5 DEPARTMENT OF PLASMA PHYSICS AND TECHNOLOGY

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Overview

In 2003, research activities in Dept. P-V embraced the continuation of previous studies in the field of high-temperature plasma physics and controlled nuclear fusion. Some new investigations were developed, particularly in the field of plasma technology. The main topics of the research activities were as follows:

1. Selected problems of plasma theory;
2. Investigation of plasma phenomena in pulse discharges of the Plasma-Focus (PF) and Z-Pinch type;
3. Development of selected methods of plasma diagnostics;
4. Research on experimental facilities for basic studies and industrial applications;
5. Modification of material surfaces by means of pulsed plasma-ion streams.

Theoretical studies concerned the numerical modeling of discharges in a coaxial plasma accelerator of the IPD type. The modification of a 2-D model concerned mainly a plasma flow along the current sheath surface, taking into consideration the development of Rayleigh-Taylor instabilities. Several series of computations were performed and different parameters of the system were determined.

As for experimental studies, we studied plasma phenomena which occur in high-current discharges of PF and Z-Pinch type. Measurements of pulsed electron beams, and their correlation with other plasma phenomena, were performed within the MAJA-PF device in Świerk and PF-1000 facility at IPPLM in Warsaw. Use was made of Čerenkov-type detectors and magnetic analyzers. It was confirmed that separate e-beams are generated in different hot-spots, and the electron energy spectrum ranges up to several hundreds keV (i.e. above the inter-electrode voltage during the radial collapse phase). We also presented papers presenting results of previous research on polarization of X-ray lines emitted from the pinch column. Experimental studies of high-temperature plasma were also carried out within the PF-360 facility in Świerk. Several papers, describing the most important characteristics of this device and results of research on plasma dynamics and anisotropy of the ion- and neutron-emission, were published. Particular attention was paid to temporal changes in anisotropy of the fusion neutron emission.

Another experimental aim was the development of plasma diagnostic techniques. In collaboration with Dept. P-I at IPJ and HIL at Warsaw University, the results of calibration measurements of nuclear track detectors (NTD) of the PM-355 type, as performed for energetic sulfur- and argon-ions, were elaborated and published. The calibration diagrams were used for identification of heavy ions emitted from a laser-plasma experiment carried out within the PALS facility in Prague. We also summarized results of previous research on the influence of electromagnetic and electron radiation on NTD characteristics. Another diagnostic aim was the application of time-resolved optical spectroscopy to study dynamics of plasma-ion streams and the interaction of such streams with different solid samples. Particular attention was paid to spectroscopic measurements in the PF-360 facility. The data obtained were analyzed in collaboration with KIPT in Kharkov, and the most important results were presented at conferences in Kiev, St. Petersburg and Warsaw. Some efforts were devoted to studies of different operational modes of the RPI-IBIS device. The results were reported at the Minsk conference. In November 2003 series of spectroscopic measurements was performed within the PF-1000 facility in Warsaw.

In the frame of technological studies, the collaboration with Dept. P-IX was devoted to changes in ceramic samples (Al_2O_3) under their bombardment by pulsed plasma-ion streams. In collaboration with KIPT in Kharkov we investigated reversible getters of hydrogen (based on $Zr_{55}V_{40}Fe_5$ alloys). It was shown that such getters can produce a plasma shielding layer. This is of importance for the construction of fusion reactor walls. A very important aim was research on the use of ultra-high-vacuum arc discharges for the deposition of thin superconductor (Nb) layers upon RF accelerator cavities. In the frame of the collaboration with Tor-Vergata University in Rome and DESY in Hamburg, we performed experimental studies of the optimization of the deposition process with the use of planar- and cylindrical-cathodes. Due to the reduction of the arc current and an increased temperature of the samples, the amount of deposited micro-droplets was reduced and the record value RRR = 80 was obtained. Other studies of plasma-ion techniques for material engineering were performed in collaboration with Dept. P-IX (another chapter of this report).

The most important achievements of Dept. P-V in 2003 were as follows: 1. The development of time-resolved optical spectroscopy for studies of plasma in different experimental facilities (IBIS, PF-360 and PF-1000) and determination of important plasma parameters; 2. Investigation of the influence of gamma- and electron-radiation on characteristics of nuclear track detectors, as well as the use of such detectors for ion measurements in different experiments; 3. The deposition of thin superconducting layers upon samples within UHV-arc devices (operated in Rome and Świerk) and the obtaining of the record RRR = 80 value. This shows the possibility of useing this technique for the production of superconducting layers upon surfaces of RF accelerator cavities.