Positron annihilation spectroscopy in materials structure studies

I. Introduction

Positron Annihilation Spectroscopy (PAS) is a non-destructive technique of detecting open-volume defects in solids, such as vacancies, vacancy clusters, microvoids or dislocations [1,2]. It can be used in cases where other popular methods such as scanning electron microscopy (SEM) or X-ray diffraction are not applicable [3]. Positron spectroscopy of defects can be performed by means of Doppler broadening spectroscopy of annihilation radiation, or positron lifetime spectroscopy (PALS). During the Summer Student Practice students will have an opportunity to learn the basics of these spectroscopies in theory and practice.

II. Experimental setup

In experiment positron will be produced through β^+ decay of ^{22}Na. The measurements will be performed using encapsulated ^{22}Na positron source. The source during measurement will be placed between the identical samples. Positrons implanted into samples annihilate and creates 511 keV quants. The registration of times difference between detection of 511 keV annihilation quanta and 1274 keV gamma quantum from β^+ decay gives information about positron lifetime. Its value can be related to kind of defect. The second method Doppler broadening spectroscopy is based on observation of broadening of annihilation line. The changes in shape of this line are caused by e.g. changes of defects concentration. To get the depth characteristics samples will be sequentially etched to reduce their thickness.

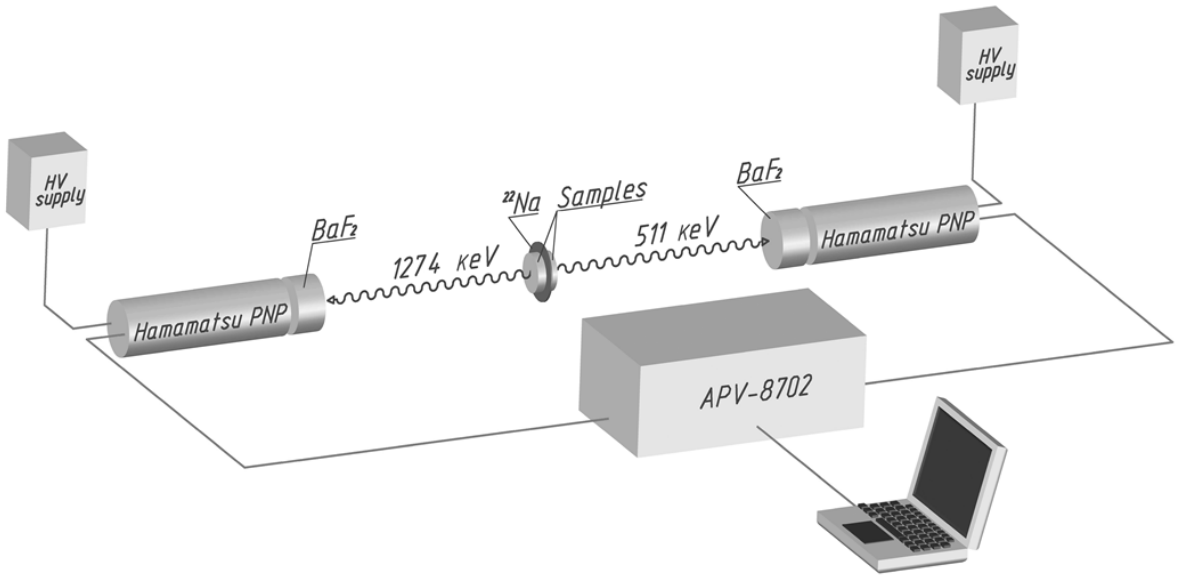

Fig. 1 Positron lifetime spectroscopy apparatus.

Fig. 2 Positron Doppler broadening spectroscopy equipment.

III. Project description:

The project include few steps. At first the students will be introduced with positron annihilation spectroscopy methods and apparatus. Then each person prepare its own sample. The students with their own samples and scientific problem are also welcome. For prepared samples the profiles of defects will be determined using positron lifetime and Doppler spectroscopies. To link up measured lifetime also simple molecular calculations using ABINIT [4] program will be performed. However, the skill of ABINIT usage is not obligatory. Finally, the students presents their results on the forum of Summer Student Practice' participants.

IV. Requirements:

The basics knowledge about material structures and open mind.

V. References:

[1] I. Makkonen, E. Korhonen, V. Prozheeva, F. Tuomisto 2016 J. Phys. Condens. Matter **28** 1-7
[2] I. Prochazka 2001 Materials Structure **8** 55-60
[3] P. Horodek, M. Eseev, A. Kobets 2015 Nukleonika **60** 721-724
[4] http://www.abinit.org

VI. Number of vacancies: 2

VII. The Project supervisor:

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