40 YEARS OF THE INSTITUTE OF APPLIED PHYSICS OF THE ACADEMY OF SCIENCES OF MOLDOVA
BRIEF HISTORY AND PRESENT STATE OF RESEARCHES

Professional investigations in the physical sciences started in the Republic of Moldova in the early fifties of the 20th century, when future academician T. Malinowsky has consolidated a group of researchers on the problems of X-ray analysis of materials in the Academy of Sciences of Moldova (ASM) and future Associate Member of the ASM Iu.Perlin has initiated some theoretical study on the condensed matter in the Moldovan State University (MSU). In this period, together with the rapid development of semiconductor physics research all over the world, the first groups carrying out technological and experimental investigations in materials science were organised in the ASM and MSU. In the sixties such investigations in several original scientific directions began in the Department of Physics and Mathematics of the ASM, when doctors of science S. Radautsan, D. Gitsu, A. Andriesh (future academicians) had returned in Moldova, as well as due to efforts of doctors V. Sobolev and Y. Boyarskaya. Also at the beginning of the sixties firstly in the Institute of Power Engineering and Automation and later in the Institute of Electrophysical Problems the researches related to the novel applications of the electricity have been started. In 1964 the researchers dealing with physics of condensed matter, material sciences and electrotechnologies have joint the new created scientific center of the ASM - the Institute of Applied Physics (IAP). Alongside with experimental research, in this period in the IAP an explosion of theoretical investigations on condensed matter physics took place, being initiated and developed on the level of scientific schools by academicians V. Moskalenco, S. Moskalenco, V. Kovarsky. With the aim to provide a complete cycle of research and development works ended in practical implementation of results the Experimental Plant was created and included in the Institute structure.

Efforts made in the sixties begun to manifest themselves by the world-recognised results in the seventies. In that period hundreds of scientific papers were published each year in the international scientific journals, a number of international conferences on condensed matter physics and materials science were also held in Chişinău. In those years the low temperature investigations started to develop as an important field of basic research. In that time the international collaboration with different scientific centres from Russia and Ukraine extended greatly. One of the main aspects of this collaboration was the “growing” in the mentioned centres (by means of post-graduate study) of a new generation of researchers, who have developed new research directions in condensed matter physics in the eighties.

In the eighties the number of the IAP members involved in the condensed matter physics and materials science research reached more than 500 persons, and this branch of science became the biggest in the Academy of Sciences of Moldova. The investigations have considerable covering over a wide range of materials (semiconductors and dielectrics, metals and superconductors, semimetals, etc.) as well as their physical properties (charge transport effects, optical and photoelectric phenomena, magnetic and mechanical properties). In accordance with the evolution of condensed matter physics and materials science research in the word scale, investigations of low dimensional solid-state structures started to develop in the majority of the IAP laboratories. In the nineties the IAP was reorganised in an academic structure with 6 scientific Centres. At present the condensed matter and solid state device research is performed in 5 of them: Centre of Materials Science (CMS), Centre of Theoretical Physics (CTP), International Laboratory of Superconductivity and Solid State Electronics

(ILSSSE), Centre of Optoelectronics (CO), Specialized Centre for Solid State Electronics Design (SCSSED). The researches related to the novel application of electricity are developed in the Centre of Electrophysical Problems (CEPP).

The main scientific direction of the CMS (Director Prof. Dr. L. Kulyuk) is growth and characterization of bulk single crystals and thin films of binary, ternary and multinary semiconductor compounds (academicians E. Arushanov, A. Simashkevich, Profs. V. Jitari, S. Pyshkin, I. Tiginyanu, Drs. hab. E. Rusu, V. Tsurkan, V. Ursaky, Drs. I. Damaskin, O. Kulikova, R. Lyalikova, O. Maximova, V. Mosneaga, A. Nateprov, T. Shemyakova, A. Siminel, V. Tezlavan, I. Tsiulyanu).

Great attention is focused on the following problems:

- investigation of transport phenomena; optical, luminescent, photoelectrical and magnetic properties;
- development of effective characterization methods of crystals and planar structures for solid-state electronics and solar cells; technological control of their fabrication;
- photovoltaic and photoelectrochemical conversion of solar energy;
- investigation of magnetic semiconductors for application in advanced electronics;
- fabrication technology and investigation of electrical and photoelectrical properties of semiconductor-insulator-semiconductor structures on the basis of Si and transparent conductive oxide;
- growth of nanoporous semiconductors by anodization and ion implantation; technologies for microporous membranes manufacturing;
- new components for integrated optics, including frequency up-converters, optical filters, photonic crystals, waveguides.
- design of devices for special applications, registration of radiation and magnetic signals.

Investigations performed in the CTP (Director Prof. Dr.H. Acad S. Moskalenko) in the field of condensed matter physics have developed historically in two main directions: 1) study of elementary excitation states and the effects of their interactions; 2) study of physical processes and properties of materials and structures, including those in extremal conditions and under the action of external factors (Academician V. Moskalenko, Profs. M. Palistrant, P. Khadzhi, I. Beloussov, Drs. D. Digor, S. Cojocaru). A short characterisation of valuable scientific results includes:

- theory of superconductors with overlapping bands; new methods and original approaches of superconductivity in order to account the presence of strong electron correlations and other specific characteristics of high-T_c materials;
- new methods for description of spin and orbital excitations in finite systems, the concept of excitonic molecule later called as biexciton;
- the possibility of Bose-Einstein condensation (BEC) of quasi-particles with finite lifetime, such as excitons and biexcitons in solids; BEC induced by the resonant monochromatic photons;
- the time structures of high density polaritons, periodic and stochastic self-pulsations in the system of coherent excitons, photons and biexcitons, the dielectric liquid phase of BEC 2D magneto-excitons with motional dipole moments.

The scientific activity of the Centre ILSSSE (Director Prof. Dr.H. Acad. V. Kantser) covers investigations in the fields of crystal structure, transport and mechanical properties of solids, superconductivity, physics of narrow-gap semiconductors and semimetals, solid state electronics and cryoelectronics, electronic properties of low dimensional structures. Remarkable scientific contribution have been made to crystallochemistry of coordination and super-molecular compounds, electron phase transitions and quantum oscillation effects in strong magnetic fields, kinetic phenomena in anisotropic materials, band structure of semimetals and semiconductors, interface states and phenomena in heterostructures, thermoelectricity of bulk and low dimensional systems. Investigations of strength, plasticity, brittleness of materials are performed in order to understand the physical nature of phenomena occurring by deformation, to establish the correlation between mechanical and other physical properties. In order to study the size effects and to develop new microsensor elements new original fabrication methods of glass coated microwires have been developed. The technologies of manufacturing (IV-VI) semiconductor structures by molecular beam and hot-wall beam epitaxy, as well as superconductor structures by magnetron sputtering are applied. Many solid state devices have been proposed and designed: medium wave IR-detectors; microwire transducers; thermoelectric Peltier microcoolers; integrated gauge pressure sensors; thin film hybrid electronic circuits for signal processing in electronic devices; microwire magnetosensors (Academician D. Gitsu, Associate Member I. Diacon, Profs. N. Popovici, A. Sidorenko, Drs. hab. T.Munteanu, A.Nicolaeva, P.Bodiul, D.Grabco, R.Jitaru, Drs. Iu. Simonov, V. Kravtsov, Iu. Chiumacov, D. Meglei, A. Grozav, E. Condrea, L. Konopko, N. Leporda, A. Nicorich, M. Dintu, E. Zasavitskii, A. Kozlov, M. Fonari, P. Bourosh, G. Volodina, B. Antoseak).

The main scientific directions of the CO (Director Prof. Dr. Acad. A. Andriesh) are physics and technology of chalcogenide glasses, investigation of generation, recombination and trapping of nonequilibrium carriers and relaxation of metastable states in amorphous chalcogenides; studies of conductivity, photoconductivity and optical absorption in doped and undoped materials in order to reveal recombination mechanisms of nonequilibrium carriers in glass chalcogenides and the influence of temperature and doping on these processes. Light-induced metastable states in undoped, doped and compensated bulk systems and films were studied in a wide temperature range. The experimental work of the laboratory groups involves the measurement of steady-state and transient photo-response of thin-film semiconductors and heterojunction devices with the aim to obtain information on important electronic parameters, such as carrier mobilities, lifetimes, distribution of electronic defect states. Research into laser-induced effects in these glasses, the change of resistivity and activation energy with composition was also carried out to understand the nature of conduction mechanism and the peculiarities of light spread in these glasses (Drs. hab. S. Shutov, M. Iovu, A. Buzdugan, V. Chiumash, N. Enachi, A. Popescu, E. Sinyavskii, Dr. V. Bivol).

The SCSSED (Director Prof. Dr.H. Acad. D. Gitsu) is the oldest centre of the IAP. Its formation in the middle of seventies was a turning point in extension of investigations in the condensed matter physics and materials sciences of the IPA to practical application. It was initiated and scientifically supervised by Academician D. Gitsu and managed up to 1997 year by Dr. hab. T. Donica. Organisation of this centre marked the formation of solid-state electronics as a professional field of research and technology transfer in the IAP. Among an extended range of elaborated devices the following ones may be named: planar silicon based Joule-Thomson microcoolers, silicon based pressure sensors, thermoelectric microwire anemometer sensors, portable mass-spectrometer for ecological purposes, equipment and devices for medicine (V. Parhomenko, V. Usenko, L. Roller, V. Smyslov, I. Caliniuc).

Research related to novel applications of electricity with the aim to improve existing processes and develop new highly-effective ones, development and implementation into national economy of technical aids for their realization are now under way **in the Centre of Electrophysical Problems** (Director Prof. Dr.H. Acad. M. Bologa).

The research performed in the IAP decisively demonstrates that electricity may be used as a kind of energy that can directly, without any transformations, provide functioning of novel processes. The advantages of electricity just can be revealed and the direct application of the electrical energy in physico-chemical processes of materials machining, heat and mass transfer processes constitute the main trend in the development of advanced techniques. This strive is driven by the problems of materials machining, improvement of their quality, creation of specific properties, as well as the problems of intensification of transfer processes.

Research and development works in the field of materials machining in the Academy of Sciences of Moldova (ASM) are linked with the name of academician, USSR State Prize winner, founder and pioneer of the electrospark materials machining method and that of the electrospark surface engineering Boris Romanovich Lazarenko (1909−1979), the first director of the Institute of Applied Physics.

The electrospark coating of metal surfaces has received the greatest development in the IAP. Advantages of the method - a great adhesion with the substrate, possibility to localize the coating process in specific surface areas, absence of heating of parts being processed, that leads to their deformation, simple and easy-to-use design of installations – stipulated its wide practical implementation. At the initiative of B.R. Lazarenko the Experimental Plant was designed attached to the Institute of Applied Physics, where various models of the installations for electrospark coating were produced (EFI, “Elitron”).

Another direction of research and application of physico-chemical machining methods in the IAP is the electro-chemico-thermal machining or machining of metals by their anodic heating in electrolytes. Various technological processes for strengthening and recovering of machine parts were developed that by an order of magnitude lower the production cycle duration, facilitate local strengthening and do not need to use toxic substances. Methods are developed for description and control of highly intensive electrochemical processes. That is an important task not only from the practical point of view (problems of electrochemical dimensional metal processing, pitting corrosion, electrochemical polishing of metals, etc.), but also from the point of view to find the rules that govern the transport processes through the interface boundary, when the state is far from the thermodynamical dissolution.

The development of electrochemical machining methods in the Institute of Applied Physics is linked with the name of academician Yu.N. Petrov (1921−1990). Under his guidance and in cooperation with laboratories of the State Agrarian University of Moldova electrolyte formulations and electrolysis regimes were developed that enable to enlarge sufficiently possibilities of the electrodeposition related to the control over operational properties of surfaces, increasing the service life and reliability of machine parts, preparation of novel composite coatings.

With the aim to ensure a long service life of machine parts and equipment a comprehensive research is performed that allows to find the optimal regimes of electrophysical methods of materials machining, increase the corrosion resistance of materials and to propose new formulations of corrosion inhibitors.

Over last decades wide-scale works on the problem of heat and mass transfer have been carried out based on the action of electric fields. They include convective heat exchange in gases, liquids and gas/liquid dispersed systems, in gas suspensions at natural and forced motion in direct and alternating electric fields with various frequencies and non-uniformity degree; heat and mass exchange at phase transitions – boiling and condensation - in non-uniform and uniform electric fields with various field strength; peculiar features and possible applications of the magnetic liquification.

One may state that the new direction in the thermal- and electrophysics has been fruitfully developing in the Institute – the research into interaction of thermally non-uniform low-conductive liquids, gases and dispersed systems with electric fields of high intensity.

The growing attention is paid to the useful application of cavitation with the aim of its broad engineering use. The cavitation phenomenon and effects of its action have been studied with the aim to apply them for intensification of technological processes. On the basis of bi-frequency cavitation action technological processes and installations have been developed, fabricated and introduced for production of highly dispersed homogeneous emulsions.

The physico-chemical principles of electroflotation of minerals and substances with various structure and nature are developed. The processes of extraction of valuable components from polymetallic ores and technological solutions are studied, as well as those that allow purification of natural, underground and waste waters from toxic contaminants. The research is carried out, based on the determination of properties of minerals and developments in the electroflotation theory, that lead to the improvement of selectivity and extend the range of flotated particles. A range of electroflotation methods and units were developed.

Original research and development works have been done related to the treatment of biological raw materials by electroplasmolysis. It consists in the destruction of medium cellular structure by the electric field action and may be surely referred to contemporary and promising high technologies. The advantage of electroplasmolysis over other processing methods consists also in the fact that it provides momentary and effective current action on raw materials.

The units for electroplasmolysis have been developed and constructed for electric treatment of raw materials with various specific conductivity coefficients and moisture content that consisted a basis for optional and license agreements with leading foreign firms. Solutions of the majority of the problems reviewed above are driven by the life demands. At the same time they are actual from the general scientific point of view.

Scientific and technological importance of novel research is a strong impetus for researchers and practitioners.

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