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Positron annihilation spectroscopy on a beam of positrons the LEPTA facility

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Abstract. The results and possibilities of the samples surfaces research by the Doppler method of positron annihilation spectroscopy (PAS) for a monochromatic beam of positrons at the LEPTA facility are presented in this paper. Method with high-resolution sensitivity to defects like vacancies and dislocations allows scanning of the surface and near-surface sample layers to a depth of several micrometers by the method of Doppler broadening of annihilation lines. The opportunities for the development of a PAS method based on the measurement of the positron lifetime in the sample irradiated by ordered flow of positrons from the injector of accelerator complex LEPTA at JINR are discussed.

LEPTA facility [1] is a complex consisting of the cryogenic positron source based on the emitter - a radioactive 22Na with an activity of 30 mCi, the electromagnetic Penning-Malmberg-Surko trap (PMS) and storage ring. After slowing down in a frozen solid neon layer a monochromatic flux of positrons with intensity up to 10^6 part./sec is formed. The width of the positron spectrum is about 2 eV. This flux can be used for fundamental and applied research [2]. It is possible to carry out layer-by-layer scanning of the defects in subsurface layers of the samples at depths from zero to several micrometers by varying the positron energy in the range of 0.05÷35 Kev. For this purpose, one of three versions of the PAS can be used [3]: observation of correlations in the angular distribution of annihilating photons – gamma quanta (ADAP), measurement of the lifetime of positrons in matter with registration the time distribution of the annihilation photons (TDAP) and the change in energy of the annihilation gamma-quanta - registration of Doppler broadening of annihilation lines (DBAL).

The most perspective methods that allow to distinguish the defects of vacancy and dislocation types in samples with a sensitivity of 1 defect per 10^7 atoms in the crystal lattice and at depth resolution of the sample in tenths of nanometer, are the last two versions - TDAP and DBAL. Currently, at the LEPTA complex DBAL PAS method is used with the

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positron beam to successfully carry out defectoscopy of different materials: the steel samples and others. [4, 5, 6].

Currently the dedicated channel with camera for positron annihilation spectroscopy is mounted. It will improve the technology of the samples study. Recently a helium cryocooler was installed that simplifies significantly operation of the formation of a layer of solid neon on the surface of ^{22}Na tablet to monochromatize the beam of positrons from the source. The method TDAP PAS for layer-by-layer scanning of the defects with a monochromatic beam of positrons is under development as well. Two implementations of TDAP are considered: controlled positron beam and operating the Penning-Malmberg-Surko trap at LEPTA, allowing to create bunches of positrons of high intensity [7, 8]. In the latter case, for realization the TDAP method can be used a bunching system for positron accumulate in the trap will be used (similar to the AEgIS experiments at CERN [9]). The bunch will be subsequently accelerated to achieve the required time resolution.

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