PHYSICAL AND TECHNOLOGICAL SCIENCES

Noise research and terahertz electronics laboratory

Vilnius University

Keywords: charge carrier transport, fluctuation phenomena, low-noise electronics, reliability of semiconductor devices, terahertz detectors and sources, THz imaging, noise spectroscopy

Research group activities

The depth of understanding of underlying charge transport mechanisms in novel electronic devices strongly relates to the success in their further development. Important information comes from the study of charge carrier fluctuations. For example, the defectiveness of semiconductor might give a rise to the excess fluctuations in the low frequency range. Therefore, a thorough examination of fluctuations delivers information on peculiarities in charge transport. Noise study allows evaluating many important parameters such like device sensitivity, response speed, stability or the quality of the device, determines expected lifetime, etc.

In particular, our research group has experience and focus efforts on the development of novel device concepts dedicated to the terahertz (THz) frequency range. In a last few decades, terahertz physics and technology has experienced a tremendous growth, as it found the potential applications in such fields as space research, security, drugs control, medical and biological imaging, quality control, etc. Much part of this growth owes to the successful development of novel methods of THz generation and detection, for which the study of electric noise is of high importance.

Main direction of our research:

- Charge carrier transport and device modelling for field-effect transistor-based terahertz detectors fabricated with Si CMOS and AlGaN/GaN HEMT fabrication technologies;
- Fast terahertz receivers for point-to-point communications;
- Development of high-speed terahertz imaging arrays and systems for hyperspectral imaging;
- Semiconductor superlattice-based terahertz generation;
- Sensitivity evaluations for different kind terahertz detectors incl. Si CMOS FETs, AlGaN/GaN HEMTs, monolayer graphene FETs, “bow-tie” diodes;
- Noise spectroscopy of novel multiferoic materials (e.g. with carbon nano particles);
- Noise measurement-based transport and reliability studies of (2–3) μm GaSb laser diodes;

Ideas that are under consideration for future focus:

- Development of terahertz detector arrays;
- Applications of terahertz imaging and spectroscopy;
- Semiconductor lasers for infrared frequency range, their design and development;
- Receivers for THz communication systems.

Proposal

The laboratory performs low-noise measurements, noise spectroscopy and characterizations for various electronic devices and materials.

Sensitivity estimations of THz detectors and receivers, evaluation of power for THz sources.

Open access noise research laboratory offers access for investigations of noise and electrical characteristics of semiconductor devices up to 50 GHz.

Meet our team

Leader researcher: Prof. Dr. **Jonas Matukas**

Research staff: Prof. **Alvydas Lisauskas**, Dr. **Sandra Pralgauskaitė**, Dr. **Juozas Vyšniauskas**.

PhD students: **Justinas Glemža, Kęstutis Ikamas, Marina Tretjak.**

Research outcomes

Recent projects performed by the research team:

- EU funded 2012 – 2015 project "Synthesis and Characterization of New Materials for Semiconductor- and Nano-Technologies by Means of Continuous and Ultrafast Spectroscopic Methods".
- 2013 - 2015: project of Operational programme for human resources development for 2001-2013 Priority 3 „Strengthening Capacities of Researchers" VP1-3.1-ŠMM-07-K „Support to Research Activities of Scientists and Other Researcher (Global Grant)": Rectification by plasma waves in 2D electron gas and its application for terahertz detection".
- 2015-2016: A cooperation with ENS, Paris on the topic "Fast planar THz detectors" supported by a bilateral Lithuanian-French programme (Gilibert).
- 2016-2018: project "Compact integrated THz components and spectroscopic THz imaging systems" funded by the Lithuanian national program "Towards future technologies".
- 2017-2019: project with European Space Agency "Directive transistor-based THz detectors (THzFET)".

Selected publications:

- **Lisauskas, S. Boppel, J. Matukas** et al., „Terahertz responsivity and low-frequency noise in biased silicon field-effect transistors", Appl. Phys. Lett., 102(15), p. 153505(4), 2013.
- **Zak, M. Bauer, J. Matukas** et al., "Antenna-Integrated 0.6 THz FET Direct Detectors Based on CVD Graphene," Nano Lett., 14(10), pp. 5834-5838, 2014.
- **S. Pralgauskaitė, V. Palenskis, J. Matukas** et al., "Reliability investigation of light emitting diodes via low frequency noise characteristics", Microelectron Reliab, 55(1), pp. 52-61, 2015.
- **S. Boppel, M. Ragauskas**, A. Hajo et al., "0.25-um GaN TeraFETs Optimized as THz Power Detectors and Intensity-Gradient Sensors," IEEE Trans. Terahertz Science Technol., 6(2), pp. 348–350, 2016.
- **S. Pralgauskaite, J. Matukas, M. Tretjak** et al., "Resistivity and low-frequency noise characteristics of epoxy-carbon composites", J. Appl. Phys., 121, p. 114303(6), 2017.

Resources

Shielded rooms (Faraday cages) allowing to avoid interfering effects from electrical network and communication systems are specially prepared for the noise (low signal) measurements. The group possesses state of the art low noise amplifiers, analogue to digital converters and various equipment for semiconductor device characterizations such like electrical spectrum analyzer FSU-26 (20 Hz – 26,5 GHz), analyzer of electrical characteristics B1500A etc. For optical measurements the group employs optical spectrum analyzers Q8341 and Q8384 (350-1700 nm), and frequency multiplier chains for measurements from 77 GHz to 750 GHz, supported with various power detectors for corresponding spectral ranges.

Contacts

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