Characteristics of the positron annihilation process in the condensed matter

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Positron annihilation is well established experimental technique for probing the electronic and atomic structure of the condensed matter. Since 1949 several experimental methods have been developed: the measurement of the angular correlation of the annihilation quanta, the positron lifetime spectroscopy, the detection of the Doppler broadening of the annihilation line and the technique of the monoenergetical positron beam. Nevertheless, experimental methods need a comprehensive theory for a deep, quantitative understanding of the results. In the case of positron annihilation, the theory includes models needed for describing the positron states as well as the different interaction processes in matter. In the report we present the status of the theory of positrons and the link between the measured positron annihilation characteristics and microscopic properties of the condensed matter. There is given the review of the positron interaction with the electron gas in a perfect crystal lattice. However, the main interest was the process of interaction of positron with defects of crystalline structure. That is important because nowadays the positron annihilation is a convenient tool for study open volume defects in crystalline lattice.

The consideration about the interaction of the positrons with defects in solid started from the presentation of the standard trapping model. There were given several solutions of the rate equations which are based on this model. The detail description of the physical parameters was given as well. The main interest was the positron trapping process at the vacancy and vacancy type of defects as the absorption process of the positron wave at the optical potential. This theory seems to be a good alternative for other approaches applied to description of positron trapping coefficient. The knowledge of the value of this coefficient is important if we with to establish the absolute value of the vacancy concentration. In the presented theory this value is related to the potential interaction between a positron and vacancy and the process of dissipation of positron binding energy. In the report the results of the theoretic calculations are compared with the selected recent results.

The aim of the report was also the extension of the standard positron trapping model to the diffusion trapping model. The last one could be applied to the study of inhomogeneous samples. We have presented the exact solution of the time dependent diffusion equation for positrons in solid which contains the grain of different shapes. For the first time we were able to present the exact relations for the mean positron lifetime and positron lifetime spectrum resulting from the positron diffusion in different systems. Application of the solution to study of physical processes in solid like recrystallization and thermal vacancy creation was presented. The considerations were supported by several experiments performed by the author.