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Development of Positron Annihilation Spectroscopy at Joint Institute for Nuclear Research

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The method of positron annihilation spectroscopy (PAS) is sensitive to point defects in a solid material and is a well-known and used in material science. It allows one to study the concentration of defects with dimensions less than 10 nm on different depths depending of the energy of the positrons. In JINR this method is under development and application since 2012 when the first experimental station for PAS has been created at the LEPTA facility at Dzhelepov Laboratory of Nuclear Problems of JINR.

The PAS at the LEPTA is based on the slow positron injector that has two unique features:

- High monochromaticity of a positron flux – spectral width (FWHM) at the exit of the positron source is of 1.5-2 eV;
- Positron energy can be varied in the range of 50 eV – 35 keV (90 keV in the nearest future) with an accuracy of not less than 1% on target.

The construction of the slow positron injector was completed in mid-2011, and the group have focused on the development of the PAS method. These works were continued during the next years, and creating a special transportation channel of monochromatic positrons and experimental stations for PAS application, equipped with instrumentation for spectroscopy has been constructed. The first version of PAS – so called Doppler PAS – was developed and used up to now performing about 30 experiment runs per year for studying different kinds of materials:

1) Metals and alloys: steel embrittlement in reactor pressure vessel, fatigue effects in aircraft wings and different power units (screw propellers), corrosion of metallic structures;
2) Ultra fine-grained metals – studies of structure;
3) Semiconductors: studies of atomic defects in semiconductors (independent of its doping and conductivity).

(The polymers and porous materials and different plastic materials are not aloud due to vacuum restriction).

The most effective version of PAS – Positron Annihilation Lifetime spectroscopy (PALS) is under development presently. PALS has a specific sensitivity to vacancy-type defects which makes their identification straightforward and can be applied to any material. The PALS version under development at LEPTA is based on the original

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scheme of formation of an ordered positron flux proposed by the authors. Special beam transfer channel has been designed and commissioned this year.

The project has attractive features due to possibility of application of slow monochromatic positron beam with variable and well controlled positron energy. All this makes the project attractive for potential cooperation.