Positron annihilation spectroscopy in material studies

Positron annihilation spectroscopy (PAS) is a method dedicated to detection of open-volume type of defects. Nowadays, this technique is of a great interest due to the practical character of obtained results. It allows to connect changes of electrical, optical, mechanical and magnetic properties of materials caused by presence of defects in their structure. PAS gives possibility to determine the defect concentration and its type starting from a single vacancy up to pore size. Such small defects as single vacancy cannot be detected by the most of methods, even for transmission electron microscopy. Nowadays, many investigations at JINR are focused on the studies of materials by ion exposure. PAS has frequently shown its usefulness in such research, which together with other experimental techniques gives information about damages of materials. In next years, major tasks of works performed at JINR will include studies of new highly irradiation resistant materials for Generation IV reactors. Besides this, research are being conducted over the surface modification caused by different processes such as i.e. ion implantation, surface mechanical attrition treatment, oxidation, obtaining of protective thin layers.

Slow positron beam operating at JINR is a continues beam based on the cryogenic ^{22}Na source with an activity of 30 mCi. It allows to obtain a monochromatic flux of positrons with intensity up to 10^6 particle/s and carry out layer-by-layer scanning of defects in a subsurface zone of samples at depths from zero to several micrometers by varying the positron energy. Currently, PAS measurements can be carried out only using a Doppler broadening method. Newly mounted ion source allow to etch sample surface and perform low energy in situ irradiation. This should enable to study at following years the influence of crystal lattice defects on deuteron fusion reaction rates at low energies. The growing interest in PAS techniques forces their further development. The works on modification of beam to pulsed beam are in progress, which gives additional possibility also on positron lifetime measurements. In future, new technique coincidence Doppler broadening is planned to be implemented. The conventional measurements employing ^{22}Na positrons emitted directly to the samples can be conducted using both mentioned methods.