PHYSICAL AND TECHNOLOGICAL SCIENCES

# Laboratory of Nanoionics

Vilnius University

***Keywords:*** *solid state ionics, solid electrolytes, impedance spectroscopy, ionic transport, ceramics, pulsed laser deposition, nanoionics*

## Research group activities

The group investigates solid state ionic materials by impedance spectroscopy. The experiments can be performed in ultrabroad frequency range of 1 Hz up to 10 GHz and high temperatures up to 1000 °C. Complex conductivity, impedance, dielectric permittivity and electrical modulus are important parameters for solid state ionic devices such as SOFCs, batteries, memristors and sensors. The processing of the ionic materials is done in the laboratory, which involves sintering of ceramics, thick film formation and thin film growth.

The main ideas in light of applications are:

- The development of solid oxide fuel cells (SOFC) working in the intermediate temperature range of 500-800 °C. It can be achieved by finding new materials for SOFC electrodes and producing thinner ion conducting membrane.
- Elaboration of oxygen conducting thin films for gas sensor application.
- Development of all solid state battery with large area electrodes.
- Understanding resistive switching in thin solid electrolyte films.

## Proposal

We offer our experience and services in:

- Investigation of electrical properties of solid electrolytes by:
  - Two electrode method in the frequency range of (100 mHz – 10 GHz) and temperature interval from room temperature to 1200 K.
  - Four electrode method in the frequency range of (100 mHz – 2 MHz) and temperature interval from room temperature to 800 K.
- Processing of ceramics and thin film growth by pulsed laser deposition (PLD) method.
- Development of advances impedance spectroscopy techniques.

The group is seeking for collaboration with chemists and engineers to develop new solid electrolyte materials, to investigate ionic transport phenomena in solids, develop devices based on solid electrolytes.

We seek partners for developing competitive research projects targeting HORIZON 2020 and other international programs.

## Meet our team

Leader of the group - Assoc. Prof. Dr. **Tomas Šalkus.**

Researchers - Prof. Habil. Dr. Emeritus **Antanas Feliksas Orliukas**, Prof. Dr. **Algimantas Kežionis**, Assoc. Prof. Dr. **Edvardas Kazakevičius**, Dr. **Vilma Venckutė**, Dr. **Saulius Kazlauskas**.

PhD students - **Saulius Daugėla, Dalius Petrulionis.**

## Research outcomes

The unique experimental possibilities led to more than 200 scientific publications in high impact journals, such as Solid State Ionics, Electrochimica Acta, Journal of Physics: Condensed Matter, The Journal of Physical Chemistry and other.

### Most important projects:

Supported by “Motorolla “Superionic accumulator”, project leader Prof. A.F. Orliukas.

National projects: “Oxygen gas sensors”, “Investigation of lithium-ion conducting ceramics and their application for CO2 gas sensor” “Fabrication and characterization of ceramics with fast oxygen ionic transport and their application in fuel cells”, projects leader Prof. A.F. Orliukas.

European project “Nanostructured lithium conducting materials”, executed on the basis of International Research Staff Exchange Scheme, Marie Curie Actions.

Lithuanian-Swiss cooperation programme “Broadband impedance study of memristor oxide films“, project leader T. Salkus.

### Selected scientific publications:

- **A. Kežionis, S. Kazlauskas, D. Petrulionis, A.F. Orliukas,** „Broadband method for the determination of small sample’s electrical and dielectric properties at high temperatures“, IEEE Trans. Microwave Theory and Techniques 62(10), 2456 (2014).
- **A. Kežionis, E. Kazakevičius, T. Šalkus, A. Orliukas,** „Broadband high frequency impedance spectrometer with working temperatures up to 1200 K“, Solid State Ionics 188, 110 (2011).
- **A. Kežionis, P. Butvilas, T. Šalkus, S. Kazlauskas, D. Petrulionis, T. Žukauskas, E. Kazakevičius, A.F. Orliukas,** „Four-electrode impedance spectrometer for investigation of solid ion conductors“, Rev. Scientific Instruments 84, 013902 (2013).

## Resources

Four impedance spectrometers have been developed in the Laboratory of Solid State Ionics. The custom construction of the coaxial lines allow us to investigate complex electrical parameters of ionic conductors by two electrode method at high frequencies (up to 10 GHz) and high temperatures (up to 1000 °C). Samples can also be investigated by four electrode method, which is important to deeper understand the processes taking place in the bulk of materials. The obtained high precision data can be processed by applying distribution of relaxation times methodology. The software for data analysis was also developed in the laboratory.

The laboratory runs pulsed laser deposition (PLD) system for thin film growth. Ceramic and thick film processing by tape casting technique can also be done.

## Contacts

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