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# Summary of the doctoral dissertation of M.Sc. Konrad Wysogląd „Implementation of a positron probe to study of biological tissues"

Cancer in an aging society is a serious challenge as a health and social problem. Relatively recently, we have learned to diagnose neoplastic diseases, recognize types of neoplasms and minimize their destructive effects on the human body in the process of treatment or their surgical removal. The technological development of modern society is conducive to the continuous improvement of the diagnostic and therapeutic process and the improvement of the quality of life of the sick. Over the decades, physicists and radiologists have refined diagnostic methods, increasing their accuracy. The techniques that dominate nowadays, apart from the use of X-rays in diagnostics, also use positrons (PET - Positron Emission Tomography). The PET technique, which was launched in 1950, allows us to determine where the cancer is located in the body. Positron Annihilation Lifetime Spectroscopy (PALS) is a technique that uses positrons and additionally positron for material research (metals, semiconductors, organic, porous materials, etc.). This technique allows the study of the structure of materials at the nanoscale level and inference about properties.

The work deals with the subject of a new approach to the study of biological tissues using positron lifetime annihilation spectrometry. From the idea, through the design of the prototype system to the working electro-optical systems, two measuring heads for the mPALS system were made.

In this work, the following research hypothesis was put forward:

Positron and positron, used as samplers of biological matter, can provide information on the diversity (at the nanoscale level) of biological systems (cells, tissues) resulting from the occurrence of pathological changes in the human body. The problem was therefore developed for two purposes:

1. Improvement of the detection process through the miniaturization of detection systems, including the design and construction of the detection system of the PALS spectrometer dedicated to the research of biological material.

2. Conducting systematic research with the use of Ps and e + probes on selected material of biological origin, indicating the existence of a relationship between the medical diagnosis and the response obtained with the PALS technique.

This dissertation is therefore of a constructional and research nature, its structure includes 17 chapters. The first chapter is an introduction. The second chapter introduces the concept and physical properties of positron, starting with its postulation by P. A. M. Dircac, through its discovery, and ending with its annihilation. The third chapter is a broad description of positronium, i.e. the hydrogen-like state of the bound electron and positron. Models of positronium annihilation in condensed matter as well as models of its creation are also described. Including the Øre model, the nest reaction model, going to Chapter 4 - Teo-Eldrup model and bubble model.

The extensive fifth chapter opens with the theory of nuclear radiation detection, which is, in a way, an introduction to the constructional part of the dissertation. The types of detectors used in positron measurements have been widely described, with the main emphasis on scintillation detectors, as well as scintillation light detectors: PMT (PhotoMultiplier Tube) and SiPM (Silocon PhotoMultiplier).

The sixth chapter describes the measurement techniques of porosimetry studies, with the emphasis on the PALS technique, as well as the preparation of positron sources for the measurement of biological materials. The subsections develop the subject of equipment for PALS research, including analog and digital spectrometers.

The seventh chapter deals with the structure and functioning of human cells. The basics of the cell structure as well as its metabolism have been described. The differences between the metabolism of healthy and neoplastic cells are outlined. The eighth chapter continues the biological aspect and is connected with the research of biological materials using the PALS method. An overview of the knowledge on the above topic was presented, as well as the most important publications cited. The ninth chapter describes the hypothesis and purpose of the research.

The most extensive chapter, tenth, describes the idea, working principle and the physical and electronic properties of the mPALS spectrometric system. In the following subsections, each module is described in detail, along with a schematic diagram and waveforms. The next section describes the functional tests of the spectrometric branch and the analysis of PALS spectra using the LT 9.2 program for standard samples.

Chapter 11 describes the topic of the biological material measurement regime with the mPALS spectrometer and its standard counterpart. Finally, chapter 12 presents the results of pilot measurements with mPALS and PALS spectrometers. The results were presented in the form of comparisons and graphs. The dissertation ends with a chapter of conclusions in which recommendations and further research directions are proposed.

The credibility and accuracy of the performed spectrometer were checked. The presented results indicate that the mPALS detector can be used to test samples, but it should be noted that the p-Ps component may be averaged in the analysis with the component derived from free e+ annihilation.