NATIONAL INSTITUTE FOR LASERS, PLASMA AND RADIATION PHYSICS
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The **National Institute for Laser, Plasma & Radiation Physics (INFLPR)** is an independent, national importance research institution established by the Government of Romania. INFLPR was founded in 1977, with the mission to advance the knowledge in several strategic areas of the sciences and technologies related to laser, plasma, and radiation physics. In 1996 INFLPR was reorganized to include the Institute of Space Sciences (ISS).

The institute employs 450 researchers and administrative staff to conduct frontier research ranging from basic photonic materials and high power lasers, nanomaterials and nanotechnologies, quantum dots and information technologies, plasma physics and X-ray microtomography to industrial photonics, biophotonics and plasma coatings. ISS branch conducts research on astrophysics, space engineering and gravitation

INFLPR is pursuing advanced scientific research at the highest international standards, funded by national and international agencies, private institutions and enterprises.

The Institute is currently a member of the EURATOM association, a partner in the Extreme Light Infrastructure (ELI), partner in LASERLAB EUROPE, ALICE, and a leader in many projects funded by the EU, NATO, and other international organizations.

We commit ourselves to education and public outreach, free dissemination of knowledge, develop and qualify the human resources by involving students in the research process. The Institute encourages the pursuit of appropriate partnerships with the industry and transfer the knowledge and technology for the benefit of the society.

The main domains of the activity are: high power lasers and applications, bio/nano photonics & nanomaterials, plasma research for fusion, space related sciences and technology, applications of space communication techniques.
INFLPR covers areas of research related to:

A. - High power lasers and applications:
• active centers in photonic materials; quantum electronic processes; X-ray laser development;
• laser biomedicine & laser micromachining;
• high energy secondary standard dosimetry;

B. - Bio/Nano Photonics & Nanomaterials:
• nanoparticles synthesis by laser pyrolisis; nanometrology; nanostructured films & particle functionalization; nanomaterials synthesis by plasma;

• biomolecular laser spectroscopy; biocompatible thin film deposition
• nonlinear nanophotonics; soliton waveguide arrays; quantum dots and metamaterials; plasmonic structures; micro/nano patterning;

C. - Plasma Research for Fusion:
• atomic processes and fusion related atomic physics; hot plasmas and nuclear fusion; plasma surface engineering;
• plasma sources & plasma coatings for fusion technology;

D. Space Science and Applications:
• High Energy Physics and Astrophysics; Theoretical physics and Mathematical Physics;
• Astroparticle Physics and Cosmology;
• Space technology and Hardware for space experiments (on-board and ground segment) and satellite data processing; Experiments, data analysis, and theoretical developments on space plasma;
• Microgravity, Space dynamics and Microsatellits;
• Distributed and parallel computing in Space and Terrestrial researches and applications;
• Applications of space and communication technologies.

The most important achievements during the last years

- Integrated Center for Advanced Laser Technologies (CETAL) which hosts a 1 Petawatt pulsed laser –WORLD CLASS RESEARCH FACILITY (see projects)
- EURATOM-which represents Romanian contribution to a task of the European Fusion Programme and is performed in close collaboration with several European Associations. (see projects)
- Development of the Combined Magnetron Sputtering and Ion Implantation (CMSII) technology from laboratory to industrial scale; application of this technique for the first wall in nuclear fusion devices JET, Culham Centre for Fusion Energy, UK and ASDEX Upgrade, Max-Planck Institute for Plasma Physics, Garching Germany. (see projects)
- BONSAI (Bio-Imaging with Smart Functionalized Nanoparticles, Contract number LSHB-CT-2006-037639) project co-funded under the European Commission's Framework 6 Programme and in the MagPro2Life (Contract number CP-IP 229335-2-2009- KMPT) project co-funded under the European Commission's FP 7;
- laser spark-plug for car engine ignition (over 300 citation in international mass media!). the realization of a compact, robust and resilient laser spark device that can be installed directly on an automobile engine is continued with Renault Technologies Romania carring out tests on efficiency and noxes .
- The first Romanian space experiment aboard the International Space Station (uploaded by the Space Shuttle “Discovery” in February 2011, and the first Romanian nano-satellite “Goliat”, selected by the European Space Agency (ESA) and launched by the VEGA rocket in January 2012

THE CENTRE FOR ADVANCED LASER TEHNOLOGIES
(CETAL)

The CETAL facility is being developed at the National Institute for Laser, Plasma and Radiation Physics (NILPRP), Bucharest-Măgurele. It is a world class facility and the first centre for research in the field of photonics in Romania and in South-Eastern Europe.

CETAL will enable new basic/applied exploratory research activities in physics, chemistry, biology /medicine, energy, material science, manufacturing, etc., providing a direct benefit to the Romanian economy and to society.

The centre consists of three major labs:

- Hyper-intense laser – mater interaction laboratory
- Laboratory for advanced technologies by laser processing
- Laboratory for photonics investigations

One of the main research fields will be in the frontier scientific domain of hyper-intense laser beam-matter interaction at levels of the electromagnetic radiation density over 10^{20} W/cm^2. The main equipment is a high power femtosecond laser system of 1 PW/25 fs. Specific experiments: physics of extreme states of matter in hyper-intense optical fields, accelerated particle beams, higher harmonic generation, X-ray beams, etc.). *This laboratory will provide a major role in training of the specialists for Extreme Light Infrastructure –Nuclear Physics (ELI-NP) and will allow the study of technological issues which must be overcame for ELI-NP laser systems.*

A suite of equipment (pulsed and CW lasers) will be dedicated for diverse exploratory research activities with applications in material processing or material synthesis, from macro to micro and down to the nanoscale level (drilling, welding, cutting, pulsed laser deposition, 3D laser lithography, photochemistry, etc.). New advanced technologies will be especially developed for Small-Medium-Enterprises (SMEs). The synthesis of new materials (metamaterials, photonic crystals, nanomaterials, etc.) will also be promoted.

Another area of investigations in the field of photonics will deal with the evaluation and application of optical radiation over the entire spectral domain between 180 nm (UV) and 1 mm (THz) (measurements, testing, metrology and education). The laboratory will facilitate studies such as: optical frequency reference based on frequency comb laser, optical clocks, chemical identification/imaging, THz technologies, coherent and non-coherent optical spectroscopy, laser metrology, etc.

CETAL will be an opportunity for the scientific photonics community to accede to the forefront of advanced research and to strengthen the innovative and technological capabilities of SMEs. INFLPR will step up the public and SMEs attention in leading-edge photonics technologies creating a rich research environment to attract SMEs, researchers, academics, and students. Encouraging spin-off products and/or start-up companies will be another goal.

The implementation of CETAL will foster mutually beneficial research collaboration on a national and European level, NILPRP joining to the European Union efforts to develop regional R&D activities.

The EURATOM Project

The National Institute of Laser, Plasma and Radiation Physics (NILPRP) has the most important contribution, within the Romanian participation to the research on controlled thermonuclear fusion in magnetically confined plasma, which is a priority domain of the contemporary research in physics, with the objective of creating a clean, safe and sustainable source of energy. The fusion research is organized in Europe with the direct involvement of the European Commission as an effectively integrated activity with common work plan and very strong collaborations.

Romania became a full member of the European structure, and funded the Association EURATOM-MEdC Romania for Fusion in 1999, long before Romania's integration in the EU. The Association coordinates, at the national level, the activities of several research groups from four national institutes and two universities. The Association had an expansion period until 2007, and subsequently it stabilized to around 90 researches, 30 ppy and 1.4 million Euro per year. The budget includes the contribution of the European Commission, which is around 33%.

NILPRP has the central role in this structure, and most of the contributions have been obtained in this institute. Since 2008, NILPRP provides the leadership of the EURATOM-MEdC Association (Florin Spineanu in the period 2008-2011 and Madalina Vlad since April 2011). The research program is complex and includes topics of tokamak plasmas physics, plasma wall interaction, wall coatings and analysis, technologies and micro production tasks. Each topic represents Romanian contribution to a task of the European Fusion Programme and is performed in close collaboration with several European Associations. Nine research teams from several Laboratories of the NILPRP (about 60 researchers) participate in this program. The integrated organization combined with the very strong European collaborations within each topic lead to a very high standard of these researches. The results of the Romanian teams are evaluated by the most recognized European experts working in exactly the same area. Researchers from NILPRP participate to the experimental programme of JET, which is the most advanced tokamak in the world.

A series of important results have been obtained both in technological research and in understanding fundamental aspects of the complex plasma processes in tokamak. These contributions were highly appreciated at EURATOM, and were positively mentioned on several occasions.

Working in the EURATOM context has improved our skills and has raised the standards of rigor and exigency, propagating this beneficent influence to other areas where NILPRP is involved. The number of researchers attracted by EURATOM subject areas has steadily increased and we expect that in future this tendency will continue.

Development of a new technology for tungsten coating of carbon based materials for the first wall in nuclear fusion devices (EFDA Task Agreement: JW6-TA-EP2-ILC-01)

As a result of a large international cooperation (Europe, Japan, Russian Federation, Korea, USA, etc.) the first fusion reactor (ITER - International Thermonuclear Experimental Reactor) will be build in south of France at Cadarache. It is designed for a nuclear power of 500 MW. In the core of a magnetic confined fusion plasma the temperature is in the range of 50-100 millions Celsius degrees. The first wall temperature can reach in some areas (divertor) 2000 °C. The current strategy for the ITER first wall is beryllium for main chamber and tungsten for divertor, but this configuration was never tested on a relevant tokamak. This is why the ITER-like Wall (ILW) project, with a value of about M€60, was lunched at JET (Joint European Torus) with the aim to replace the CFC (Carbon Fiber Composite) wall with a new one containing materials designed for ITER. JET is located at Culham, UK and it is the biggest operational tokamak in the world.

Since a large number of CFC tiles (about 1800) had to be tungsten coated, in order to minimize the risk for the project, a competition was lunched in the R&D phase with the aim to identify the best European technology for W coating of this material. In this competition, INFLPR used the Combined Magnetron Sputtering and Ion Implantation (CMSII) technique that has been developed in house during the last decade.

All W coated samples were tested at Max-Planck Institute for Plasma Physics (IPP), Garching, Germany according to a Specification agreed by all Associations. During the high heat flux tests the W coatings reached in some cases 2000 °C or even more. The only coatings which survived these tests were those deposited by CMSII technology. During the next two years CMSII technology was developed from laboratory to industrial scale including design, manufacturing and commissioning of a new coating unit with 24 magnetrons and a power of 25 kW. This was an interdisciplinary project with practically no literature data available.

After qualification of the W coating technology for each type of tile the production process started. A very strict quality control procedure in accordance with ISO 9001:2001 standard was implemented in INFLPR. Production of these coatings took about 2 years. In August 2011 the first plasma was produced in JET with the new ITER like wall and the W coatings behaved very well during the experimental campaigns.

Our activity in the field of W coating was highly appreciated by European Union with different occasions. *"Romanian scientists have developed a new technology for reinforcing the wall of a fusion reactor to resist hot plasma. This marks an important step forward for the success of ITER, the world's biggest experimental fusion reactor. The "Combined Magneton Sputtering and Ion Implantation" Technology (CMSII) - developed by the Romanian Fusion Association (Euratom/MEdC) - which is a member of the Euratom Fusion Research Programme - has been chosen as the best "coating technique " in terms of resistance to the high heat loads." (News Alerts on EU Research_14 August 2009).*

Due to the high quality of our W coatings, since 2008 IPP Garching changed the W coating supplier for ASDEX Upgrade tokamak and now we are working for IPP on commercial bases. In addition, we have initiated collaborations with CEA Cadarache, France and Consorzio RFX Padova, Italy for W coating a large number of graphite tiles for other fusion devices.

LASER SYSTEM FOR IGNITION OF AN AUTOMOBILE ENGINE

In response to concerns about the global environment and dwindling fossil fuel resources, research and development into clean vehicles and clean energy sources has been progressing worldwide. It is difficult, however, to replace immediately all conventional gasoline vehicles to clean vehicles due to lack of infrastructure, cost, performance, as well as to some technical problems. Therefore, in present, the improvement of the efficiency of conventional internal combustion gasoline engines and the reductions of CO and NOx harmful pollutant emissions are very important subjects of research and action.

The project main goal is realization of a compact, robust and resilient laser spark device that can be installed directly on an automobile engine. This include the laser spark itself, but also the developing of the laser and the engine control unit(s), which in this case is different of a classical laser spark. The flame dynamic of the engine has to be recorded and analyzed, and the engine efficiency and the level of the emitted noxes have to be measured. In the end, an automobile engine moved partially or/and entirely by laser sparks could be accomplish.