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International Workshop on the Physics and Technology of Laser-Induced Plasma for Green Energy and Biomedical Applications!

Japan – Georgia – Europe

Laser Plasma Applications



Tbilisi 2025

Laser Plasma Applications

Tbilisi 2025

Workshop Program

Day 1: Thursday, 2 October 2025

10.00 – 11.00 Welcome opening and introduction: Chairmen: Ambassador Ishizuka Hideki, Academician David Gurgenidze. Communications: Minister of Education and Science of Georgia, Chairperson of the Parliamentary Committee of the Georgian Parliament, Ambassador of Japan, Minister of Economy of Georgia, Ambassadors of France, Italy and other distinguished guests.

11.00 – 13.15 **Session I:** Novel approaches to Laser induced methods and technologies. Chairpersons: Prof. Tamar Lominadze (Georgia); Prof. Fabrizio Consoli (Italy).

11.00 – 11.30 Prof. Dimitri Batani (France): Future of Laser Induced Fusion

11.30 – 11.45 Coffee Break

11.45 – 12.15 Prof. Paata Kervalishvili (Georgia): Laser-Synthesized Quantum Materials for Energy and Computing.

12.15 – 12.45 Toshimori Sekine (Japan): Warm Dense Matter Characterized by Laser Shock Compression.

12.45 – 13.15 Aldo Bonasera (USA): Nuclear Astrophysics and Applications Using Lasers.

13.15. – 15.00 Lunch Break

15.00 – 16.30 **Session II:** Laser Driven Technologies.
Chairpersons: Prof. Tamar Berberashvili (Georgia), Professor.
Aldo Bonasera (USA)

15.00 – 15.30 Shigemori Keisuke (Japan): Laser Plasma Interactions.

15.30 – 16.00 Victor Malka (Israel-Romania): Laser driven electron acceleration and their applications.

16.00 – 16.30 Boris Chichkov (Germany). Laser Printing Technologies.

16.30 – 17.30 Round table Discussions

19.30 – 22.00 Workshop's Reception

Day 2: Friday, 3 October 2025

10.00 – 13.15 Session III: Nuclear Fusion: Methods and Tools. Chairpersons: Prof. Tamar Bzhalava (Georgia), Prof. Shigemori Keisuke (Japan).

10.00 – 10.30 Fabrizio Consoli (Italy): Advanced Diagnostics for Particle Identification in Laser-Triggered Nuclear Fusion Experiments

10.30 – 11.00 Katarzyna Jakubowska-Batani (Poland) Proton boron fusion for laser driven medical applications.

11.00 – 11.15 Coffee Break

Session IV: Coherent Light Based Methods and Tools for Nanoobjects Investigation. Chairpersons: Prof. Irina Gotsiridze (Georgia), Prof. Victor Malka (Israel-Romania).

11.15 – 11.45 Pablo Cirrone (Italy): Laser driven Particle Acceleration (Ion/Electrons) for Medical Applications.

11.45 – 12.15 Kaoru Yamanouchi (Japan): Short Laser Pulses and Femtosecond Chemistry

12.15 – 12.45 Zviad Kirtava et al. (Georgia), Toward a Paradigm Shift: Transitioning from Pharmaceutical to Biophysical Approaches in Modern Medicine.

12.45 – 13.15 Tamar Bzhalava et al. (Georgia): Study of Pathogenic Microorganisms by Optical Spectrometry Methods.

13.15 – 15.00 Lunch Break

15.00 – 17.00 Session V: Laser Physics and Technology Applications. Chairpersons: Prof. Lia Petriashvili, Prof. Dimitri Batani (France)

15.00 – 15.20 Levan Chkartishvili et al (Georgia): Boron Isotopes Based Neutron Detection Concept

15.20 – 15.40 Amiran Bibilashvili et al. (Georgia): Laser-Plasma application in Thin-Film development.

15.40 – 16.00 Nugzar Gomidze et al. (Georgia) LIBS Technology for Plasma Characterization: Data Processing and Theoretical Analysis.

16.00 – 16.20 Tamaz Minashvili et al. (Georgia) Preparation of Gold nanoclusters on GaP(001) Surface by Method of Galvanic Displacement.

16.20 – 16.40 Tamar Berberashvili et al. (Georgia) Laser Based Optical Spectrometry Studies of Molecular Mechanisms in ATP Reactions.

16.40 – 17.30 Discussion (Joint Research Project Group Formation, follow-up plans)

19.30 – 22.00 Conference dinner

Day 3: Saturday, 4 October 2025

10.00 – 11.45 Session VI: Advances in Laser-Driven Physics and Technology. Chairmen: Kaoru Yamanouchi (Japan), Paata Kervalishvili (Georgia)
(Communications 15 minutes each.)

11.45 – 12.30 Closing remarks and Press conference

12.30 – 22.00 Excursion and cultural program. (Sightseeing to old capital of Georgia - Mtskheta and tour to Choportipoint of Mtsheta-Mtianeti national cuisine).

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WORKSHOP ABSTRACTS

Current state and future of research Inertial Fusion Energy in Europe

D. Batani

*University of Bordeaux, CELIA, Bordeaux, France
On behalf of the HiPER+ coordination team*

The recent achievement of ignition at the National Ignition Facility sets a historic milestone in fusion research. This paves the way to using laser fusion as a viable approach to future energy production. However, it does not seem possible to extrapolate the indirect drive scheme used at NIF to energy production due to complicated targets, intrinsic low efficiency, and implication for defense programs. Direct laser drive and in particular the shock ignition approach appear as the needed pathway towards Inertial Fusion Energy (IFE).

The talk will revise the progress in studying inertial fusion physics in Europe in the framework of EURO Fusion Enabling Research Projects. After, I will present the proposal (HiPER+) for establishing a European program on IFE with the mission to demonstrate laser-driven ignition in direct drive and develop pathway technologies for the commercial fusion reactor. The proposed roadmap, published in HLPSE in 2023 [1], is based on four complementary axes: i) the physics of laser plasma interaction and burning plasmas, ii) high energy high repetition rate laser technology, iii) fusion reactor technology and materials and iv) reinforcement of the community by international training programmes. We foresee collaboration with universities, research centers and industry and the establishment of joint activities with the private sector involved in laser-fusion. Along with the expected high level socio-economic impact, this project aims to stimulate a broad

range of high-profile industrial developments in laser, plasma, and radiation technologies.

References

- [1] D. Batani, A. Colatis, F. Consoli, C. N. Danson, L. A. Gizzi, J. J. Honrubia, T. Kuhl, S. Le Pape, J.-L. Miquel, J. M. Perlado, R. H. H. Scott, M. Tatarakis, V. Tikhonchuk, and L. Volpe “Future for Inertial Fusion Energy in Europe: A roadmap” High Power Laser Science and Engineering, Volume 11, e83 (2023) DOI: <https://doi.org/10.1017/hpl.2023.80>

Laser-Synthesized Quantum Materials for Energy and Computing

Paata J. Kervalishvili

Georgian Technical University

The synthesis of advanced nanomaterials with tailored electronic and magnetic properties is pivotal for next-generation technologies. The concept of creating "nanospin" and "nanoquant" structures via laser-induced plasma is an innovative bottom-up approach that holds significant promise for both green energy and quantum computing applications.

This technique, often a form of laser plasma or laser pyrolysis, involves focusing a high-power laser beam onto a solid target within a controlled reaction chamber. The intense laser energy instantaneously vaporizes the target material, creating a highly energetic plasma plume composed of atoms, ions, and electrons. As this plume expands into a background gas and cools with extreme rapidity, the species nucleate and condense to form nanoparticles. The critical advantage of this method is the precise control over experimental parameters—such as laser wavelength, energy, background gas type, and pressure—which allows for meticulous engineering of the nanoparticles' size, crystallinity, and, most importantly, their quantum properties.

For **green energy**, this facilitates the creation of laser induced plasma process useful for obtaining 2D structures of different materials including carbon and silicon substructures. The solar energy converter based on combination of Silicon wafer and Graphene nanolayer with its robust but flexible structure with unique phonon modes allows preparation of of high efficient photovoltaic devices. In some sense, graphene brings together issues in quantum gravity and particle physics, and also from

soft and hard condensed matter. The nanosize graphene nanolayer, which was deposited on the silicon surface at its back side will play the role of charge carrier pump.

In the realm of **quantum computing**, the method is ideal for fabricating "nanoquant" structures like quantum dots or defined spin qubits ("nanospin") from materials such as silicon, diamond (NV centers), or superconductors. The ultra-clean, gas-phase synthesis minimizes surface contaminants that can decohere quantum states.

In summary, laser-induced plasma synthesis provides a versatile and controllable platform for manufacturing nanomaterials with specific spin and quantum characteristics. This makes it a cornerstone technology for developing high-performance energy solutions and scalable, stable qubits essential for the future of quantum information processing.

References

- Vlasov, I. I., Shiryaev, A. A., Rendler, T., et al. (2014). Molecular-sized fluorescent nanodiamonds. *Nature Nanotechnology*, 9(1), 54-58.
- H. Bakhtiari, T. Berberashvili, P. Kervalishvili, (2022), Preparation of Graphene Structures by Continuous Wavelength Laser Deposition Method, *American Journal of Condensed Matter Physics*, 12(1) 2-11.
- Paata J. Kervalishvili, (2025). Spintronics and Spinqunt 2D Structures Prepared Using Laser Plasma Method, *Proceedings of the Eighth International Symposium on Dielectric Materials and Applications (ISyDMA'8)* Conference paper, Springer nature, , pp 71-78.
- Sajti, C. L., Sattari, R., Chichkov, B. N., & Barcikowski, S. (2010). Gram scale synthesis of pure ceramic nanoparticles by laser ablation in liquid. *The Journal of Physical Chemistry C*, 114(6), 2421-2427.

Warm Dense Matter Characterized by Laser Shock Compression

Toshimori Sekine

*Center for High Pressure Science and Technology Advanced
Research and Graduate School of Engineering, University of Osaka*

Recent advanced technologies of high-power lasers and related proving methods enable us to characterize the extreme states of shocked materials including warm dense matter. High power pulsed laser makes strong shock wave that achieves high pressure and high temperature state in nanoseconds. The shock compressed state is proved by optical methods to determined pressure, density, and temperature as well as some physical properties. The results can be applied to simulate condensed matter physics and chemistry, natural impact conditions and planetary interiors. I will introduce some recent experimental results.

Nuclear Astrophysics and Applications using lasers

A. Bonasera¹

*1 Cyclotron Institute, Texas A&M University, College Station, TX
77843, USA*

In this talk I will discuss experiments performed at the PW laser facilities at Vega3 located in Salamanca-Spain, ELI-beamlines in Prague, SGII-Shanghai, the PW laser at the University of Texas in Austin and the ABC-ENEA laser in Frascati. First, I will show how we can measure fusion cross sections and temperatures (@UT) in plasmas at 'air' densities and temperatures of tens of KeV (CD2+3He targets). Using many lasers (@SGII) we can compress the targets to much higher densities than solid but very low temperatures (<1KeV). Energetic ions maybe produced using short pulse lasers with the so-called Target Normal Sheath Acceleration (TNSA). To understand and better control the TNSA method we have performed experiments at Vega3 and ELI-beamlines using a PW laser for $p+^{11}\text{B}$ fusion reactions (third generation fusion power plant). We show that highly non equilibrated and non-neutral plasmas are responsible for the acceleration of ions to tens of MeV which may be directed on a target. These energetic ions can also be used for other applications such as radioisotope production for medicine or other purposes. Measuring the yield of produced ions give an insight to the plasma time evolution and its deviation from neutrality (Solitons?).

Laser driven electron acceleration and their applications

Victor Malka

Weizmann Institute of Science, Rehovot, Israel

ELI-NP, Magurele, Romania

Laser-plasma-based wakefield accelerators are changing the scientific landscape bringing on one side new hopes for emerging applications in medicine and industry, and on the other side for probing ultra-fast phenomena. Many of these applications critically require the precise characterization of the accelerated electron bunch as well as the plasma wakefield that largely affects the bunch's quality. Advanced diagnostics of such highly transient, microscopic bunch and field structures, however, remains very challenging.

After introducing the context and the physical processes involved in plasma accelerators and relied on our ability to manipulate relativistic electrons with intense laser, I will report on recent major results obtained at the Weizmann Institute of Science that demonstrate for the first time the real-time visualization of laser-driven nonlinear relativistic plasma wave, its transition to electron-driven wakefield and the femtosecond microscopy of relativistic electron bunch.

This presentation will be followed by a short review of their applications including the status of our EIC project ebeam4therapy and of ELI NP before discussing of their perspectives for Science and Society.

Laser Printing Technologies

Boris N. Chichkov

*Leibniz University Hannover, Institute of Quantum Optics,
Welfengarten 1, 30167 Hannover*

I will discuss our progress in laser-based printing technologies which can be applied for the generation of complex 2D and 3D material structures by two-photon polymerization and by laser printing very small and delicate objects like nanoparticles, biomaterials, living cells, and microorganisms. I will consider a few application examples of these technologies for printing of metasurfaces, fabrication of 3D scaffolds for tissue engineering, and development of 3D brain models. Our recent results on biofabrication of vascularized tissue constructs and novel laser-assisted microbial culturomics technology will be presented.

Advanced diagnostics for particle identification in laser-triggered nuclear fusion experiments

F. Consoli

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The detection of accelerated particles is a powerful method to get information on the physics of intense laser-matter interaction, in both Inertial Confinement Fusion and Laser-Plasma Acceleration schemes. This is an issue quite delicate, especially in high-repetition laser-matter interaction schemes. Several methodologies of particle detection exist and are commonly used, but in many situations they lack in the capability of identifying the specie of the ion accelerated, in particular for $Z > 1$. In some situations the problem can be resolved by the simultaneous combination of several diagnostic methodologies. In this presentation the limitations of common diagnostic methodologies of ion characterization and identification will be discussed, and advanced solutions combining different methodologies will be also presented.

This work has been carried out within the framework of the EUROfusion Consortium, funded by the European Union via the Euratom Research and Training Programme (Grant Agreement No 101052200 — EUROfusion). Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Commission. Neither the European Union nor the European Commission can be held responsible for them.

Proton boron fusion for laser driven medical applications

Katarzyna Batani

*Institute of Plasma Physics and Laser Microfusion (IPPLM),
Warsaw, Poland*

The record production of a particles obtained by irradiating boron-hydrogen targets with high-intensity lasers [1], [2] opened the way to studies on proton-boron fusion related to: nuclear fusion [3], generation of novel laser-driven α -particle sources[4], enhancing the effectiveness of Proton Boron Capture Therapy (PBCT) [5], and, finally, the production of radioisotopes of medical interest [6].

The present work discusses the results from experiments performed using the PW-class, short duration and high repetition laser VEGA-III at CLPU, Spain. In the experiment, we used the pitcher-catcher scheme, using thin Al foils to produce accelerated protons, which were directed on various targets including boron catchers (BN, BNH₆) to produce α particles through proton boron fusion reactions. We used a HPGe (High-purity Germanium) detector to detect gamma ray emission lines from the activated catcher showing emission lines from ⁷Be, ¹¹C, and ¹⁸F, measuring their lifetime and estimating their activity [7,8].

We also used high density calcium silicate (Ca₂SiO₄) catchers to produce scandium radioisotopes either by the interaction with α -particles produced by pB fusion or directly by the accelerated proton beam[8]. The results indicate the presence of the

scandium radioisotopes: ^{43}Sc , ^{44}Sc , and ^{48}Sc . We are reporting on two experiments. The first one demonstrated possibility of radioisotope production, the second one put light on developments, which might allow developing laser-driven sources of radio-isotopes for medical applications.

References

- ¹D.Margarone, et al. Applied Sciences, 12, 1444 (2022)
- ²J.Bonvalet, et al. Phys. Rev. E 103, 053202 (2021)
- ³F.Belloni, Laser and Particle Beams, 3952779, 2022
- ⁴V. Ikstoksaia, et al. Communications Physics 6, 27 (2023)
- ⁵G.A.P. Cirrone, et al. Scientific Reports, 8, 1141 (2018)
- ⁶K. Szkliniarz, et al. Applied Radiation and Isotopes 118, 182 (2016)
- ⁷M. R. D. Rodrigues, et al., MRE 9, 037203 (2024)
- ⁸ K. L. Batani et al., HPLSE 13, e11 (2025)

Toward a Paradigm Shift: Transitioning from Pharmaceutical to Biophysical Approaches in Modern Medicine

Paata Kervalishvili¹, Tamar Berberashvili¹, Zviad Kirtava²

1-Georgian Technical University,

2- Caucasus University, Tbilisi, Georgia

For more than a century, the dominance of pharmaceutical-based therapies has shaped the foundations of modern medicine. While drug-based treatments have achieved remarkable success in combating infectious diseases, chronic illnesses, and a wide spectrum of pathological conditions, their limitations—including adverse side effects, systemic toxicity, and the accelerating problem of drug resistance—have become increasingly evident. These challenges highlight the urgent need to explore complementary and alternative therapeutic strategies that can offer higher precision, reduced toxicity, and improved patient outcomes.

Recent advances in medical physics have given rise to the field of biophysical medicine, which integrates physical sciences into clinical practice. By leveraging physical principles and advanced technologies, biophysical approaches aim to: (i) minimize chemical side effects, (ii) provide site-specific and personalized interventions, (iii) employ real-time imaging and feedback systems, and (iv) utilize the intrinsic physical properties of cells and tissues for enhanced therapeutic efficacy.

Among the most promising modalities are nuclear medicine, magnetic resonance-based diagnostics and treatments, and neurophysical methods. Particularly noteworthy is laser-

plasma medicine, a rapidly emerging field that uses ultra-short laser pulses to generate plasma capable of interacting with biological tissues at the cellular and molecular levels. Applications include targeted cancer cell ablation, sterilization, and wound healing, with minimal damage to surrounding tissues. Cold atmospheric plasma (CAP) therapies, in particular, are demonstrating considerable potential in oncology and dermatology, offering non-invasive and selective treatment pathways.

This paradigm shift from a predominantly pharmaceutical model toward an integrated biophysical framework underscores a transformative vision for the future of medicine. By combining physics-based methods with clinical expertise, biomedicine may move toward safer, more effective, and personalized therapeutic strategies that reduce dependence on chemical drugs and open new horizons in healthcare.

References:

- Keidar, M. (2015). Plasma for cancer treatment. *Plasma Sources Science and Technology*, 24(3), 033001.
- Vanneste, J. L., & Smets, T. (2019). Cold atmospheric plasma in oncology: Mechanisms and therapeutic opportunities. *Cancers*, 11(2), 201.
- Cherry, S. R., Sorenson, J. A., & Phelps, M. E. (2012). *Physics in Nuclear Medicine* (4th ed.). Philadelphia: Elsevier.
- Paata J. Kervalishvili, Laser technologies of nanosystems preparation. Conference “Nanotechnology”, Georgian Technical University, 4 – 7 October 2021, Tbilisi, Georgia, p. 62.
- Paata J. Kervalishvili, Applied Biophysics, (Biophysics for Engineers through 15 Chapters). Georgian Technical University, Tbilisi 2021. 281p.

Study of Pathogenic Microorganisms by Optical Spectrometry Methods

Tamar Bzhalava¹, Paata Kervalishvili², Ana Palavandishvili³, Sergi Kapanadze⁴, Lali Chakhvashvili⁵

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Modern detection and identification systems of pathogenic microorganisms are based on biochemical and biophysical methods, immune-enzymatic and serological analysis, PCR testing and others. Currently, ultraviolet (UV), visible-infrared (Vis-IR), and Raman spectroscopy are widely employed for spectral analysis of bio-materials. Challenges encountered during experimental studies include issues with sample preparation, low signal intensity, the accuracy of measuring instruments, and the processing of spectroscopy data. Infected biological samples, particularly bio-fluids like blood, saliva, tears, urine, and sweat, contain recognized biological markers such as lipids, peptides, tryptophan, tyrosine, and cortisol, among others. Spectrometers determine the spectra associated with specific bonds, molecules or functional groups within various substances. Optical spectrometry methods enable the

determination of the scattering or absorption spectra of pathogenic microorganisms. Our research focused on the relationship between the scattering intensity of bio-particles and the wavelength of the radiating source. The resonance wavelength ranges are determined using both empirical formulas and theoretical models. Our approach views the bio-sample as a micro/nano system comprised of bio-particles that contain pathogenic microorganisms and exist in different phases—solid, liquid, or gaseous. The results obtained are based on a simulation method and classical electrodynamics boundary problem solutions. Spectra of viral bio-particles are proposed for consideration. Our findings indicate that the resonance scattering wavelengths for viral particles are predominantly observed within the UV range.

Work is supported by Shota Rustaveli National Science Foundation of Georgia [Grant № FR-23-4069].

Keywords: Spectra; Spectrometry; Scattering; Simulation; Virus-like particles.

Boron Isotopes Based Neutron Detection Concept

**Levan Chkhartishvili, Tamar Berberashvili,
Paata Kervalishvili, Mikheil Chikhradze**

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Two stable boron isotopes, ^{10}B and ^{11}B , differ significantly in their neutron capture cross sections: for thermal neutrons, they are 3837 and 5 barns, respectively. The high values of the neutron capture cross section by ^{10}B nuclei, combined with its monotonic dependence on neutron energy, make structural modifications of boron, as well as compounds and composites with a high boron content, very attractive not only as materials for nuclear reactors, but also for the development of efficient neutron detectors. The concept of neutron detectors and sensors based on boron isotopes is presented through an analysis of their operating principles, designs and characteristics.

In particular, for boron-based neutron detectors the following are considered:

- Types (gas-filled; scintillation; solid-state; multilayer; combined, e.g. with gas-electron-multiplier technology, etc.);
- Applications (monitoring of nuclear reactors, accelerators and environmental neutron sources, including cosmic rays;

radiation safety and nuclear security; neutron imaging, diffraction and spectroscopy to study the shape of objects and the structure and dynamics of materials; medicine, e.g. boron-neutron-capture-therapy, etc.);

- Advantages (high neutron absorption cross-section, especially thermal; relatively low cost and availability of boron-containing materials; compact and robust solid-state detectors; potential for high detection efficiency; combination with other technologies to enhance performance, etc.); and

- Challenges (gamma-ray discrimination, as gamma-rays can interfere with neutron detection; pile-up effects in high-flux environments, potentially affecting neutron counting accuracy, etc.).

It is concluded that despite existing challenges, boron-based neutron detectors and sensors offer a versatile and efficient way to detect and characterize neutrons in a wide range of applications.

Laser-Plasma application in Thin-Film development

**A. Bakhtiari¹, T. Berberashvili¹, A. Bibilashvili²,
P. Kervalishvili¹, Z. Kushitashvili²**

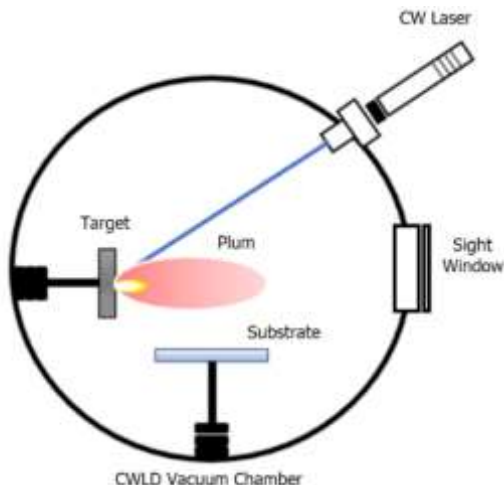
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Two-dimensional (2D) materials have attracted enormous research interest due to their predominant quantum effects and fascinating materials properties, that potentially lead to different important applications. 2D materials physical properties such as the other materials come out their structure quality. On the other hand, refer to their critical Nano sizes, manufacturing requires very accurate methodology. Hence, Thin-Film methodology is significant.

There are various methods, but they categorized in 2D Thin-Film methodologies as *Physical Vapor Deposition* (PLD) and *Chemical Vapor Deposition* (CVD). Thin-Film methodologies assessment are correlated to the final product quality and production cost. Therefore, the methodology flexibility and feasibility are the main factors.

In the presenting work, a novel and patented method as Thin-Film preparation by Laser-Plasma is introduced [1,2]. Also, the method is comprised to the other common methods and its flexibility and feasibility is investigated.



References

- [1]Bakhtiari, Maier, Kervalishvili, Device for obtaining solid-state films by laser-plasma method Georgian Intellectual Properties Center,Patent applied 2021 (Case No. 15728/1)
- [2]Bakhtiari, Berberashvili, Kervalishvili, Preparation of Graphene Structures by Continuous Wavelength Laser Deposition Method, American Journal of Condensed Matter Physics 2022

Keywords: laser plasma, thin film, 2D materials.

Work is supported by Shota Rustaveli National Science Foundation of Georgia (Project # FR-23-9442)

LIBS Technology for Plasma Characterization: Data Processing and Theoretical Analysis

**Paata Kervalisvili, NugzarGomidze, Miranda Khajishvili,
Davit Jakobia, Jaba Shainidze**

Batumi Shota Rustaveli State University

Laser-induced breakdown spectroscopy (LIBS) is a versatile technique for the elemental analysis of materials by generating and studying laser-induced plasma. This conference session focuses on the use of LIBS systems to characterize plasma parameters and elemental composition in various metallic samples, including copper, aluminum, lead, and other samples. The presentation emphasizes the processing and interpretation of experimental data.

Diagnostic methods, such as Stark broadening, Boltzmann diagrams, and the Saha equation, are used to estimate critical plasma parameters such as electron temperature and density. The paper discusses the challenges of data analysis, including signal fluctuations that occur due to ionization-recombination dynamics and noise in spectral measurements.

By integrating experimental results with theoretical models, the talk aims to improve the accuracy and reliability of LIBS-based diagnostics in practical applications such as materials identification, quality control, and environmental monitoring. Participants will gain insight into the interpretation of LIBS spectra and the prospects for modeling the complex behavior of laser-induced plasmas.

Preparation of gold nanoclusters on GaP(001) surface by method of galvanic displacement

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Patterning of semiconductor surface by nanoclusters of noble metals are of great importance for practical applications in and also for fundamental investigating the interaction between localized plasmons of the nanoclusters with semiconductor electronic states. Our article reports on preparation and studies of Au/GaP structures with an on-surface gold nanoclusters. To prepare such the structures, we used chemical procedure known as galvanic displacement. In the procedure sufficiently oxidizing metal ions, with a redox potential more positive than that of substrate, are reduced by electrons derived from the bonding electrons of the substrate lattice valence band; the reaction is accompanied by substrate etching. Experimentally, GaP(001) surface after cleaning was treated by water solution of tetrachloroauric HAuCl_4 and orthophosphoric H_3PO_4 acids. The latter component provides a removal of etching products from GaP surface. The obtained structures are characterized with help of scanning electron microscope (SEM), the results being presented in Fig. 1a,b.

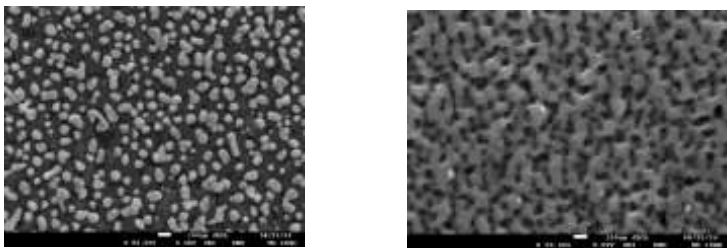


Fig.1 SEM images of

a) - after chemical deposition of gold, b) - after removal of gold.

The SEM-image Fig. 1a demonstrates a layer of Au nanoclusters formed at GaP(001) surface as a result of treatment in the solution during 40 min. at room temperature. It is seen that Au nanoclusters are randomly distributed over the surface, but homogeneously on the average. The shape of the clusters in surface plane is also random, some of them is close to circular, but seen are the elongated clusters. The SEM image Fig. 1,b was obtained after complete removal of gold clusters from the sample surface, it reveals numerous pits on the substrate surface GaP(001). These pits occur due to the etching induced by transferring electrons from surface bonding orbitals during the ox-red reaction between GaP crystal and the solution.

Laser Based Optical Spectrometry Studies of Molecular Mechanisms in ATP Reactions

**Tamar Berberashvili, Irina Gotsiridze,
Zviad Gurtskaia and Paata Kervalishvili**

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New achievements in optical spectrometry, laser and molecular physics, nanoscience and nanotechnology together with modern experimental and simulation tools are today's engine of studies of the mechanisms and transformations in the different biophysical and biochemical processes, and as example of the effect of energy production by the Adenosine Triphosphate molecules (ATP) [1,2].

The study of the activation mechanism of Adenosine Triphosphate using vibration spectroscopy is an interesting and complex area of research. ATP is the primary energy currency of cells, involved in processes like metabolism, muscle contraction, and signaling. It provides a powerful tool for understanding the molecular details of energy release and transfer in biological systems. By monitoring the vibrational modes of ATP, researchers can gain insights into the dynamics of ATP hydrolysis, its interaction with enzymes, and its role in cellular processes. This knowledge can be applied to fields ranging from biochemistry to pharmacology.

The main aim of our studies was investigation of possibilities of activation of ATP-ADP reaction by using the methods of vibrational spectroscopy including Raman scattering. It includes: a) Elaboration of effective method - experimental (spectrometric) and simulation, bridging over the gap between experimental and computational data analysis, relevant or alternative of spectroscopic measurements to gain the new



knowledge in optical, scattering and absorption properties of Adenosine Phosphate (AP) reactions; b) Development and verification of the concept considering activation of AP reactions by the set of optical –electromagnetic parameters determined their acceleration;c) Study of mechanisms of influence of magnetic impurities (Mn, Fe) on the oscillation effects occurring in AP reactions. (Fig.). [3,4].

Fig. Graphical representation of a concept of the experimental works related to influence of ferromagnetic impurities on ATP reaction conditions: a) ATP molecule interacting with magnetic ions/nanoparticles; b) Enzyme (ATPase) catalyzing the hydrolysis or synthesis of ATP; c) Possible binding sites of magnetic impurities on ATP or enzyme; d) Control and test samples with different magnetic impurities. Detection methods: Spectroscopy, NMR, EPR, electrochemical assays. Generated by author with a help of AI (ChatGPT, OpenAI, 2025)

References:

1. P. Kerrvalishvili, Vibration and Resonance Spectroscopy - Tool for Investigation and Activation of Adenosine Triphosphate Molecule. Annual Medical Conference, Euroscience-Georgia, 23 December (2023) Tbilisi, Georgia.

2. J, Dunn, M.H Grider. Physiology, Adenosine Triphosphate. [Updated 2023 Feb 13]. In: Stat Pearls [Internet]. Treasure Island (FL): StatPearls. Publishing January. (2025) <https://www.ncbi.nlm.nih.gov/books/NBK553175/>.
3. M. Bonora, S. Patergnani A. Rimessi, E. De Marchi, et al. ATP synthesis and storage. Purinergic Signalling (2012) 8:343–357, DOI 10.1007/s11302-012-9305-8.
4. Paata J. Kervalishvili, Ferromagnetic Nanosystems in Biomedicine – Some Examples. (2025), J. Social, Ecological and Clinical Pediatrics. № 27- 22-21, p.25-32

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