THE IBR-2 PULSED REACTOR

In 2017, the activities on the research nuclear facility IBR-2 (RNF IBR-2) were carried out in accordance with the objectives of the theme "Development of the IBR-2 Facility with a Complex of Cryogenic Neutron Moderators"

In 2017, the IBR-2 research nuclear facility was operated in a nominal on-power mode under Rostekhnadzor license valid until 30.09.2022.

Table III-1-1 presents data on the IBR-2 operation for physics experiment in 2017.

***Table III-1-1**. Data on the IBR-2 operation for physics experiments.*

№ cycle	Period	Reactor operation for physics experiments, h	Activation of the safety system	Moderator type
1	16.01-28.01	**264**	**-**	water
2	08.02-18.02	**230**	**-**	cryogenic
3	13.03-28.03	**336**	**-**	water
4	04.04-14.04	**238**	**-**	cryogenic
5	15.05-26.05	**264**	**-**	water
6	26.09	**4**	**1**	water
7	09.10-27.10	**432**	**-**	water
8	14.11-25.11	**247**	**-**	cryogenic
9	04.12-23.12	**456**	**-**	water
Total		**2471**	**1**	

On September 26, 2017 in the 6th cycle the reactor for physical experiments was operated for 4 hours and interrupted by the activation of the safety system because of the 1DNOK pump shutdown caused by a contact failure in the block-contact group 2L of the contactor KT 7023BC of the pump control scheme. In accordance with the FLNP Order № 105 issued on 06.10.2017 the IBR-2 operation in the 6th cycle was suspended, as well as changes were proposed in the duration of the 7th and the 9th cycles. Due to multiple power supply failures in May 2016 caused by voltage drops, cycle №5 of IBR-2 operation for physical experiments was terminated before the scheduled date with a loss of about 130 hours of experimental beam time.

IREN FACILITY

The IREN (**I**ntense **R**esonance **N**eutron **S**ource) is a complex of electrophysical and technological equipment that comprises a travelling-wave linear electron accelerator LUE-200 of 10-cm frequency range (2856 MHz) and a non-multiplying neutron-producing target. The realization of the IREN project is conducted in several stages. The physical startup of the IREN facility with the LUE-200 accelerator comprising one accelerating section was conducted in 2009-2010. The first stage of the accelerator has operated for experiments for several thousand hours at a repetition rate of 10 - 25 Hz providing a pulsed electron beam with a current of 1.5 - 2.0 A, pulse width of 100 ns and energy of 30 – 35 MeV (spectrum maximum). The maximum values for the integral neutron yield obtained at a repetition rate of 25 Hz, are close to $(3 \div 5) \cdot 10^{10}$ n/s.

In 2016, the second accelerating section with a TN2129 klystron and modulator of 180 MW/180 kW was installed and put into operation. As a result of the startup of the second section, the energy of the accelerated beam was increased: the position of the spectrum maximum shifted to 52 ± 54 MeV, and the maximum electron energy reached 60 MeV. The estimates of the integral neutron yield from the W-target based on the measurement of the neutron flux density, show a 3-4-fold increase in the integral neutron yield as compared to that of the first stage. In 2017, the second stage of the LUE-200 accelerator operated for experiments for 1049 hours at a repetition rate of 20-25 Hz.

EG-5 ACCELERATOR

In 2017, the EG-5 electrostatic accelerator operated for 515 hours. The elemental depth profiles of near-surface layers in various samples were studied using a variety of nuclear-physical analytical techniques including Rutherford backscattering (RBS), elastic recoil detection (ERD) and particle induced X-ray emission (PIXE).

In cooperation with the Lebedev Physical Institute of the Russian Academy of Sciences the process of accumulation and redistribution of deuterium and hydrogen atoms in the assemblies of two high-purity zirconium and titanium foils under high-temperature pulsed action of deuterium plasma at the PF-4 plasma focus setup was studied. Using analytical methods, namely Rutherford Backscattering Spectrometry (***RBS***) and Elastic Recoil Detection (***ERD***), it was found that the redistribution of implanted deuterium and hydrogen gas impurities in the assemblies of irradiated foils occurs to great depths that far exceed the ranges of deuterium ions. The observed phenomenon can be explained by the redistribution of the implanted deuterium and hydrogen under the influence of powerful shock waves formed in the metal foil under the action of high-temperature pulsed plasma.

In cooperation with Maria Curie-Skłodowska University (Lublin, Poland), a large amount of research has been conducted on the effect of heavy ion implantation on the optical properties and chemical composition of near-surface layers of GaAs crystals. The investigation of the complex dielectric function in the near-surface layers was carried out using the ellipsometry technique. The chemical composition of the surface layers was studied using the X-Ray Photoelectron Spectroscopy (XPS) technique. The investigation of the real and imaginary parts of the dielectric function and of the atomic and chemical composition was performed near the surface of GaAs crystals implanted with indium ions at an energy of 250 keV and a dose of $3 \cdot 10^{16}$ cm^{-2}. The influence of heat treatment in the temperature range 400°C-900°C on the structure and optical properties of GaAs crystals implanted with indium ions was also investigated. A series of studies was made of the effect of implantation of Ne, Ar, Kr, Xe ions at an energy of 100 keV and doses from $1 \cdot 10^{12}$ cm^{-2} to $3 \cdot 10^{15}$ cm^{-2} on the change in the dielectric function and atomic composition in the surface layer of GaAs crystals.

The effect of fluence and the mass of implanted ions on the optical properties and chemical composition of the near-surface layers of implanted GaAs(100) crystals was studied as well. Depth profiles of heavy elements in these studies were measured using the RBS technique. To study the oxygen content in the surface layers subjected to heavy ion implantation, the resonant scattering of helium ions with an energy of 3,045 MeV by oxygen atoms (NRA technique) was used, which ensured a high accuracy in measuring depth profiles of oxygen in the samples under study.

In cooperation with the Institute of Electrical Engineering of the Slovak Academy of Sciences we investigated the structural, magnetic and electrical properties of $La_{0.67}Sr_{0.33}MnO_3$ epitaxial films grown on (001) $SrTiO_3$ crystalline substrates. Depth profiles of various elements in silicon carbide samples prepared by Plasma Enhanced Chemical Vapour Deposition (PECVD) were studied using RBS and ERD techniques. The characteristics of these samples ensured their use for various applications, such as the absorption of electromagnetic energy in the spectral region of 0.1 - 2.0 THz, the creation of transparent photocathodes by depositing a film on a quartz glass substrate, as well as providing the possibility of using layered structures in the aggressive environment.