LASER TECHNOLOGIES IN LITHUANIA
2015

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On the cover:

J.Adamonis (Ekspla) and T.Stanislauskas (Light Conversion) assist in the development of TW-class OPCPA system at multifunctional laser facility NAGLIS of Vilnius University.

Cross polarized light photo of “International year of light 2015” logo fabricated using femtosecond laser by inducing birefringent nanogratings in fused silica glass bulk (Courtesy of Workshop of Photonics).
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The chief direction of long-term development in Lithuania is knowledge-based economy driven by strong interactions among industry, science and education. Such economy favors the establishment and growth of high technology companies producing high added value and creating jobs for top-level professionals earning salaries competitive at the European level.

This publication is dedicated to one of the strongest sectors in Lithuanian knowledge-based economy: laser industry, science, and education. This sector, along with biotechnologies, information technologies, and mechatronics, is one of the most progressive sectors in the country.

The output of Lithuanian laser sector consists of different lasers, optical, electronic, mechanical laser components, assemblies, parts or different combinations thereof. It is not uncommon for the same product to have different names among different customers. For example, one customer needs a multicolor laser, another – a parametric oscillator, yet another – an optical device to be integrated in the system being developed.

Fundamental and applied research in laser physics in Lithuania is nearly fifty years old. Training of top-level professionals has been pursued for forty years. Lithuanian laser industry has just celebrated its 30th birthday. Creative and persistent efforts of the people working in the sector have made Lithuanian lasers and laser components desirable goods exported to all the developed countries. The publications of the scientists are widely recognized and well cited, their contributions stand out in the most prestigious conferences all over the world.

The last six years have been truly impressive for the industry. The sales of the sector have grown more than twice – from EUR 29.4 million in 2009 to EUR 70 million in 2014. The major part of the production, over 90 %, is exported. Ten years ago, laser sector consisted of 10 companies, whereas in 2015 the count reached 25. Previously focused on the scientific laser niche, the activities of the recent years helped enter the industrial market, where a quarter of total sales is made now. Lithuanian laser products are flying to cosmos.

It is interesting to mention the collaboration of Lithuanian laser sector with the distant country of Japan. In 1993, the lasers were the only products exported from Lithuania to Japan; in the recent six years, they constituted 10 – 25 % of the total exports to Japan.

The export situation in laser sector is quite unusual: the sector is actually pleased with the relative decrease of export share, although the volume of export is constantly growing. Such paradox is easy to explain: 20 years ago, no customers in Lithuania could afford Lithuanian lasers, and all production was exported. In contrast, presently, Lithuanian companies and scientific institutions can acquire world-class goods made in Lithuania.

From the first glance, the contribution of the laser sector to the gross domestic product of Lithuania may seem tiny. However, in relative terms, the added value of products, the sector exceeds the average of the industry by almost a factor of three.

The laser sector is also visible to the wider public, not just the specialists in the field. Laser people are regularly awarded different local and international prizes for the results of their work and products developed.

The projects important to the laser science and business are developed via an integrated program of science, studies, and business titled “Saulėtekis” (Sunrise). The program is just gaining speed, therefore new areas and opportunities of cooperation between laser scientists and businessmen are just round the corner. The plan of laser industry reaching the volume of 1 % of the Lithuanian GDP that seemed utopian ten years ago is quickly becoming realistic.
One of the key factors in the success of the Lithuanian laser industry is the constant and diverse collaboration of the researchers in the scientific institutions and engineers in the laser companies. It gives rise to a dynamic and constantly expanding laser ecosystem.

The products of the Lithuanian laser sector are extremely diverse. Usually, however, they are different lasers, optical, electronic, mechanical laser components, assemblies, parts or combinations thereof.

After starting its activity 30 years ago in the scientific laser niche, recently Lithuanian laser sector has also gained a foothold in the industrial laser market, a market that exceeds that of the scientific lasers by an order of magnitude (Laser Focus World, January 2015. Laser Marketplace 2015). In 2014, a third of all sales took place in this industrial market.

All the pioneering Lithuanian laser companies and most of the recently founded ones have been established by private initiatives, without foreign investment or direct government support. Initially, they only tapped the scientific potential available within the country, whereas currently the collaboration ties have also been forged with foreign universities. In the two decades of Lithuania as an independent state, the national added value chain has developed: ideas of new products born in research labs propagate through the manufacturing chain all the way to the wide network of distributor and service branches all over the globe.

In 2014, the sales volume of Lithuanian laser industry has reached EUR 70 million. The average yearly growth is more than 15% a year. The projections show the same growth in the coming few years.

The export of Lithuanian laser industry is over 80% of the total production volume; in 2014 the export of this sector reached EUR 60 million.
Laser science and technology in Lithuania started its journey almost 50 years ago, just a few years after the invention of the laser. Currently, lasers have become ubiquitous in a wide range of research and development areas, from laser physics and optical technologies, all the way to laser biomedicine.

The following R&D directions were pursued in the past decades:

1. Research of the interactions between laser radiation and matter, search for the new ways of generating coherent light using laser radiation. This leads to a better understanding of our environment and methods of using laser radiation in industrial processes.
2. Search for new materials to be modified and processed using lasers; applications of such materials in electronics, photovoltaics, photonics, biomedicine and automotive industry.
3. Research of active laser media and mode-locking techniques in order to generate picosecond and femtosecond laser pulses, and develop new generation of lasers featuring high average power, high pulse energy, high pulse repetition rate. Development of solid-state and fiber lasers for science and industry.
4. Investigation of parametric light amplification phenomena in transparent media (including interactions with conical waves) and development of widely tunable laser sources. Generation of optical harmonics for high power laser systems.
5. Research of factors influencing the resistance of optical materials to the damage induced by laser radiation; development of standardized diagnostics and characterization techniques for laser components.
6. Studies of interactions of ultrashort laser pulses with matter in order to develop efficient technologies for sub-micron (nanometer) scale material processing and programmable property control. These studies also include the applications of femtosecond pulses for the formation of functional structures for photonics and medicine using two-photon photopolymerization technique.
7. Research of ultrafast energy transfer and relaxation processes in semiconductor structures and organic compounds; development of new methods and equipment for ultrafast spectroscopy.

A huge boost for the development of laser science and applications has been provided by the High Technology Development Program (HTDP). The first fruits of investment in Saulėtekis Valley project – a governmental program of research infrastructure development – are just getting ripe. To keep in step with global and European progress in the field, and to continue the development of new technologies and competitive products, it is vitally important to keep the momentum of fundamental research. HTDP continuation and the planned National Science Program of the Lithuanian Research Council Towards the Future Technologies will allow Lithuanian laser science and industry to remain visible and competitive on the global scale.

The list of Lithuanian scientific institutions involved in laser technologies and their brief descriptions are given in the Annex.
Investment in R&D activities is the key factor determining the competitiveness of the products manufactured by the Lithuanian laser industry. Only the products in step with the cutting-edge developments in laser science and technologies can succeed in the global market. Therefore, most of the Lithuanian laser companies invest at least 10% of revenues in their research and development infrastructure, participation in scientific projects and development of new innovative products.

Investments in R&D of Lithuanian laser companies have been consistently growing in the recent years; in 2012-2013, they have passed EUR 5 million mark. This is more than twice the annual R&D investments made in the period of 2005-2008. The overall amount invested by the companies in R&D over the past four years is nearly EUR 20 million.

The main part of investments was allocated for R&D infrastructure development. Light Conversion, Ekspla, Optolita, Optida, Altechna, and Brolis Semiconductors are all carrying out large scale projects to expand their labs and industrial premises, setting up cleanrooms required for new technologies being developed.

High priority is placed on the acquisition of the newest diagnostic instruments, equipment for technological processes and production. The remaining part of investments is used for funding in-house research work, research on demand and public programs.

Analysis of the return on investment clearly shows that the country regains invested funds rapidly and with a large profit margin to boot. There is no doubt that investment in R&D has made significant contribution to the fast growth of industrial output and created new jobs. The projections for 2014-2018 place the volume of company investments in R&D at respectable EUR 29 million.
Investment in laser science and research of optical technologies is vitally important for the successful development of the Lithuanian laser industry. Projects in applied research are usually intended for the development of innovative laser equipment and the improvements of current products.

Fundamental research in laser science is equally important (and remains an imperative necessity). They provide better understanding of physical processes important in the operation of lasers and nonlinear optical devices. Additionally, they often stimulate the birth of qualitatively new commercial products and allow finding new applications for laser equipment.

The major part of research in these areas is carried out at the Laser Research Center of Vilnius University, the Center for Physical Sciences and Technology. However, as research infrastructure builds up at the laser companies, and the number of employees with PhD degrees increases, the amount of research performed at the companies is also growing.

Investment in R&D of lasers and optical technologies is used for developing scientific and technological infrastructure, funding specific projects in applied and fundamental research, acquiring services from other industrial companies.

In 2009-2013, the total amount of investment in R&D projects and research infrastructure of scientific institutions and laser companies has been over EUR 43 million. It must be noted that investments of companies in R&D amount to nearly 50% of all laser-related R&D funding in Lithuania.

R&D projects carried out in collaboration between scientific institutions and companies are another important source of overall investment. In 2009-2013, more than 100 different R&D projects were underway, with more than EUR 20 million total funding. The major part of this amount, EUR 16 million, was received from EU programs FP 6, FP 7, EUROSTARS, EUREKA, Lithuanian foundations and agencies ASIT, RCL (the Research Council of Lithuania), LBSA research support funds; the remaining EUR 11 million were allocated by laser businesses.

Lithuanian laser companies are increasingly active in the R&D fields. In the past five years, almost half of all public funds allocated for research in laser science and other fields of photonics were used for research performed by laser companies.
STUDYING IN LITHUANIA: EXPERIENCE, OPPORTUNITIES, PROSPECTS

Lithuanian education system has been successfully training laser specialists for several decades. The science centers where these young minds are sharpened are famous for their high competence and world-class laser research. A special place among them belongs to the Faculty of Physics of Vilnius University, where laser physicists have been studying and teaching for over 40 years.

The major in quantum electronics was first chosen by 10 freshmen in 1970 (albeit the first laser-related graduation works were performed by the students majoring in other fields already in 1971). Quantum electronics was made an official direction of research and studies in 1974, when the Department of Astronomy and Quantum Electronics was founded. In 1975, the first graduates in quantum electronics received their diploma. In 1988, a separate Department of Quantum Electronics was formed, where laser physicists are being taught to this day. From 1975, the Department of Quantum Electronics has graduated over 550 people in laser physics.

Currently, the Faculty of Physics offers courses on lasers starting from the bachelor level. Students can choose the subjects titled Laser Physics, Technological Applications of Lasers, Laser Technology, and Quantum Electronics.

Two master programs are dedicated to training laser specialists in Lithuania: Laser Physics and Optical Technologies, and Laser Technology. They are both managed by the Faculty of Physics. The goal of these programs is to train high level professionals able to develop and use modern laser technologies in practice.

From 2007, specialists of optoelectronics are trained under the program Optostud offered by Vilnius University, Faculty of Physics. The program is mainly oriented towards LED technologies and applications.

Students make use of modern teaching and research labs at Vilnius University Laser Research Center and Vilnius University Institute of Applied Research. They are encouraged to attend the workshops given by Lithuanian and foreign scientists, and the public defenses of PhD theses. The scientific quality of MSc graduation works is commendable: a significant fraction of graduates publish the results of their MSc works in peer-reviewed scientific journals.

Professional PhD studies in laser physics are also available in Lithuania. Vilnius University Quantum Electronics Department and Laser Research Center employs a number of graduate students in Physics and Materials Engineering. Laser-related PhD careers can also be pursued in other scientific centers in the country: divisions of Laser Technology and Optoelectronics at the Center for Physical Sciences and Technology, the Department of Mechanical Engineering at Vilnius Gediminas Technical University, the Institute of Material Science, the Institute of Mechatronics and the Department of Production Engineering at Kaunas Technical University.

All research centers are equipped with excellent research infrastructure, which has been funded by EU structural funds, High Technology Development Program, other international and national projects and in some cases by Lithuanian laser companies. Modern research equipment is used for practicums. The students participate in the international exchange programs opening access to world-famous science centers abroad, where their competences and training level is well regarded.

Prof. Dr. Valdas Sirutkaitis with students at the University of Vilnius teaching laser laboratory
A large number of graduates from Vilnius University and Lithuanian science institutes have found their places abroad in the world-famous laser laboratories. Many of them retain close ties with Lithuanian science and education institutions and laser companies. They give lectures and share experience visiting Vilnius University (VU) and the Center for Physical Sciences and Technology (CPST), pursue joint development projects with laser companies and scientists using the projects of Eurostar and High Technology Development Projects, attend events held by the Lithuanian Laser Association.

The largest Lithuanian group working with high intensity ultrashort pulse lasers is headed by Prof. Andrius Baltuška at the Technical University of Vienna. This group currently hosts three Lithuanian researchers and three to four graduate students. Close collaboration ties are maintained with Lithuanian scientists and companies developing generators and amplifiers of femtosecond laser pulses in 2-6 μm wavelength range and researching the generation of attosecond pulses.

Another group worth mentioning is the group under the leadership of Prof. Kęstutis Staliūnas at the Polytechnic University of Catalonia (Barcelona), where two to three graduate students, MSc students or post-docs from Lithuania are working. Together with groups from VU, CPST and Lithuanian laser companies, the group is pursuing research of the application of photonic crystals for spatial filtering of laser beams.

Prof. Almantas Galvanauskas from the University of Michigan has been advising CPST scientists on the development of fiber lasers for about five years; he invites scientists and graduate students from Lithuania to work in his scientific group.

Prof. Saulius Juodkazis from Swinburne University of Technology in Australia has been collaborating with Lithuanian laser scientists and laser companies for many years. His interests include the growth of new laser materials, technological research of ultrashort pulse lasers and their applications. Two or three graduate students, MSc students or post-docs from Lithuania are always a part of his team. He is also often enlisted by different Lithuanian projects as a consultant.

The list of Lithuanian laser scientists abroad maintaining close relationships with Lithuanian scientists and companies would be incomplete without Prof. Virginijus Barzda from the University of Toronto, Prof. Valdas Pašiškevičius from the Royal Institute of Technology in Stockholm, Dr. Rimantas Juškaitis from the University of Oxford, Dr. Vygandas Mizeikis from Shizuoka University in Japan, Dr. Aleksandr Ovsianikov from Vienna University of Technology, Dr. Gediminas Jonušauskas from the 1st University of Bordeaux (France), Dr. Arvydas Ruseckas from St. Andrews University in Scotland, Dr. Donatas Zigmantas from Lund University (Sweden) and many others, whose experience and knowledge in different laser-related fields add significantly to the knowledge of Lithuanian scientists and businessmen.
Strategic advantages of cooperation between business and research institutions include:

- Establishment of research contacts and building long-term partnerships;
- Consolidation of funds and specialist efforts of developing globally competitive high technology production, creation and implementation of new technologies;
- Creation of jobs for highest-level professionals, as a partial solution to brain drain problem.

The two major forms of collaboration between laser companies and research institutions are joint research and development projects, and research-on-demand performed by the scientific institutions.

The majority of the projects are carried out via the High Technology Development Program (HTDP) managed by the Agency for Science, Innovation and Technology (ASIT). During the period of 2009-2013, research institutions together with businesses have completed or are still carrying out more than 30 projects, the total value of which is EUR 5 million. The range of the topics covered extends from the development of different types of lasers and laser equipment to the application of lasers in different areas.

The projects mainly focus on:

- Characterization and performance improvement of optical laser components, search for novel materials and specialized coatings and investigation of their potential applications in optical technologies. Development of new types of lasers and nonlinear optical devices for the generation of coherent radiation in different spectral ranges;
- Research of energy-saving lighting systems and components thereof;
- Development of specialized laser equipment and technologies, their industrial and biomedical applications.

Intelektas LT, the program carried out by the Lithuanian Business Support Agency (LBSA) has opened a range of new possibilities of business-science collaboration. Making use of this program, Altechna, Ekspla and Light Conversion, ELAS, Sprana and Brolis Semiconductors have successfully completed or are underway with several large scale projects. They are dedicated to the development of multi-functional laser platforms, laser systems for the production of solar panels, optoelectronic devices for medical applications and lasers for ophthalmic surgery. The total value of these projects is EUR 4.3 million.

Collaboration between laser businesses and foreign research institutions is growing. In 2009-2013, Ekspla, Light Conversion, Optolita, Teravil and Altechna were (or still are) the partners of ten international projects of FP 7, EUROSTARS and EUREKA programs. Project topics cover the development of novel laser sources, application of lasers and optical techniques in nanotechnologies, biomedical research, identification of explosives or pollutants, diagnostic systems and industrial processes. The Lithuanian funding share in these projects is over EUR 3 million.

The volume of research-on-demand of laser businesses performed by research institutions in 2009-2013 was around EUR 1 million. The annual volume of such services has grown more than three times compared to the period of 2005-2008. The typical tasks of such research include the development of specialized optical coatings, feasibility studies of different types of lasers and laser components, characterization of nonlinear optical devices; improvements of diagnostic equipment, laser applications in micromachining and micro-structuring, etc.

Funding of joint projects of research institutions and laser companies (million EUR)

The volume of joint projects carried out by Lithuanian companies and research institutions in 2009-2013 was around EUR 14 million. More than 30% of the project costs were covered by the companies.

Joint projects are not the only form of collaboration, there are also joint workshops, exchange of research equipment, and the annual national conference Lasers: Science and Technologies.
DEVELOPMENT OF LASER APPLICATIONS IN LITHUANIA

Industrial lasers

Lasers make for universal and flexible production tools. The majority of industrial lasers in Lithuania, as everywhere, are used for cutting sheet metal. They are typically powerful kilowatt systems, with powers up to 6 kW, able to cut through 20-30 mm metal sheets. Fast, precise, and automated cutting, and flexible process control has made such systems indispensable in metal processing industries. CO2 lasers that have traditionally dominated this market are being superseded by more efficient fiber lasers; however, these are still uncommon in Lithuania.

Around 40 sheet metal cutting laser systems are currently operating in the country (with the total equipment value of over EUR 0.5 million). Laser cutting was pioneered by companies Astra and Elga. The number of systems took off when the metal processing industry started receiving production orders from Western countries. Most systems are located in Vilnius and Vilnius region, with additional systems in Šiauliai, Kaunas, and Alytus.

Smaller CO2 lasers with powers ranging from 100 to 500 W are used in sewing and furniture industry. They find applications in cutting fabrics and artificial leather. Similar laser cutting systems are becoming ubiquitous in advertisement industry.

Although laser welding technologies still have to find their way to the Lithuanian heavy industry, point welding with pulsed solid-state lasers is widely used, e.g. in telecommunication device manufacturing. Welding services are offered by Aštuonetas and Standa; many such instruments are used by dental technologists and jewelers.

Laser marking and engraving technologies are spreading rapidly in Lithuania. They offer the advantages of flexible production and small investment. Laser-based instruments are used to record personal data in passports, driver’s licenses, other personal ID or discount cards, to prevent fraud. Laser engraving is also used for producing stamping dies. The pioneer of such technologies in Lithuania is the company Aštuonetas, founded in 1994.

Lithuanian laser companies are also increasingly active as laser system producers.

Vilniaus Ventos Puslaidininkiai use fiber lasers for dicing the manufactured semiconductor devices out of silicon wafers. Dicing system developed by the company Elas was awarded the Lithuanian Product of the Year prize in 2012.

Innovative laser machines are designed and manufactured in Lithuania by Precizika Group. The company boasts a laser system for manufacturing distance measuring scales developed jointly by the Center for Physical Sciences and Technology and Ekspla. Using lasers allows for faster and more flexible production of non-standard precision measurement instruments. Altechna has designed and installed laser systems in Precizika-MET SC for use in silicon solar cell manufacturing process.

Companies Lazerinės Idėjos and Optronika offer custom laser illumination for different events and advertisements; they design and manufacture laser projectors and other laser-based illumination sources.
Lasers in research

Lasers have been in use at Lithuanian research institutions for more than four decades. The achievements of Lithuanian scientists in developing ultrashort pulse lasers and researching parametric light amplifications are widely known and numerously cited by the global scientific community.

In recent years, increasing amount of efforts was aimed to apply laser technologies in industry and medicine. European Union support has enabled science labs to acquire modern lasers, laser systems, test and measurement equipment, providing the boost for research activities aimed to find applications for lasers manufactured in Lithuania.

Laser systems at Lithuanian research institutions

In the past five years, Lithuanian research institutions have acquired laser systems for nearly EUR 3 million. A significant part of these systems (worth EUR 0.6 million) was designed and manufactured by Lithuanian companies: Ekspla, Light Conversion, Standa, Optida, Optolita, Altechna, Elas, etc.

Local manufacturers can quickly and flexibly provide equipment and components required for research, which is especially important in R&D projects carried out in collaboration with research institutions. This promotes Lithuania’s competitiveness in international markets and projects the image of Lithuania as an advanced country with deep traditions in laser applications.
**Continued growth can only be achieved through long-term cooperation of business, science, and government**

The dynamic growth of Lithuanian laser sector is evidenced by high-quality education programs, contributions of laser research community to large-scale international projects, and the products of laser companies exported to all the continents of the planet. The laser industry has consistently been doubling the sales volume every four or five years, with concomitant growth of the volume of taxes and salaries paid out.

Lithuanian laser sector is essentially operating in the global market only, competing with the best, therefore its development has to be viewed in the context of the global development of laser markets, where the annual growth of nearly 20% is predicted for the coming five years. In the past twenty years, the laser sector of our country has been growing faster than the global market; therefore its growth projections for 2014-2017 exceed global trends. The companies are actively getting prepared for the new spurt, collaborating with both research institutions and among themselves. They are expanding and diversifying the spectrum of their products, developing new generation of lasers for industry and putting them into serial production.

Two factors are important for the competitiveness of the business: highly qualified professionals and marketable products generating the income to allow appropriate salaries for laser professionals. Lithuanian laser companies with their competitive products are already creating jobs desirable on the Lithuanian, European, and global scale. These, however, must be complemented by the initiatives from the government allowing laser-related (and other) businesses to continue creating jobs. This would allow high technologies (including lasers) to increase their contribution to the Lithuanian gross domestic product, increasing the share of laser industry to 1% GDP, and the volume of taxes paid to the Lithuanian budget beyond EUR 100 million.

Lithuanian universities graduate a number of talented students each year; PhD students and researchers work at research centers. However, the collaboration of science, studies, and business must be pursued further, by investing in their joint projects. Teaching of natural sciences and technological skills should be made priority from the first years at school.
Laser science and industry were active participants of the new stage of R&D development in Lithuania, defined by the governmental programs of development of integrated science, studies, and business centers (valleys), approved in November 2008. Saulėtekis (Sunrise) Valley played a special role in laser development.

Historically, almost all the laser companies in Lithuania have spun off from two strongest scientific institutions – Vilnius University Quantum Electronics Department and the Laser Research Center, located on Saulėtekio Street, and the Institute of Physics of the Center for Physical Sciences and Technology, situated on Savanorių Avenue. Most of the companies are still located next to their parent institutions; therefore, almost the entire laser sector operates in two specific geographic locations. The Laser Research Center of Vilnius University has been allocated an annex where multifunctional ultrashort pulsed laser complex Naglis is located. It functions as an integral part of the High Intensity Laser Laboratory. This complex will collaborate with research centers abroad in the development of new and promising laser and optical technologies, to be industrialized by Lithuanian laser businesses. Together with standardized component testing capabilities it will make Naglis an indispensable facility for developing highly desirable optical components able to withstand huge laser beam intensities.

On Saulėtekio Street, a new building, the National Center for Physical Sciences and Technology, is under construction. It will house laboratories of lasers and optics, material science and nanotechnology, semiconductors and electronics. The new clean rooms will open yet unprecedented possibilities of carrying out research and developing new technologies and devices.

In the same part of Vilnius, Light Conversion Ltd. has moved into a newly constructed modern building with manufacturing facilities and research labs.
The program of integrated science, studies, and business center Saulėtekis includes the Technology Transfer Office to be established on Savanorių Avenue, next to the Center for Physical Sciences and Technology (CPST). The location was chosen to be close to the laser companies Ekspla, Eksma Optics, Optida, and Elas. They are already involved in two development projects, Training and Research Center for Laser and Engineering Technology Cluster (under the funding instrument InoklasterLT+ of the Ministry of Economy) and Adaptation and Incubation Center of Research and Technology of Optoelectronic Components (under the funding instrument InogebLT of the Ministry of Economy). These projects are coordinated by the Science and Technology Park at the Institute of Physics in collaboration with CPST and high technology companies. The Training and Research Center has already been launched. It has become home to an integrated dynamic chain of researchers, suppliers, manufacturers and vendors, who joined their efforts in improving global competitiveness of laser and engineering companies, exchanging expertise and developing new high added-value products.

The center will hold technological training workshops forging ties between company employees and university students and organize business-targeted PhD programs. Technological and non-technological research of laser-related products and services, manufacturing processes, and supply chains is planned.

The Adaptation and Incubation Center of Research and Technology of Optoelectronic Components (OC) has already been constructed and is currently being equipped with technological instruments. Reliability and parameter reproducibility of optical components are at the core of the entire laser business. In order to achieve record parameters of lasers being produced (which, in turn, ensure commercial success), the products must combine record properties of optical, microelectronic, and precision mechanical components. Lithuanian research institutions have performed a number of studies characterizing different parameters of such components; however, until now nobody has attempted to standardize them and produce a single integrated testing system.

In the spring of 2013, several laser companies have started their activities in an ultramodern building on the intersection of Geležinio Vilko and Mokslininkų streets, dedicated to the experimental production of solar cells and modules and research laboratories.
Laser industry and research is one of the fields where Lithuania is visible on the global map. In 2012, we celebrated the 25th anniversary of showing Lithuanian lasers to the Western world: the largest European laser exhibition in Munich hosted a laser developed and manufactured by Eksma. Since then, three decades of continued efforts have yielded their fruits. In 2016, we will celebrate the 50th anniversary of the first laser launch in Lithuania.

- **1978.** The first international event in the field of lasers and nonlinear optics is organized in Vilnius, the 1st Vilnius International School on Laser Applications in Atomic, Molecular, and Nuclear Physics (ISLA’78). Organizers include Vilnius University, the Lithuanian Academy of Sciences, and the Institute for Spectroscopy of the Russian Academy of Sciences, Troitsk. Presentations were delivered in the form of tutorial lectures. Due to great success of this school it later became a periodic school held in Vilnius every three years. The next five schools were held in 1981 (ISLA’81), 1984 (ISLA’84), 1987 (ISLA’87), 1990 (ISLA’90), and 1993 (ISLA’93) respectively. The number of participants varied in the range of 80–100.
- **1983.** Establishment of the first laser company Eksma.
- **1984.** USSR National Conference on Non-Resonant Interactions Between Optical Radiation and Matter is held in Palanga. Organizers included the Institute of Physics (Lithuanian Academy of Sciences) and Vavilov State Optical Institute (Leningrad, currently St. Petersburg).
- **1987.** Vilnius hosts the 5th (UPS’87) International Symposium on Ultrafast Processes in Spectroscopy. UPS symposiums were organized under the auspices of the European and Lithuanian Physical Societies, Vilnius University and the Lithuanian Academy of Sciences. Scientists from widely varying fields in physics, chemistry, biology, and medicine got together to share their common interest in ultrafast processes taking place on picosecond and femtosecond time scale. The number of invited and contributed papers in those conferences was in the range of 100–120. The event returned to Vilnius six years later (UPS’93)
- **2002.** Vilnius hosts the International Conference on Laser Applications in Life Sciences (LALS-2002) covering the fields of Biomedical Imaging, Laser spectroscopy, Laser- Tissue Interactions, Light Microscopy, organized by Vilnius University and Moscow Lomonosov University. The number of participants was about 100.
- **2007.** Two companies, Light Conversion and EKSPLA, together with the head of Quantum Electronics Department and Laser Research Center of Vilnius University Prof. A. P. Piskarskas, Light Conversion Science Director Dr. R. Danielli, Eksma executive R. Kraujalis and Eksma executive K. Jasiunas, were awarded the National Progress Prize for the concentration of Lithuanian laser science and industry for the breakthrough to the global markets.

- **2009.** Vilnius hosts the International Conference Northern Optics 2009 (NO 2009), the 4th conference in the Northern Optics series. The aim of the meeting was to bring together optical scientists and people from the optics industry and optics companies in the Nordic and Baltic countries. The conference was organized by the Lithuanian Physical Society including Vilnius University and the Institute of Physics (Vilnius). The number of participants was 120.
- **Laser, optics and photonics scientists receive Lithuanian Science Awards (started in 1993) every second or third year.
- **The sales volume of laser companies has been consistently growing 15-20% per year in the past decade. From EUR 12 million in 2003, they have reached more than EUR 60 million in 2013, which is more than five-fold.**
- In the past five years, ten new laser companies have been founded, including Lidaris, Evana Technologies, Brolis Semiconductors, Integrated Optics, Sprana, Optonas, Elas, Femtika, Luvertera, and Quantum Light Instruments. Currently, the total number of companies is 24.
- **2011.** Eksma receives the Prism Award for Photonics Innovation, the so-called laser Oscar.

- **2011.** EU Commissioner for Research, Máire Geoghegan-Quinn, visits Light Conversion.
2011. Optolita becomes a certified supplier for the European Space Agency.
2011. The Lithuanian Center for Physical Science and Technology signs a long-term collaboration agreement with the largest Japanese research institute RIKEN.
2011. Altechna is awarded the German Business Award, Responsibility for the Future.

2011. Altechna receives the Swedish Business Award for the most sustainable growth.
2012. Ekspla receives the Swedish Business Award for the best introduction of Lithuanian products in foreign markets, for promotion of Lithuania’s name in the world.

2012. Prof. A. P. Piskarskas is awarded the Baltic Assembly Prize for his pioneering research in the field of laser physics and nonlinear optics, for the development of innovative laser instruments and fruitful international collaboration in the European area and world-wide.
2012. The President of the Republic of Lithuania Dalia Grybauskaitė visits Ekspla.

2012. The Congress Life Sciences Baltics names the company Integrated Optics one of the most promising start-ups.

2013. Light Conversion receives the Lithuanian Business Leaders’ Award as the most efficient company.
Lithuanian lasers for research at highest intensities and shortest time scales

- 2013. OPCPA technique based TW-class laser system was demonstrated at the Laser Research Center of Vilnius University. A more advanced version of this system providing possibilities for cutting-edge research on laser-matter interaction at extreme light intensities in femtosecond and attosecond regimes is on-schedule to come online at Vilnius University laser facility NAGLIS in beginning of 2015.

- 2014. A consortium led by National Energetics, Inc. in partnership with Ekspla was awarded a contract to develop and install an ultra-intense laser system producing 150 fs pulses with power in excess of 10 PW for the European Union’s Extreme Light Infrastructure Beamlines (ELI-Beamlines) facility in the Czech Republic.

- 2014. A consortium made of Ekspla and Light Conversion was awarded a Euro contract for OPCPA-based laser system that will be the core component of a unique Attosecond Light Pulse Source at Extreme Light Infrastructure ELI-ALPS Laser Research center in Szeged, Hungary. The OPCPA system will provide CEP stable sub-10 fs pulses with power of 4.5 TW at repetition rate of 1 kHz.

Laser technologies developed in Lithuania enter space exploration programs

- Lithuanian company Optolita, part of Eksma Group, is a manufacturer of ultraprecise optical components for the satellite developed by the European Space Agency. The satellite Aeolus dedicated to the laser-based exploration of Earth atmosphere will use optical converters manufactured from non-linear crystals and coated in Lithuania.

- The precision mechanical components developed and manufactured by Standa, another Lithuanian company, are already in use in satellites. Many innovative solutions were required to enable their operation in nearly absolute vacuum and temperatures approaching absolute zero.

- 2014. The new building of Light Conversion is opened by the President of the Republic of Lithuania Dalia Grybauskaitė.

- 2014. Vilnius hosts the 15th International Symposium on Laser Precision Microfabrication (LPM 2014). The number of participants was about 230, making it the largest laser-related conference ever held in Lithuania. LPM is the world’s number one meeting of the laser user community where the most advanced developments and recent trends in laser application for fine and precise fabrication of diverse materials are discussed among industry, research and academia representatives. The symposium provided a floor for researchers, end users of lasers and laser manufacturers to discuss the fundamental aspects of laser-matter interaction, the state-of-the-art of laser material processing, and topics for the next generation. It was organized by the Center for Physical Sciences and Technology (CPST), Lithuania and Japan Laser Processing Society (JLPS), Japan.

- 2014. Light Conversion received the Swedish Business Award for the sustainable growth.

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- 2014. Light Conversion received the Swedish Business Award for the sustainable growth.
Research in quantum electronics was started at Vilnius University in 1969 when few young doctors educated in lasers and nonlinear optics at Moscow Lomonosov University came back to Vilnius University. In 1974 the Department of Astronomy and Quantum Electronics (QED) was founded at the Faculty of Physics; the Laser Research Center (LRC) established in 1983 has significantly expanded the experimental infrastructure available for research. Since its foundation, the department has graduated more than 550 students in laser physics, and more than 50 young researchers have completed their PhD research. Currently, the department employs around 40 permanent staff, among which 10 doctors with habilitation qualification and 20 PhDs. Each year, the department hosts around 20 graduate students and more than 40 students follow MSc programs. At modern labs, covering more than 2,000 square meters, research groups are investigating the phenomena of ultrashort pulse optics, biophotonics, laser nanophotonics, laser-induced breakdown and optics testing, parametric light phenomena, ultrafast spectroscopy and femtosecond technology.

QED/LRC has been a member of the European Integrated Laser Infrastructure LaserLab since its inception in 2004, providing transnational access for the researchers from all around the EU. The scientists are involved in joint research activities with the colleagues from the best European scientific centers. New opportunities for the modernization of infrastructure for science and studies were opened by the European Structural Fund projects, such as the creation of the transnational access lasers complex Naglis, the National Center for Physical Science and Technology (laser macro and micromachining, characterization of optical coatings, fiber lasers), and the National integrated program LaMeTech Infrastructure. In addition to the infrastructure development and purchases of cutting-edge equipment, continuous efforts are made to enhance the collaboration with the Lithuanian laser industry and development of high technologies.

Vilnius University Laser Research Center Facility “Naglis”

Head of the open access center: Dr. Arūnas Varanavičius

We are the laser center of excellence with the longest history in Lithuania. Laser Research Center (LRC) established in 1983 on the basis of Department of Quantum Electronics of Vilnius University, where laser science has been developing since 1969. Later, in 2013, LRC started to provide access to their R&D resources at the open access center Laser Research Center Facility “Naglis” of Vilnius University.

Core research and services:
- Optics characterization and laser damage testing
- Nonlinear optics
- Laser 3D micro/nanostructuring
- Femtosecond laser fabrication
- Ultrafast spectroscopy

State-of-the-art laboratories with the wide range of ns and fs laser systems open to business and researches:
- R&D technology development services. We pay great attention to development of technologies and new laser sources in cooperation with companies from the laser technology sector;
- Joint business and science projects,
- Laboratory facilities for hire. We provide access to unique laser systems and measurement devices for qualified employees of business companies.

Address: Saulėtekio Ave. 10, LT-10223 Vilnius, Lithuania
E-mail: laser.apc@ff.vu.lt
Website: http://www.lasercenter.vu.lt/

Address: Saulėtekio Ave. 10, LT-10223 Vilnius, Lithuania
Website: http://www.lasercenter.vu.lt/
The main topics of research include the development of optical components, fiber and solid-state lasers and applications them in material processing. The results of the research are embodied in complicated dielectric optical coatings, high pulse energy fiber lasers, and high power pulsed solid-state lasers for custom technological applications. The interactions between laser radiation and materials are investigated in search of new laser micromachining methods. Part of the research is also directed at the modeling, creation, and characterization of nanophotonic structures, waveguides and metamaterials for light control.

FTMC DLT offers its services for development and implementation of customized laser-based micromachining technologies, specialized solid-state and fiber lasers. It also offers design services, and small-scale production of dielectric optical coatings; also, it performs modeling of waveguides and photonic crystal structures and light propagation within them.

The study of optical properties of semiconductors by using lasers was started at the Semiconductor Physics Department back in the late 1960s and has now evolved into extended investigation of semiconductors and semiconductor heterostructures for electronic and optoelectronic applications. Temporally and spatially resolved luminescence spectroscopy and nonlinear optical techniques are employed as tools to study the interaction between light and semiconductor materials. Research results enable the development of novel solid-state light sources – light-emitting diodes and laser diodes emitting in a wide spectral range, currently expanding into UV region. Research is also focused on the application of solid-state light sources for the detection of hazardous agents, in medicine and transport, disinfection, plant cultivation, customized lighting solutions. Most of the major projects currently being implemented in the total amount of over EUR 1 million per year involve laser light sources as tools to study or fabricate semiconductor devices or materials. Annually, three to four PhD theses are completed.

Address: Saulėtekio Ave. 9, Bldg. III, Vilnius
Website: http://www.ff.vu.lt/lt/

Department of Optoelectronics (DO)
Head: Prof. Habil. Dr. Arūnas Krotkus
Professors: 1
Researchers with PhD degrees: 14
PhD students: 2

The Department of Optoelectronics includes the laboratories of Ultrafast Optoelectronics, Optoelectronic Technologies, Terahertz Photonics and Semiconductor Optics. The main goal of the DO is the development of scientific and technological infrastructure for business and society in order to develop novel optoelectronic devices and optoelectronic systems, and maintaining the competence required for employing these technologies. The focus of the labs is centered on the growth of dilute bismide layers and structures for terahertz and infrared detectors and emitters using molecular beam epitaxy. The lab has developed the first compact THz imaging arrays operating at room temperature that are suitable for security and diagnostic systems. As a consequence, terahertz spectroscopy of carbon nanostructures and their composites has emerged. Another field is the research of nanostructured composite systems – hybrid synthetic photonic opals, pored semiconductors containing magnetic nanoparticles, quasicrystals and quantum semiconductor structures, employing the techniques of spectral ellipsometry and various modulation spectroscopies.

Address: Savanoriu Ave. 231, Vilnius, Lithuania
Website: www.ftmc.lt
The General Jonas Žemaitis Military Academy of Lithuania
Department of Engineering Management
Head: Prof. Dr. Aušrius Juozapavičius
Professors: 1
Researchers with PhD degrees: 3

The department was founded in 1994. One of the directions of research pursued here is the detection of explosives and pollutants using laser-based methods. The scientists of the department are developing selective methods and sensitive equipment for detecting pollutants on army training grounds and the environs, using modern laser techniques. The department also investigates critical phenomena (material destruction) and related changes in transparent media, resulting from intense laser irradiation. The research uses cutting-edge laser technologies and mathematical modeling methods. Close collaboration is maintained with the Institute of Physics, Institute of Biochemistry and company Ekspla.

Address: Šilo St. 5A, Vilnius, Lithuania
Website: www.fmi.mil.lt

Kaunas University of Technology
Institute of Materials Science
Department of Surface and Thin Film Research Laboratory of Optical Technologies (together with KTU Center for International Studies)
Head: Dr. Mindaugas Andrulevičius
Professors: 2
Researchers with PhD degrees: 3
PhD students: 1

The department and laboratory is involved in the applications of laser technologies and optical spectroscopy. Techniques based on laser interference are used for the formation and analysis of periodic microstructures, the methods of holographic interferometry are used for the investigation of deformations in micro and macrosystems. The methods of digital holography are developed and their potential applications in the document security markings are investigated. Optical sensors for real-time measuring of refractive index in liquids are developed and applied in the analysis of biological processes. The laboratory collaborates with the University of Ancona (Italy), University of Southern Denmark and other scientific centers abroad.

Address: Savanorių Av. 271, Kaunas, Lithuania
Website: www.fei.ktu.lt

BALTfab is an open access facility within FTMC with tools and expertise in emerging micro/nanofabrication techniques. Our key feature is multidisciplinary research and competences from photonics and light manipulation to biomaterials and nanobiotechnology. Laser physicists with theoreticians, cell biologists, specialists in electronic and organic chemistry and biophysicists are gathered under one roof from Departments of Laser Technologies and Nanoengineering.

Keywords
- Biocompatible surfaces and biochips
- Electrochemical and plasmonic sensor development
- Laser equipment development: e.g. fiber laser system with control software
- Laser micromachining and lithography
- Soft and scanning probe nanolithography
- Optical coatings, wave guides and photonic-crystal
- Ellipsometric SPR simulations and measurements of self-assembling
- Custom Organic synthesis

Our multidisciplinary team is ready to investigate the synergies between unconventional fabrication methods and explore the possible combinations. Balfab is open for technology consultation, training and education.

Address: Savanorių Ave. 231, Vilnius, LT-02300, Lithuania
E-mail: customer@baltfab.lt
Website: www.baltfab.lt

National Cancer Institute
Laboratory of Biomedical Physics
Head: Prof. Dr. Ričardas Rotomskis
Professors: 1
Researchers with PhD degrees: 5
PhD students: 5

Research of interactions between laser radiation and biological objects began at Vilnius University Laser Research Centre in the 1970s. In 1989, the Lithuanian Oncology Center has started applying photodynamic cancer therapy employing lasers. More than 700 patients received treatment. The Biomedical Physics Laboratory was founded in 2004.

It continues research of interactions between laser radiation and biological objects, including techniques and methods of optical biopsy, photosensitized cancer therapy, biomedical imaging, nanobiophotonics and nanomedicine. The laboratory maintains close collaboration with the University of Oslo and the Norwegian Radium Hospital in Norway, Munich Grosshadern Clinic and Leibniz-Institute of Photonic Technology (Jena) in Germany, Swinburne University of Technology in Australia, Biodesign Institute at Arizona State University in the USA.

Address: Baublio St. 38, Vilnius, Lithuania
Website: www.nvi.lt
Kaunas University of Technology
Faculty of Mechanical Engineering and Design
Department of Production Engineering
Head: Dr. Kazimieras Juzenas
Professors: 2
Researchers with PhD degrees: 33
Graduate students: 4

The department pursues research activities related with the applications of lasers in production processes. Directions of research include the effects of laser irradiation in the thermal processing and microstructuring of engineering materials, laser applications in fast production systems, and integration of laser technologies in production systems. The department collaborates with Lappeenranta University of Technology in Finland, Ilmenau University of Technology in Germany, Tallinn University of Technology in Estonia and other universities and research centers.

Address: Studentų g. 56, LT–51424, Kaunas, Lithuania
Website: www.ktu.edu

Vytuntas Magnus University
Department of Physics
Group of Modeling of Nonlinear Optical Phenomena
Head: Ass. Prof. Dr. Valdas Girdauskas
Researchers with PhD degrees: 2

The group works on the theoretical modeling of the propagation of short laser pulses in the media with quadratic and cubic nonlinearity and thermal effects on laser active media. Numerical modeling methods for these phenomena are developed and applied in solving research problems. The modeling is performed in collaboration with the researchers from the Nonlinear Optics and Spectroscopy and Applied Research laboratories of the Institute of Physics. The group collaborates with Ekspla and the Center for Ultrafast Optical Science at the University of Michigan (USA).

Address: Vileikos St. 8, Kaunas, Lithuania
Website: www.mgk.me.vgtu.lt

Vilnius Gediminas Technical University
Faculty of Mechanics
Department of Mechanical Engineering
Research Laboratory of Vibroacoustics and Diagnostics
Professors: 2
Researchers with PhD degrees: 2
PhD students: 2

Research Laboratory of Vibroacoustics and Diagnostics
Head of laboratory: Prof. Dr. Vladas Vekteris

The Vibroacoustic Research and Diagnostics Science Laboratory (VRLD) was established at Vilnius Gediminas Technical University, Faculty of Mechanics, Department of Machine Engineering 16th of November 1993. VRDSL performs vibrodiagnostics and monitoring of different mechanical systems: compressor stations, gas pumping stations, pump-houses, air blowing, electric motors, motors of internal combustion, turbines, turbo motors, turbo generators, technological equipment (machine tools etc.), carloads, locomotives, mechanical devices, printing-polygraph machines, automobiles and their assembly units. The commonly arising problems of detection, analysis and damping of noise sources are solved, and other electro-acoustic research tasks are performed. In addition, the laboratory performs research of tribological losses in the sector of energy transformation, transport, and general machine production, defines wear reasons, recommends the solution for durability increase and necessary lubricant additives, and other energy saving methods; measures light levels and selects location of luminaires in work places, performs the balancing of revolving parts in workplaces. Vibrations and errors of precision linear and angular comparators are analyzed using laser-based methods. The laboratory also investigates noise and oscillations and the methods allowing to reduce them; performs vibroacoustic assessment and diagnostics of industrial objects and mechatronical systems; testing of vibrostands; balancing of rotors; investigations of tribological systems (i.e. materials of lubrication, friction, wear, tribological pairs); jobs of design and manufacturing of machines and equipment, scientific expertise’s, researches of machine functioning quality.

Address: Basanavičiaus St. 28, Vilnius, Lithuania
Website: www.mgk.me.vgtu.lt

Vilnius Gediminas Technical University
Faculty of Mechanics
Department of Mechanical Engineering
Research Laboratory of Vibroacoustics and Diagnostics
Professors: 2
Researchers with PhD degrees: 2
PhD students: 2

Research Laboratory of Vibroacoustics and Diagnostics
Head of laboratory: Prof. Dr. Vladas Vekteris

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Address: Basanavičiaus St. 28, Vilnius, Lithuania
Website: www.mgk.me.vgtu.lt
Altechna  
Established: 1996  
Director: Mindaugas Anužas  
Staff: 58

Altechna is a reliable supplier of custom and standard laser optics, polarization optics, laser and nonlinear crystals, lasers and laser accessories for manufacturers of femtosecond lasers, academic, and industrial customers.

**Company key activity fields:**

- Laser related components: laser optics, crystals, lasers and optomechanics.
- Distribution of well-known photonics industry brands in local markets: motion control; scientific cameras; spectroscopy; laser systems.
- R&D solutions in laser optics: optical systems; optomechanics; laser optics.
- Manufacturing of laser related components: optical coatings; optical elements; laser related devices; optical systems.
- Quality assurance and measurements to guarantee the highest quality – metrology laboratory.

*Altechna* engineers not only find out more about the needs of the clients, but also advise them and, if necessary, find new solutions in the market. Developing new concepts with our R&D professionals we’ve created products that changed the use of lasers in various industries. A considerable number of successfully implemented complicated non-standard orders speak of our expertise.

Altechna – your custom optics supplier

Address: Mokslininkų St. 6A, LT-08412 Vilnius, Lithuania  
Website: www.altechna.com

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Workshop of Photonics  
Established: 2007  
Director: Eugenijus Kurtinaitis  
Employees: 16

*Workshop of Photonics* (brand of the company Altechna R&D) is all about laser micromachining. We develop instruments and solutions for laser micromachining tasks: from feasibility studies to customized optical modules and from electronic devices to laser machines. Our services are targeted to both industrial and academic customers.

**Workshop of Photonics key competencies:**

- Feasibility studies on femtosecond laser micromachining
- Development of custom femtosecond laser micromachining workstations and optical modules
- Small scale production (job shop) in the area of laser micromachining
- Laser system automation software

The products made by Workshop of Photonics are used in industry (to increase the effectiveness and precision of manufacturing and other processes), in medicine (to improve devices), and in the scientific field (to carry out various tasks).

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Optida  
Founded: 1997  
Director: Mindaugas Bružas  
Employees: 51

Optida is the largest Lithuanian company, among the Eastern and Central European Union countries, that focuses on research, design, development and manufacturing of optical coatings and components for laser systems and optical devices targeting leading OEM’s. Main products are high-precision interference filters, light and beam splitters, polarizers, dielectric high reflection mirrors, anti-reflective, protection and decorative dielectric interference coatings. The company collaborates with technological and research institutions such as Optical Coating Department of CSPT Institute of Physics (the department foundation was initiated by Optida), Laser Research Centre of Vilnius University and other laboratories or research centers. Continuous technological improvements, investments in R&D activities, complex technological solutions and professional staff with years of experience, are the key factors that determines the best results of the company.

**TOP solutions:**

- Ultra High UDT Mirrors  
- Low Loss Optics  
- Complementary Chirped Mirror Pairs  
- Low Tension Coatings

WE START where others stop

Address: Savanoriu 231, Vilnius, LT-02300 Lithuania  
Website: www.optida.lt

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Aštuonetas  
Founded: 1994  
Director: Dr. Jonas Oberauskas  
Employees: 7

Aštuonetas offers the services of laser marking, microwelding and cutting. The company develops in-house laser marking software and equipment. The customers of the company include advertisement producers, manufacturers of optomechanical and electronic equipment, printers, jewelry producers, organizers of events and shows etc.

Address: A. Goltauto St. 12, LT-01108, Vilnius, Lithuania  
Website: www.astuonetas.lt
**Brolis Semiconductors**

Founded: 2011  
Director: Dominykas Vizbaras  
Employees: 13

*Brolis Semiconductors* is a infrared laser diode maker offering a range of products from 800 nm to 3000 nm for industrial, medical, research and defense applications. Company develops state-of-the-art:

- High-power CW GaAs laser diodes at 800 nm – 1100 nm with E-O efficiency up to 60%  
- High-power CW GaSb laser diodes at 1500 nm – 3000nm with E-O efficiency of 30%  
- Single-mode laser diodes at 1500 nm – 3100 nm  
- SLDs and gain chips at 1500 nm – 3100 nm offering > 100 nm tuning/chip

Brolis runs a state-of-the-art 210 m² class ISO 6 cleanroom facility dedicated for III-V semiconductor epitaxy, laser diode testing and packaging. The company is ISO 9001:2008 certified.

Address: Moliety Rd, 73, LT-14259, Vilnius, Lithuania  
Website: www.brolis-semicon.com

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**Eksma**

Founded: 1983  
Director: Dr. Petras Balkevičius  
Employees: 8

*Eksma* is an umbrella company of a group that has been working in high technologies for over 30 years. *Eksma Group* includes two companies involved in laser technologies, *Ekspla and Optolita (Eksma Optics).* The start of *Eksma Group* was in 1983, when the Experimental Plant of Laser and Electronic Equipment was established at the Institute of Physics of the Academy of Sciences. In 1988, *Eksma* was the first company in Lithuania, rented out by the state to its employees. *Eksma* is a shareholder of the joint Lithuanian-Russian company *Sibirskij Monokristall-Eksma* specializing in the growth of nonlinear and laser crystals. In addition to laser business, the company is involved in the sales, installation and support of medical and laboratory equipment (*Eksma* is one of the large shareholders of *JSC Bioeksma*).

Address: Mokslinkinkų St. 11, LT-08412, Vilnius, Lithuania  
Website: www.eksma.lt

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**EKSMA Optics**

Founded: 2006  
Director: Dainius Tumosa  
Employees: 39

*EKSMA Optics* is a manufacturer of precision optical laser components, used in lasers, laser systems and in other photonic instruments. Utilizing more than 30 years of expertise in the laser and optics fields The Company has proven experience providing custom solutions and also offering a wide range of catalogue products for the fast off-the-shelf delivery.  

*EKSMA Optics* annually exports its products to more than 60 countries around the world. Product range includes optical components, dielectric thin film coatings, DKDP, BBO and KTP Pockels cells, laser & nonlinear crystals, optical systems, opto-mechanical mounts, motorized stages, optical tables and ultrafast pulse picking systems. Components cover by applications a wavelength spectrum starting from UV (193nm) through VIS to IR (20μm) and at terahertz (1-5 THz) ranges.  

Company owns clean room facilities for components assembling and polishing facilities which specialize in the polishing of optics made of BK7, UVFS, Infrasil and also DKDP, LBO, ZGP crystals where precision polished faces are required for high power laser applications.  

All components are subject to quality testing and certifications in Quality Control laboratory.  

*EKSMA Optics* is an ISO 9001:2008 certified company.

Address: Mokslinkinkų St. 11, LT-08412, Vilnius, Lithuania  
Website: www.eksmaoptics.com

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**Ekspla**

Founded: 1992  
Director: Kęstutis Jasiūnas  
Employees: 126

*Ekspla* is a manufacturer focusing on high-performance advanced solutions. Drawing on 30 years of experience and close partnership with the scientific community, it designs, develops and manufactures solid-state lasers, laser systems and accessories for R&D and industrial applications; complete spectroscopy systems; ultrashort fiber lasers; high energy laser systems; and laser optoelectronics.  

Strong R&D team enables customizing and supplying products from single unit to OEM series. In-house design and manufacturing ensures effective development and manufacturing of new products. Products are available from several standard units for R&D applications to series customized solutions for OEM (Original Equipment Manufacturers).

The in-house design and manufacturing ensures effective development and launch of new products. High peak power laser systems, short pulse generation and amplification, tuneable nonlinear OPO/OPG/OPA and nonlinear spectroscopy are among *Ekspla* core competencies. The company is one of the few in the world that make SFG spectrometers for material surfaces investigation.  

*Ekspla* exports 90% of its production to more than 60 countries worldwide. Customers include the most famous universities across Europe, the USA and Australia, CERN, Cambridge University, Lawrence Livermore National Laboratory, NASA, RIKEN Nishina Center in Japan and the Chinese Academy of Sciences.  

*EKSPA* has become proficient in carrying out EU projects, both international (FP7, EuroStars, Eureka) and national (in the framework of structural funds). The cooperation involving numerous partners taught new knowledge and skills, and widened EKSPA’s scope.  

In 2011, EKSPA became the first company from Central and Eastern Europe to win the *Prism Award for Photonics Innovation* (known as the Oscar of the photonics industry). In 2012, Ekspla was named the Business IQ of the Year at the Swedish Business Awards ceremony. Every two years the national *Innovations Prize* is received either for some exceptional new product or awarded to the entire company.

Address: Savanorių Av. 237, LT-02300 Vilnius, Lithuania  
Website: www.ekspla.com
Evana Technologies
Founded: 2012
Director: Dr. Egidijus Vanagas
Employees: 5

The business of Evana Technologies is the commercialization of light and laser technologies and the manufacture of systems employing these technologies for industry. Activities related to technologies development for processing materials with a laser beam. Specifically at present, the development and manufacturing OEM solutions for semiconductor industries for scribing sapphire and silicon carbide wafers.

Address: Mokslininkų St. 2A, LT-08412, Vilnius
Website: www.evanatech.com

Geola Digital
Founded: 2003
Director: Dr. Stanislovas Zacharovas
Employees: 12

World-wide holography leader, Geola is the inventor of digital holographic printing using pulsed lasers, hologram copying with laser radiation slit method and other methods and instruments used in modern imaging and security holography. In addition, the company has developed customized pulsed lasers for holography. Since the lasers for holography have exceptionally good lasing properties, they can also be used for research purposes. Lasers manufactured by Geola are employed at such R&D centers as Rutherford Appleton Laboratory, Indira Gandhi Atomic Research Centre and others.

Geola is the only company in the world producing security holograms with deep 3D image. Address: Naugarduko St. 41, LT-03227, Vilnius, Lithuania
Website: www.geola.com

Elas Ltd.
Established: 2010
Director: Saulius Mikalauskas
Employees: 11

Elas is Lithuanian manufacturer of laser micromachining systems. Highly customized micromachining workstations incorporate nanosecond, picosecond and femtosecond laser sources in combination with advanced beam steering in order to achieve micrometer scale machining precision and repeatability.

In depth knowledge of micromachining processes is at the disposition of Elas’ engineers, since it comes from two associated application labs. Processes are tested for feasibility, tuned for performance and skillfully embodied into reliable and efficient workstations. Know-how is being accumulated mainly for ablation, drilling, scribing and intro-volume marking processes, whereas ever extending range of materials, already includes silicon, SiC, sapphire, diamond, tungsten carbide, biological materials, biodegradable polymers, glasses, majority of metals, ferroelectric ceramics, etc.

Special attention is always paid to ergonomics and safety of the systems. Company’s advantage is the ability to meet sophisticated functionality requirements. Due to this, Elas’ customers varies from world famous universities, research centers to industrial companies.

Applications:
- Metals micro-marking
- Laser drilling for solid oxide fuel cells
- Ultra short pulse laser micro machining
- Scribing of thin films
- Patternning glass coating
- Silicon wafer cutting
- Tungsten carbide / Cermet ablation
- PET drilling / Selective ablation

Address: Savanoriu Ave. 231, LT-02300, Vilnius, Lithuania
Website: www.e-lasers.com

FEMTIKA
Founded: 2013
Director: Evaldas Pabrėža
Employees: 14

Femtika is a Vilnius University Laser Technology Center spinoff company with deep working knowledge in the area of laser polymerization and optics solutions. The main activities of the company are the design and production of custom 3D laser precision micro processing systems and the fabrication of 3D micro- and nano- structures using the femtosecond laser for applications in different fields, such as tissue regeneration, photonics, micro optics, micro fluidics, mTAS, etc. Femtika is working in two promising new areas of femtosecond laser enabled formations in micro and sub micro levels:

1. Three-dimensional polymer micro formations technology based on laser two-photon initiated polymerization reaction;
2. Three-dimensional photonic crystal development using direct laser writing to glasses or polymers.

Motto of Femtika: we can materialize microscopic version of anything you can imagine in 3D.

Website: www.femtika.it

Integrated Optics
Founded: 2012
Director: Evaldas Pabrėža
Employees: 14

Integrated Optics is a manufacturer of ultra-compact CW laser sources as well as miniaturized pulsed lasers. Proprietary manufacturing technology allows tight integration of optics and electronics.
The MatchBox series of lasers consists of direct diode and DPSS lasers covering over 25 different wavelengths. These continuous wave lasers are most compact on the market and feature superior power stability, low noise and most of them have narrow-spectrum versions, including a single frequency option. Single-mode fiber and PM fiber options are also available. Compact MatchBox lasers are used in numerous life science applications, such as Raman spectroscopy, fluorescence imaging, food sorting as well as diagnostics.

Address: Kalvarijų st. 125, LT-08221, Vilnius, Lithuania
Website: www.integratedoptics.com

**Light Conversion**

Founded: 1994
Director: Dr. Algirdas Juozapavičius
Employees: 118

Light Conversion is the leading manufacturer and global leader of tunable wavelength femtosecond laser systems. Femtosecond optical parametric amplifiers produced at Light Conversion take up to 80% of the world market. The main products of the company are TOPAS and ORPHEUS series optical parametric amplifiers, diode-pumped femtosecond laser system PHAROS, time-resolved absorption and fluorescent spectrometers. In 2014, the company had more than 1,800 optical parametric amplifiers and over 300 PHAROS systems installed worldwide. Light Conversion exports about 95% of production. Its customers include industrial companies and research institutions in more than 40 countries. The largest part of the production is exported to Germany, Japan, the USA, China, and Great Britain. Currently, the company has 24 representatives in the European, North American and Asian countries dedicated to product sales and service.

Address: Keramikų St. 2B, LT-10233, Vilnius
Website: www.lightcon.com

**Lidaris**

Founded: 2012
Director: Dr. Andrius Melninkaitis
Employees: 6

Lidaris Ltd. is the provider of laser optics characterization and certification services mainly delivering Laser-Induced Damage Threshold (LIDT) and Total Integrated Scattering (TIS) related measurements. The company is also offering laser optics manufacturing process optimization services based on Design of Experiments (DoE) approach as well as other R&D services related to original hardware and software development. Lidaris was founded as a spin-off of Vilnius University Laser Research Center in Lithuania (EU) after more than 10 years of intense research in the field of laser damage phenomena. The core of Lidaris staff consists of scientists and PhD students: mainly graduates and former Faculty of Physics employees of Vilnius University. The company is operating highly sophisticated measurement systems dedicated to accurate LIDT and TIS testing in accordance with currently existing international (ISO) standards. Lidaris is acting in the global market serving European, American and Asian companies worldwide – the leaders of today’s laser market, including manufacturers and suppliers of optics and laser systems.

Address: Saulėtekio Al. 10, LT-10223, Vilnius, Lithuania
Website: www.lidaris.com

**Lifodas**

Founded: 1994
Director: Piotr Levin
Employees: 79

Lifodas is the manufacturer of fiber optical components and portable test and measurement instruments for fiber optics, including optical reflectometers, testers, attenuators, light sources, power meters.

Address: Naugarduko St. 41, LT-03227, Vilnius, Lithuania
Website: www.fods.com

**Optinės Dangos**

Founded: 2003
Director: Kęstutis Niaura
Employees: 4

Optinės Dangos offers a wide range of unique optical coatings that match the highest quality standards. The company’s products are used in lasers and other optical systems that are applied in a number of areas. Optinės Dangos uses in-house developed technologies allowing the company’s products to achieve unprecedented reliability, innovativeness and meet very high technical requirements.

Address: A. Goštauto St. 12, LT-01104, Vilnius
Website: www.opticalcoatings.lt
Email: info@opticalcoatings.lt; odangos@gmail.com

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Email: info@opticalcoatings.lt; odangos@gmail.com
Optoteka, Rimkevičius and Gintautas, general partnership
Founded: 1991
Director: Remigijus Rimkevičius
Employees: 30

Optoteka is the developer and manufacturer of precision optical components from optical glasses and crystals. Such components are used in the manufacturing of optical equipment for research, industry, medicine, lighting, etc. Component production is based on the unique in-house technologies, created in 1993, which is constantly being developed. This enables manufacturing extremely high quality products. In addition to the main production, the company is the manufacturer of mechanical components for lasers. The company exports 40% of its production. The ultrathin scatter-free optical crystals and linear optical elements are widely known in more than 30 countries worldwide. The company has a number of regular customers, and maintains long-term close collaborations.

Address: Mokslininkų St. 11, LT-08412, Vilnius
Website: www.optoteka.com

Optronika
Founded: 2006
Director: Mindaugas Stankevičius
Employees: 6

Optronika is the producer of RGB laser projectors for industry and advertisements, unique shutters for laser micromachining, chillers for research equipment, optical analyzers of cleaning quality and freezing point of liquids and other spectrometric equipment. Currently, Optronika is participating in a cluster project developing a new generation laser-based orthopedic devices and energy-efficient building solutions. The company also manufactures laboratory and education equipment for research institutions. The company is also the largest provider of laser advertisement and illumination services for events, exhibitions, and concerts.

Address: Kalikštikės, Maišiagala Township, LT-14247, Vilnius Distr., Lithuania
Website: www.optronika.lt

Quantum Light Instruments
Founded: 2014
Director: Andrius Rinkevičius
Employees: 2

Quantum Light Instruments Ltd (QLI) is focusing on development and production of diode-pumped solid-state lasers for analytical instrument and research. Our product range starts with compact air-cooled pulsed Q-switched lasers and ends with advanced solutions featuring controlled pulse waveform or coherence length. QLI also offers equipment for laser beam quality diagnostics and active control.

Address: Mokslininkų St. 6A-351, LT-08412, Vilnius, Lithuania
Website: www.qlinstruments.com

Sprana
Founded: 2012
Director: Dr. Raimundas Steponavičius
Employees: 7

Sprana is a new high-tech company of applied spectroscopy providing solutions for online monitoring and analysis of industrial processes (streams). The main focus is the quantitative analysis and characterization (i.e. estimation of the particle size distribution) of light scattering media using advanced UV-Vis-NIR spectroscopic methods and techniques. Research and development of new analytical instrumentation/solutions (process analyzers) along with multivariate calibration models is one of the key work areas.

Address: Mokslininkų St. 6A, LT-08412 Vilnius
Website: www.sprana.eu

Standa
Founded: 1987
Director: Dr. Michail Berba
Employees: 140

Standa is one of the largest European companies designing and manufacturing high-precision mechanical components for photonics. The company also develops and manufactures DPSS sub-nanosecond SLM microlasers for research, and in-
Tertifies them in biological, chemical and medical spectroscopic equipment. Standa produces high-precision mechanical and optomechanical devices (nanometric precision motorized and manual positioners of optical components, translation and rotation stages, motion control for vacuum, fine adjustment screws, micrometer screws), optical honeycomb tables, vibration isolation equipment (e.g. for atomic force microscopes), light power and energy meters. The company exports over 90% of production to more than 60 countries worldwide. Its products are widely used in the research labs of Lithuanian universities and research institutes.

Address: Švitrailgos St. 4–39, LT-03222, Vilnius, Lithuania
Website: http://www.standaphotonics.com

Teravil
Founded: 2006
Director: Dr. Gediminas Molis
Employees: 7

Teravil is a developer and manufacturer of the terahertz (THz) range spectroscopic systems and components. Company’s competence lies in developing and manufacturing of THz radiation spectroscopy systems based on solid state or fiber lasers and photoconductive antennas. Currently, the company manufactures and sells THz radiation sources and receivers, for use with ~800 nm and ~1000 nm wavelength lasers, and complete THz spectroscopy systems based on these devices. Nearly 100% of the production is exported.

Address: A. Goštauto St. 11, LT-01108, Vilnius
Website: www.teravil.lt
Altos Photonics, Inc. offers lasers & laser systems, optics, crystals, opto-electronics, and opto-mechanical components to research institutes and industrial customers. Since 1995, we have worked with customers and suppliers to enable breakthrough technologies, innovative products, and cutting-edge research by matching our clients’ application requirements to products from our supplier-partners Ekspla, Light Conversion, Eksma Optics and Standa.

Our pulsed lasers range from high-energy systems used in high-energy physics and non-linear spectroscopy to DPSS systems used in micro-machining and ultra-fast applications. Our femtosecond, mode locked, and Q-switched lasers and tunable OPO/OPA systems are used by leading scientists in their quests to understand chemical processes and interactions, biologic processes, and to understand basic questions of physics. Passive laser components include UV and IR optics, non-linear crystals (BBO, KTP, ZGP, KYW, KGW, etc.), optical mounts, and motorized stages & positioners. Opto-Electronic products include high energy flashlamp drivers, Pockel’s cell drivers, laser pump chambers.

Together with our outstanding customers, we are working to improve our environment and human health by enabling advances in clean energy, bio-medical polymers, heart stent manufacturing, battery technology, cancer treatment, eye cataract surgery, and in understanding of environmental interactions related to climate change.

We actively encourage laser safety by promoting laser safety products and by participating in ANSI Z136 the committee for laser safety, working to define and implement standards for the safe use of lasers.

Altos Photonics is managed by Lucian Hand, president and shareholder, together with major shareholders Light Conversion and Ekspla.

Address: 201 South Wallace, Suite B-2C, Bozeman, MT 59715, USA
Website: www.altosphotonics.com

Ekspla Shanghai representative office is established to expand and to support sales of industrial lasers and optoelectronics devices to customers from mainland China. The sales of picosecond and nanosecond DPSS and fiber lasers is expected to increase significantly in this country due to concentration of advanced manufacturing industries: electronics, medical devices, transportation vehicles, new energy solutions and other fields where ultrafast solid-state laser based microprocessing equipment is used. The strategic decision to open the office in China was based on the photonics market trends and Ekspla’s general intention to expand to industrial market segment.

The office is also managing the sales of Eksma Optics photonics products to China’s OEM customers and provides marketing support to other Lithuanian partners or associated companies. The office is capable of providing servicing and technical support to Ekspla clients located in East Asia region since beginning of year 2014.

Address: Ekspla Shanghai representative office, Suite 3008, Bldg 4, No.18 Huangyang Road, Pudong, Shanghai, 201206, P.R. China
Websites: www.eksplachina.cn ; www.eksmaoptics.cn

Сибирский монокристалл – ЭКСМА (Sibirskij Monokristall – EKSMA)

Country: Russia
Founded: 1999

Sibirskij Monokristall-EKSMa is a joint Lithuanian-Russian venture. Almost 50% of the shares of this company is owned by the company Eksma. The company is the manufacturer and vendor of nonlinear optical and laser crystals. The manufacturing is based on unique in-house developed technologies and the company has extensive experience in material characterization. A part of the production of the company is marketed via Optolita, another company of Eksma Group. Sibirskij Monokristall-EKSMa closely collaborates with the Institute of Geology and Mineralogy of the Russian Academy of Sciences, and the Institute of Applied Physics.

Address: Ul. Russkaya 43, Novosibirsk, Russia