2017

International projects

- Bilateral Lithuania-France program Gilibert project "**Regular metal oxide nanotubes arrays for gas sensing (Gaz-Sens, S-LZ-17-2)**", funded by Research Council of Lithuania is carried out together with scientists form University of Nantes, Institute of Materials - Jean Rouxel (France), project leader dr. Sigitas Tamulevičius (**2017-2018**).

Aim of this project is to create nanotube based sensors for detection of toxic gasses. Nanostructures will be patterned in thin metal films employing holographic lithography. Nanotubes will be formed by an oxidation of lithographically formed nanostructures. Patterns will be investigated at KTU MMI and the sensors will be evaluated at the partner laboratories.

- "**Low Secondary Electron Emission Coatings for CERN Superproton Synchrotron**" **(SEM)**, funded by Lithuanian Academy of Sciences funded, in relation to program for cooperation with CERN, project leader dr. Sigitas Tamulevičius (**2017**).

Project is being executed in relation to the program by Lithuanian Academy of Sciences for Lithuanian scientists and other researchers to participate in CERN scientific research programs, projects and other events, related to Agreement and Protocol implementation. In 2017 the project is being implemented without any partners.

A problem related to secondary electron emission is evident during the experiments in elementary particle accelerators. This translates to significant losses of the accelerated particle beam. The electron cloud formation in the CERN superproton synchrotron (SPS) must be eliminated in order for it to be able to deploy a beam of protons or positrons of sufficient density and achieve the highest possible luminosity at the intersection points at the Large Hadron Collider (LHC). Ideally, the secondary electron emission coefficient from the walls must be <1 for this problem to be solved completely. However, in real systems, depending of the geometry and magnetic fields, it is often enough for this coefficient to be lowered to values slightly above 1. This phenomenon is influenced by a 3–5 nm thick layer of material on the walls, which can be controlled by employing an appropriate surface modification. A lot of possibilities can be seen in growth of special coatings which decrease the emission of secondary electrons. Various allotropes of carbon here are very promising, most of all, amorphous carbon films, also known as diamond-like-carbon, and variations of nanocrystalline graphite. The roughening of surfaces can decrease the secondary electron emission as well – nanostructured surface of copper also has a very low secondary electron emission coefficient. Thus, the aim of this project is to develop new materials based on carbon allotropes and nanocomposites that have a low secondary electron emission coefficient. During the project a cooperation with CERN TE-VSC-SCC will be ensured.

- "**Graphene/Silicon Schottky Contact Based Plasmonic Infrared Sensors**" **(PLASMOGRAF)**, funded by European Space Agency, project leader dr. Šarūnas Meškinis (**2017‑2019**).

Project is being executed after applying to the Second call for outline proposals under the plan for European cooperating states (PECS) in Lithuania. Project is being implemented without partners.

Schottky contact infrared sensors operates in near (NIR) and short wavelength IR (SWIR) ranges (1–5 µm). Ranges of the near and short wavelength infrared radiation (NIR and SWIR) (1–5 µm) are very important for different space exploration missions. 1–3 µm wavelength IR radiation range is very important for satellite based observation of the land-water boundaries, meteorological studies, observation of the forest fires and lava flows as well as for estimation how much water is present in plants and soil. IR sensors operating in 1–3 μm wavelength are applied for geological (mineralogical) investigations of the surface of the planets as well as for studies of the atmospheric phenomena in other planets. Photo sensors operating in 3–5 μm wavelength range are most often used to study Earth's thermal radiation in the dark of night.

In Schottky sensors minimum energy of the absorbed photon is limited by Schottky barrier height. Therefore, sub-bandgap photons can be detected. Thus silicon can be used for fabrication of these sensors instead of the narrow bandgap semiconductors such as Ge or CdHgTe. Therefore, main project idea is design, fabrication and investigations of the advanced Schottky IR photo sensor.

Main problem of the Schottky IR sensors is as follows. Probability of the photoemission from the metal to the semiconductor increase with metal layer thickness. However, it results in decreased absorbance of the photons. In suggested project graphene would be used as Schottky contact metal. That is monolayer of the hexagonal sp2 bonded carbon. Due to the 0 eV bandgap graphene is excellent Schottky contact material. There is no free electron scattering problem in graphene. Therefore, most of the photoenerated charge carriers can reach junction at appropriate angles and flow to the Si. Metal film of such thickness would be non-continuous.

Relatively small absorbance of NIR and SWIR photons in graphene in present study will be compensated by fabrication of the ultra-thin (thickness smaller than electron free path) nanostructured plasmonic absorbers. Photon will be absorbed and photoelectrons will be generated in these absorbers. These processes will be enhanced by surface plasmon resonance. Hot plasmonic electrons will be injected to the graphene. Afterwards these electrons will be emitted to the Si along with photoelectrons generated in graphene.

Project goal – fabrication and investigations of the novel near and short wavelength infrared sub bandgap Schottky photo sensors operating by emission of the plasmonic photoelectrons.

- Project of European Union Investment Fund for priority programmes „**Biopolymer Based Smart Materials for Glucose Sensing Application**“, project leader dr. Sigitas Tamulevičius (2017-2019)

Hydrogels are regarded as hydrophilic polymer networks having very high water absorption ability. Hydrogels can convert one form of energy into other form. Due to their chemical and physical properties, biocompatibility and pH responsive properties, hydrogels can be used as important tool in diagnostics and sensors. In this research proposal we are focusing on the use of hydrogels in glucose sensing application, enzyme biomolecules can be entrapped in hydrogels matrix. Glucose enzyme biosensors have been utilized in different type of fields such as diagnosis, beverage industry, bioprocess and environmental problem. The stability and functionality can be increased by loading the nanoparticles into the hydrogels matrix. There is synergistic action between hydrogels and nanoparticle for glucose sensing application. The immobilization of the enzyme into hydrogel matrix can be favored by porosity of hydrogels structure, which can further help in glucose oxidation. Nanoparticles can promote the decomposition reaction of hydrogen peroxide throughout the enzymatic reaction. All these transfer charges will be measured electrochemically by using a series of multifunctional robust three dimensional conducting hydrogels.

- Project of European Union Investment Fund for priority programmes „**Synthesis and investigation of electrooptical properties of UV region plasmonic aluminium**

nanostructures by means of ultrafast spectroscopy methods”, project leader dr. Šarūnas Meškinis (2017-2019)

During the project, Al nanostructures will be synthesized and investigated. The Al nanoparticles are characterized by localized surface plasmon resonance (LSPR), which can have a wide range of applications: sensors, medicine, nonlinear optics, solar cells, light emitting devices, and so on. Unlike other plasmonic metals (Ag, Au, Cu), LSPR of Al-goes far to the UV range (may reach 100 nm). Due to these properties, Al nanostructures can be used in a spectral range in which other plasmonic metals cannot be employed. For Al, one of the most common element on Earth, production costs are expected to be significantly lower than other plasmonic metals. During the post-doctoral internship, the synthesis of these nanoparticles will be performed by plasma, lithographic, chemical methods (task I) and systematic studies of their optical properties will be done (task II). Reactive magnetron deposition will be used for nanoparticle synthesis, and electro-optic properties and plasmon relaxation studies will be performed using electro-optical methods. The project will mainly focus on the systematic studies of ultrafast relaxation processes of Al nanoparticles, which determine the speed of potential sensors and their application areas. Using the transient differential absorption spectrometer, it is planned to investigate in detail the LSPR relaxation processes, to link plasmonic properties of Al nanoparticles with the used technologies, and to evaluate potential applications (bio-sensors, solar cells).

National projects

- “**Plasmonic Self-Saturating Absorption Mirrors for Fibre Lasers**” **(NAMSIS)**, funded by Research Council of Lithuania, project leader dr. Šarūnas Meškinis (**2017-2019**).

Ultrashort pulse fibre lasers are used in a broad range of the areas such as cutting and engraving of the materials, optical communications, sensors, spectroscopy, medicine. One of the main parts of the fibre laser is self saturable absorber mirror. It is used for the generation of ultrashort pulses by mode locking. At present, mostly semiconducting saturable absorber mirrors (SESAM) are used. Large modulation depth, low saturation fluence, fast recovery can be achieved by using such devices. However, SESAM‘s are expensive, inflexible, bulky and works only in a narrow wavelength range. Therefore, alternative solutions employing novel saturable absorber materials are highly appreciated.

At the present sp^2 nanocarbons such as graphene and carbon nanotubes as well as group IB metal nanoparticles (Au, Ag, Cu) are under considerable interests as potentially new self saturable absorber mirror materials. In this study combination of these two materials will be done by using modern thin film deposition methods. In such a way advantages of the sp^2 nanocarbons and plasmonic nanoparticles will be merged, while disadvantages will be eliminated. In the proposed research carbon nanocomposites with embedded group IB metal nanoparticles as well as their multilayer structures will be deposited and studied as functional layers for saturable absorber mirrors applied for fibre lasers.

Therefore, the aim of the project is deposition and study of the amorphous and/or nanocrystalline sp2 carbon based nanocomposites with embedded plasmonic nanoparticles for applications in fibre laser saturable absorber mirrors.

- **“The smart anti-drowning collar creation and testing for children to protect from drowning”**, funded by MITA, project leader Tadas Juknius, (**2017-2018**).

Drowning is defined as suffocation by submersion, especially in water. It continues to be the third most common cause of accidental death in the general population and, for children in many countries, the second most common cause after road accidents.

Various anti-drowning items are currently used in the world. The most popular are life jackets, but they are not comfortable for permanent wear. Particularly, their wear problems arise from the high temperature of the air, when the body sweats and people in open areas want to enjoy the sun. Therefore, when children playing near the water without adult attendance and have no swimming skils and life jackets, often ends in death.

The project idea is to create the unique anti-drowning collar for children. The inovation will be applied into device manufacturing process and product will be sold as the unique personal protective equipment. The early stage device has unique properties as a product, to save children's life when accidentally fall into water. The collar automatically (without human intervention) activates when sensors detects the water and device starts inflates airbags to lift up children's head above water level.

- Institutional project „**Creation of algorithm for rendering of the hologram image and its realization in mobile devices (HoloApp)** "carried out in cooperation with Department of Multimedia Engineering of KTU project leader dr. Tomas Tamulevičius, (**2017**).

The protection against counterfeiting and reliable authentication of variety of products, banknotes and documents is becoming a more and more important in the daily life of modern society. The ever-increasing demand for anti-counterfeiting tags with various kinds of hologram effects requires additional visualization means for efficient design and tailoring of light diffraction effects for the future products. Such software would enable to evaluate the optical effects and ensure their proper visualization for the hologram customer that could be directly enrolled in its creation process. Designing process of the hologram security labels faces a fundamental problem - the image seen on such security labels by the observer is dynamic, because the colour and animation effects are caused by the diffraction of light. The goal of this project was to develop novel hologram security labels and diffraction image visualization algorithm for smart device (tablet, smart-phone, App). During the interdisciplinary project financed by Research and Development and Innovation fund of Kaunas University of Technology the prototype algorithm for designing hologram image based on physical light diffraction principles was created and implemented on a smart device for real-time interactive visualization and perception of the designed hologram project under spectral and spatial illuminations conditions selected by the user. The hologram security labels designed employing this new software were originated employing direct laser interference patterning. The diffraction images of the holograms were quantitatively investigated under defined illumination conditions. The developed software was validated comparing the experimental results with the rendered hologram images. The application of advanced laser lithography and creation of the software for rendering the hologram image and enabled proper perception and visualization of a widely consumed product (hologram security seals), together with advanced lithography technologies enable a breakthrough in the market of the anti-counterfeiting means.

- Institutional project „**Bipolar organic materials for electrochromic devices**" carried out in cooperation with Department of Polymer Chemistry and Technology of KTU project leader dr. Dalius Gudeika, (**2017**).

Nowadays, most of electrochromic devices used in sun glasses, smart windows, etc. are based on non organic electrochromic materials. However, the need of flexible and cheap devices pushes the search of applicable materials in the field of organic and polymer materials. To produce effective and long life devices, the materials with characteristic reverse oxidation/reduction reaction and absorption in visible light region must be synthesized. Additionally, the materials for flexible electrodes has to be investigated and selected. By default, indium tin oxide is used as transparent electrode but it is fragile at high bending angles. Alternative for ITO could be graphene showing good electrical, optical and mechanical properties. The task of this project is to synthesize bipolar organic compounds and test these materials for electrochromic performance in the system with graphene electrodes.

Self-supporting projects

- "**Smart Label**", JSC Novakopa, 5682.16 EUR, project leader dr. Pranas Narmontas (**2017–2018**).
- "**Integration of Holograms into New Generation Advertisements**", IC InSpe, 5682.16 EUR, project leader dr. Pranas Narmontas (**2017–2018**).
- "**Investigation of the Surface Quality of Materials used for Restored Tooth Prosthetic Components (tooth, support, implant)**", JSC Signata, No. SV9 – 1268, 4696.00 EUR, project leader dr. Asta Guobienė (**2017–2018**).
- "**Formation of Nanotexts for Document Security Measures via Laser Technology**", JSC Holtida, No. SV9 – 1261, 4696.00 EUR, project leader dr. Tomas Tamulevičius (**2017–2018**).
- "**Creation of methodology for assessment of polydispersity of multi-component paraffin wax products** ", JSC LT Rimina, No. SV9-1155, project leader dr. Tomas Tamulevičius (**2017**).
- "**Creation of methodology for assessment of polydispersity of multi-component paraffin wax products at elevated temperatures** ", JSC LT Rimina, No. SV9-1243, project leader dr. Tomas Tamulevičius (**2017**).