PHYSICAL AND TECHNOLOGICAL SCIENCES

Nitride epitaxial technology and device research group

Keywords: *GaN, InGaN, AlGaN, nitrides, epitaxy, layer, quantum well, surface functionalization, photonics, hybrid structures, device*

Vilnius University

Research group activities

White LEDs come to the forefront in general lighting. Plenty of new application niches have emerged for the white monolithic LEDs, important ones are the control and therapeutics devices in medicine, LED automotive lighting and adaptive driving beam technology.

On-chip optical circuits start to overtake communication, sensing and quantum technology markets. The outcome of this optical circuit is an enhanced integration level of the devices. The gallium nitride photonic crystal resonators already demonstrate excellent performance in submicro- and nanooptics. 2D photonic crystal resonators, photonic membranes-bridges, microdiscs, optical buffers are the few of the high potential elements for the on-chip optical circuits. We advance to develop GaN photonic devices for sensor, non-linear optics, quantum technology applications, including optical circuits.

Nanostructures – quantum dots, nanowires, nanosheets – feature almost defect free inside crystalline structure, prerequisite for best optical and electrical properties. GaN nanostructures demonstrate good perspectives to be applied in piezoelectronics, piezophototronics, plasmonics. Nanowire LED-based pressure sensor array mapping of the 2D distributions of strain have already been demonstrated, what provided a major step towards the digital imaging of mechanical signals by optical means, with potential applications in the artificial skin, touchpad technology, personalized signatures, bio-imaging and optical MEMS. Another excellent example, the heterostructure engineered GaN-based nanobelts – highly desirable for fabricating nanogenerators and piezotronic devices with high-output and stable performance. We put forward the development of the GaN nanostructures (nanodots, nanoneedles) technology with a focus on various applications in biosciences (selection, killing and labeling of the molecules, etc.).

Research and technology:

- Epitaxy of III-group nitrides with varying complexity of alloys (GaN, InN, AlN, BN, InGaN, AlGaN, BGaN, InAlN) (detectors, sensors).
- Heteroepitaxy on sapphire, silicon, silicon carbide, rear earth oxides.
- Homo-epitaxy on GaN and AlN wafers or templates.
- Growth of InGaN/GaN, AlGaN/GaN quantum structure devices (LEDs, HEMT).
- Growth and investigation of semipolar and non-polar GaN.
- Surface functionalization: organics on GaN. Development of hybrid interfaces (gas, liquid sensor).

Our research is focused in these directions:

- Development of GaN LEDs, detectors, gas sensors for niche applications – from modeling to prototype production.
- Lab-on-chip technology. GaN photonic device development and application in ICT and metrology.
- Growth and investigation of GaN nanostructures for biomedical applications.

Proposal

We offer our experience and partnership for:

- GaN, InGaN, AlGaN, BGaN, including SQW, MQW, epitaxy;
- epilayer surface morphology, p-n junction homogeneity, defect distribution investigation by SEM, EDX, EBIC;
- optical lithography and reactive ion etching, rapid thermal annealing;
- optical poling of azo chromophores.

We look for partners:

- with new ideas on III-group nitride based epitaxy, GaN nanotechnology;
- expertise in device manufacturing;
- GaN surface functionalization.

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

Meet our team

Head - Prof. Dr. Roland Tomašiūnas. He is the co-author of more than 50 ISI publications. During his 30 years of research experience prof. R. Tomašiūnas gathered deep knowledge of surface functionisation and nanotechnologies. He has experience in leading large scale Research infrastructure Projects of the EU Structural Funds in Lithuania and with his group is involved in FP7 Integrated projects, is an expert of the H2020 programme.

Research staff: Dr. Tadas Malinauskas, Dr. Arūnas Kadys, Dr. Tomas Grinys, Dr. Ignas Reklaitis, Dr. Vytautas Grivickas, Dr. Vitalijus Bikbajevas.

PhD students: Mantas Dmukauskas, Marek Kolenda, Kazimieras Badokas.

Research outcomes

Selected publications:

- J.Juodkazytė et al. InxGa1-xN performance as a band-gap-tunable photo-electrode in acidic and basic solutions. Sol. Energy Mater. Sol. Cells, 130, 36 (2014).
- E.Jelmakaset al. A systematic study of light extraction efficiency enhancement depended on sapphire flipside surface patterning by femtosecond laser. J. Phys. D: Appl. Phys. 48, 285104 (2015).
- T.Grinyset al. Facet analysis of truncated pyramid semi-polar GaN grown on Si(100) with rare-earth oxide interlayer. J. Appl. Phys. 120, 105301 (2016).
- M.Dmukauskas Influence of metalorganic precursors flow interruption timing on green InGaN multiple quantum wells. J. Phys. D: Appl. Phys. 49, 505101 (2016).
- I.Reklaitis Differential carrier lifetime in InGaN-based light-emitting diodes obtained by small-signal frequency-domain measurements. J. Appl. Phys. 121, 035701 (2017).

Most important projects:

- FP7 IP „Compact ultrafast laser sources based on novel quantum dot structures (FAST DOT)" (2008-2012).
- FP7 IP „Nanostructured efficient white LEDs based on short-period superlattices and quantum dots (NEWLED)" (2012–2016).
- NORDIC ENERGY RESEARCH PROJECTS „High efficiency Integrated Solar Energy Converter (HEISEC)" (2012-2014).
- RESEARCH COUNCIL OF LITHUANIA „Development of nonpolar GaN on silicon growth technology with rare-oxide interlayers (NEAPOLIS)" (2015-2017).
- M-ERA.NET „Functional inorganic layers for next generation optical devices (FLINGO)" (2016-2019).

Collaboration with industry: UAB Altechna, UAB Ekspla, UAB Quantum Light Instruments, Translucent (USA), OSRAM (Germany), TOPGAN (Poland), STR (Russia), Compound Semiconductor Technologies (UK), Picosun (Finland).

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