus on applying this ferrite composite in flexible printed temperature sensors.

Keywords: Temperature sensing, NTC thermistor, ferrite composite, humidity.

Motivation

Temperature sensors used for measuring temperature changes are an essential component in most industries and in everyday life. They are used to monitor temperature in different industrial machinery, the working environment, domestic appliances, medical applications and many others. Negative temperature coefficient (NTC) thermistors remain a good solution for detecting small temperature changes and they are widely applied as temperature sensors in a wide range of electronic system [1]. The operating principle of a NTC thermistor semiconducting material is that its resistivity decreases with increase in temperature. Semiconducting metal oxides including ferrites remain in focus as potential NTC thermistor materials in the field of printed sensors, and have potential for application in flexible temperature sensors [2, 3]. Humidity has significant influence on sensor performance, including NTC thermistors, as increased humidity commonly leads to decrease in resistivity resulting in lower sensor sensitivity. Development of sensing materials that are insensitive to humidity or this influence is small can be of considerable significance. The basic characteristic parameters of a NTC thermistor material are the material constant (B in Kelvin) and temperature sensitivity at room temperature (commonly 25 °C). The material (thermistor) constant (B) in a certain temperature interval is determined from the Arrhenius equation that is generally used to model the resistance decrease with temperature growth [4]. Commercial thermistors generally have a B value between 2000 and 5000 and sensitivity between -2 and -6 %/K.

Results

Fig. 1 shows the measured change in impedance in the temperature range 10 – 90 °C, frequency 50Hz – 1 MHz, calculation of the material constant at 100 Hz, and the influence of change in relative humidity on change in impedance at 25 and 50 °C at 100 Hz.

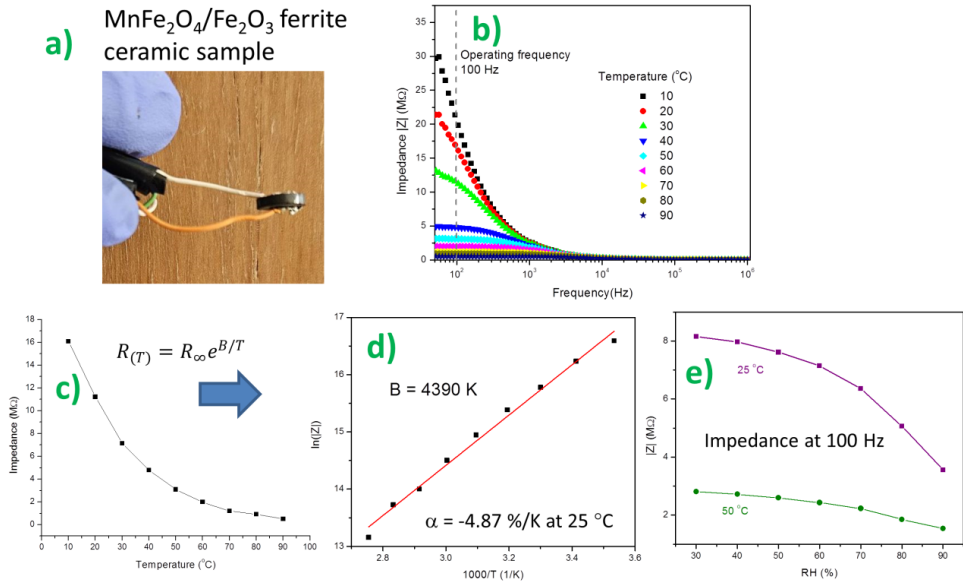


Fig. 1: MnFe₂O₄/Fe₂O₃ ceramic sample (a) change in impedance with frequency and temperature (b), dependence of impedance at 100 Hz on change in temperature (c), linear fit using the Arrhenius equation (d) and change in relative humidity (RH) measured at 25 and 50 °C (e).

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Author Index

A

Adavi, Karamat 52
Aleksandrova, Mariya 200
Aleksic, Stanko O. 184
Aleksic, Stanko 216
Altmann, Jakob 15
Amalu, Emeka H. 80
Andreea, Gombo? 202
Angelov, George 130, 160
Anghelescu, Petre 182
Anthati, Shiva Goud 104
Arnaudov, Dimitar D. 90, 130

B

Babets, Vasyl 18
Bacîs, Irina Bristena 218
Baga, Erik 186
Bande, Vlad 196
Barth, David 128
Beena, Nithin Anujan 50
Benešová, Andrea 144
Blecha, Tomáš 58, 60, 172, 174, 178, 192
Bock, Karlheinz 66, 70, 188
Bock, Volker 50
Bodic, Milan Z. 184
Bogdanov, Stoyan G. 180
Bogdanova, Nina R. 180
Bonyár, Attila 36, 162, 164, 166
Borók, Alexandra 162, 164
Bozsóki, István 120
Branzei, Mihai 46
Brazda, Martin 186
Brguljan, Nana 44
Burcea, Irina Madalina 190
Bušek, David 86, 112

C

Cadar, Sergiu 30

Ceuca, Emilian 202
Cho, Jeong-hyeon 170
Choi, Jae-Ho 170
Choi, Se-Woong 170
Chvosta, Tomáš 78

C

Citakovic, Vladimir 214

C

Csiszár, András 146

D

Damnjanovic, Mirjana 214, 216
Davidas, Ana Cristina 210
Dayoub, Ali 76, 86
Depiver, Joshua 80
Djemour, Rabie 56
Dojcinovic, Milena P. 24
Dornheim, Johannes 40
Dulf, Eva 220
Dušek, Karel 76, 78, 86, 94, 98
Dusíková, Dominika 48, 138
Dziedzic, Andrzej 42, 44
Dzivy, Daniel 74

E

Erdogan, Hüseyin 32

F

Farcas, Cristian 152
Farkas, Csaba 146
Flutur, Alexandru-Florin 196
Franke, Jörg 32, 34, 40, 132
Fridrich, Michael 142
Froš, Denis 92

G

Gál, László 146
Galasso, Michele 108

Gardian, Lukas 186
 Garnek, Lukas 88
 Gavenda, Jakub 186
 Gebele, Jonas 132
 Géczy, Attila 94, 120, 146, 154, 158, 212
 Gharaibeh, Ali 72, 76
 Gierczak, Mirosław 42, 44
 Gieva, Elitsa 160, 180
 Glombikova, Viera 58, 60
 Gross, Nicolae Ioan 64
 Gurčík, Tomáš 78

H

Handrejch, Jan 178
 Hartleb, Moritz 106
 Häusler, Max 66
 Häußler, Felix 32
 Havellant, Gergo 154
 Hecht, Christoph 34
 Hedesiú, Horia 122
 Hintermüller, Jan 86
 Hirman, Martin 58, 60, 144
 Hornak, Peter 74
 Hrzina, Pavel 136

I

Ilies, Adelina Ioana 122
 Iliev, Ivo 200
 Illés, Balázs 120
 Imrich, Peter 106
 Ionescu, Ciprian 190
 Iontchev, Emil 204

J

Janda, Martin 16, 28, 176
 Jarkovsky, Martin 100
 Jeong, HyeonMin 56

K

Kaczkowska, Katarzyna 38
 Kalas, David 16
 Karbownik, Iwona 38
 Kardos, Slavomir 206
 Kasper, Jan 136
 Katanic, Mirosław 214
 Kemeny, Martin 186
 Khatibi, Golta 106, 158
 Kim, Do-Hyung 170
 Kim, Ji-Won 170

Kishkin, Krasimir Y. 90, 130
 Kisic, Milica G. 184
 Kisic, Milica 214, 216
 Kisiel, Ryszard 54
 Klarmann, Steffen 132
 Klimtová, Markéta ... 62, 68, 76, 86, 92,
 140
 Knap, Václav ... 108, 136, 142, 148, 156
 Kocí, Jan 148
 Köst, Victoria Constance 188
 Kovács, Patrik 116
 Kovács, Rebeka 36, 166
 Králov, Iva 92
 Králová, Iva 18, 62, 76, 86, 140
 Krammer, Oliver 116

L

Lau, John H. 11
 Lazar, Eniko 126
 Lee, KilSu 56
 Lenger, Tomas 88, 96, 100, 150
 Lin, Vito 134
 Lodin, Alexandru 126
 Lorenz, Lukas 50
 Lotfi, Saeedeh 172, 174, 176
 Ludewig, Thomas 50
 Lukacs, Peter 88, 96, 100, 150
 Lyu, Chengzhe 70

M

Mach, Pavel 82, 84
 Mallik, Sabuj 80
 Markowski, Piotr Marek 110
 Medgyes, Bálint 72, 76
 Meier, Karsten 52, 66, 70
 Meier, Sven 132
 Michal, David 22
 Mihailescu, Bogdan 46, 190
 Mikolasek, Mirosław 186
 Miletiev, Rosen 204
 Milutinov, Miodrag 216
 Minkov, Dorian 160
 Mitulescu, Corina Ruxandra 46
 Moga, Daniel 126
 Mohamadpour, Golshan 172, 174
 Moise, Madalin Vasile 190
 Molnár, Barbara 212
 Müller, Xaver 52
 Muth, Alexander 40

Mysliwiec, Marcin 54

N

Napetschnig, Evelyn 9
Navratil, Jiri 58, 60
Negroiu, Rodica Cristina 190
Nemcokova, Renata 58, 60
Nieweglowski, Krzysztof 188
Nikolic, Maria Vesna 24
Nikolov, Georgi 200
Novak, Matej 186

O

Olariu, Eliza Maria 122
Olteanu, Mirela 118

P

Pantelic, Dragica 214
Patarau, Toma 30, 194
Pavlov, Krystian 54
Pelikánová, Ivana 82, 84
Pena, Madalina 202
Perisoara, Lucian Andrei 218
Petreus, Dorin 30, 114, 118, 126, 194
Petri, Ana-Maria 118
Petrisor Jr., Traian 210
Pietrikova, Alena 74, 100
Pilnaj, Dominik 20, 86, 98
Plachý, Zbynek 86, 94, 156
Platz, Hanno 52
Pokryszka, Piotr 38
Pop, Ovidiu A. 210
Pop, Septimiu Sever 196
Pražanová, Anna 136, 142, 148, 156
Pretl, Silvan 28

Q

Quednau, Sebastian 52

R

Rac-Rumijowska, Olga 38
Radonov, Rossen 160
Radouchova, Michaela 192
Rajs, Vladimir M. 184
Ramaiya, Umang Bharatkumar 32
Reboun, Jan 22, 208
Rehman, Faisal 48
Reinhardt, Kathrin 42
Reynoso, Dexter Inciong 56

Rigler, Dániel 72
Rohlena, Jaroslav 84
Röhrl, Franz 10
Roshani, Saeed 176
Roshani, Sobhan 176
Rous, Pavel 102
Rusev, Rostislav 160
Ruskova, Ivelina 160
Rybicki, Tomasz 38

S

Sacaleanu, Dragos Ioan 218
Sârbu, Nicolae Alexandru 114
Schwunk, Simon 108
Sedláček, Josef 20
Šenkýr, Jaroslav 68
Seo, Dong-Yoon 170
Serea, Vlad 104
Shen, Yaochun 124
Shih, Teny 134
Siah, Kok Siong 32
Sima, Karel 16
Simic, Mitar 198
Sinnaduraj, Nihal 13
Sitko, Vladimir 14
Slauf, Josef 208
Song, KyoungMin 56
Šormaz, Nikola 214
Sorokina, Kristina 86
Sprenger, Mario 34
Stadermann, Felix 188
Steiner, František 102, 144
Steiner, Frantisek 58, 60
Stoyanov, Stoyan 124
Stroia, Nicoleta 126
Suchorska-Wozniak, Patrycja 38
Svasta, Paul 64
Szabo, Ioan 152, 220
Szalóki, Melinda 168

T

Tamási, Patrik 76
Tarpataki, Nóra 164
Teodosescu, Petre Dorel 194
Thielen, Nils 40, 132
Tilford, Tim 124
Todorov, Venelin 90
Tomov, Rade 200
Töper, Florian 132

Tucek, Radek 26
Tulbure, Adrian 220
Tulbure, Andrei 152, 220

U

Urban, Adam 28
Uricár, Jonáš... 18, 20, 86, 98, 112, 156

V

Vasiljevic, Zorka Z. 24
Vehec, Igor 88, 96, 150, 206
Veres, Miklós 168
Veselý, Petr 62, 68, 86, 98
Viman, Liviu 210
Voigt, Christian 40
Vojtech, Lukáš 26

W

Wirth, Vaclav 12
Wiss, Erik 104, 128
Wodak, Irina 158
Wójcik, Szymon 42, 44
Won-Seop, Lee 170

Y

Yakymovych, Andriy 158
Yordanov, Rumen 204
Yuile, Adam 128

Z

Zangana, Shireen 168
Zdráhal, Jakub 140
Zechner, Johannes 106
Zemen, Jan 48, 138
Zeng, Tzu-Chi 134



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