Spectroscopy of defects in II-VI compounds

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The II-VI compounds are promising materials for phosphors, to be adopted in new generation light sources based on high-quantum efficiency semiconductor junctions. Doping with alkali-earth metals allows to tune the absorption and emission properties of these phosphors but usually induces defects [1]. Their presence lead to additional, parasite emission and causes failures in ready devices. In the present work we report positron annihilation studies of defetcs in ZnSe single crystals with Be, Mg, Mn. Samples were grown from the melt by slow procedures, to assure small concentration of defects.

We have investigated lifetimes in ZnSe crystals by Ortec PLS system in Torun [2]. The analysis of lifetime spectra was performed with the LT package by J. Kansy. In ZnSe samples two lifetimes are visible - a short one τ_1=241 ps in bulk and defect-like τ_2=330 ± 1 ps. The latter one would agree with a theoretical prediction for Zn vacancies [3].

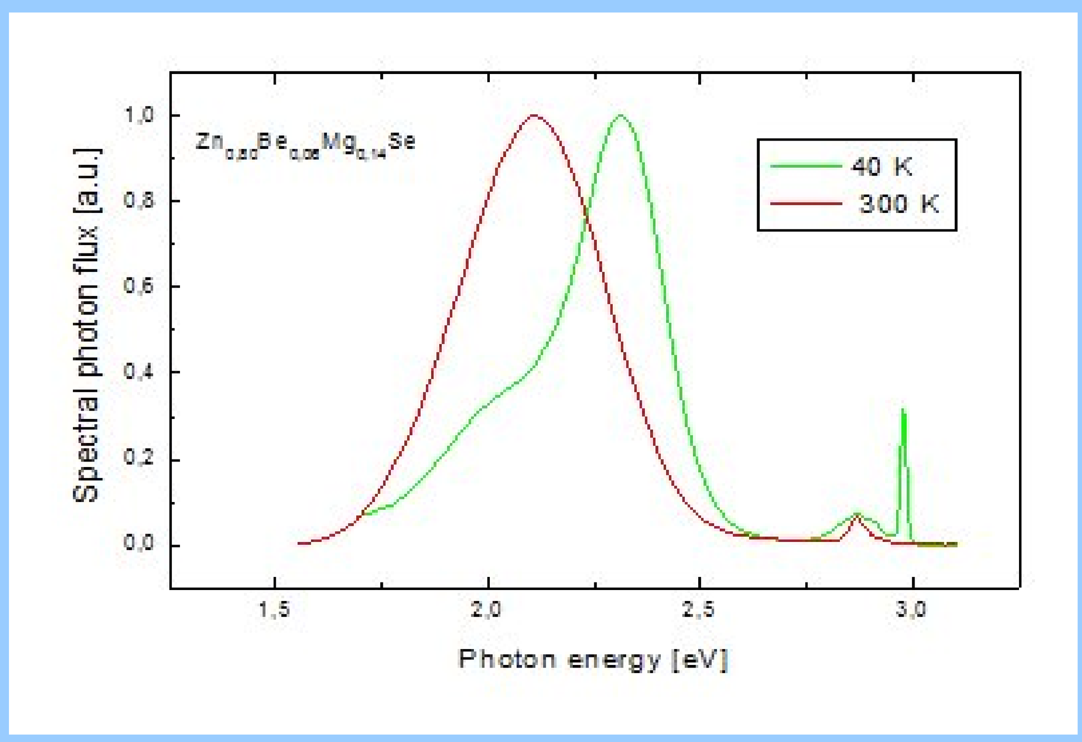

Fig. 1. II-VI compunds should show green-blue photo-emmision but the spectra are dominated by a parasite orange broad band!

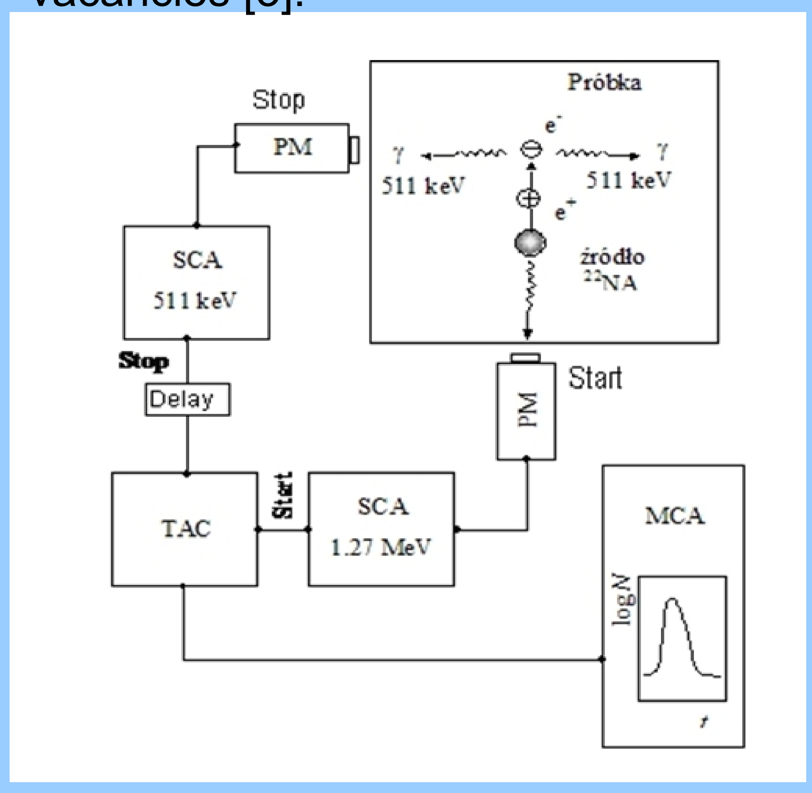

Fig. 2. The scheme of positron lifetime measurements.

Fig. 3. Ortec Positron Liftime System in laboratory in Torun.

Table 1. Positron lifetimes for ZnSe measured in Institute of Physics, NCU Torun.

No.	τ_1 [ps]	τ_2 [ps]	I_2 [%]	variance
1	241	329	38.5	1.06
2	241	331	39.4	1.06
3	241	331	39.7	1.06

The bulk measurements of lifetime do not allow to study *profiles* of defets in depth. Therefore, ZnSe samples were additionally measured by pulsed low energy positron beam system (PLEPS) for lifetime measurements at the Munich positron beam facility NEPOMUC. The implantation energy was changed between 0.5 keV and 16 keV. We have got two lifetime components in bulk and on surface, the longer one (due to defects) seen only near to the sample surface.

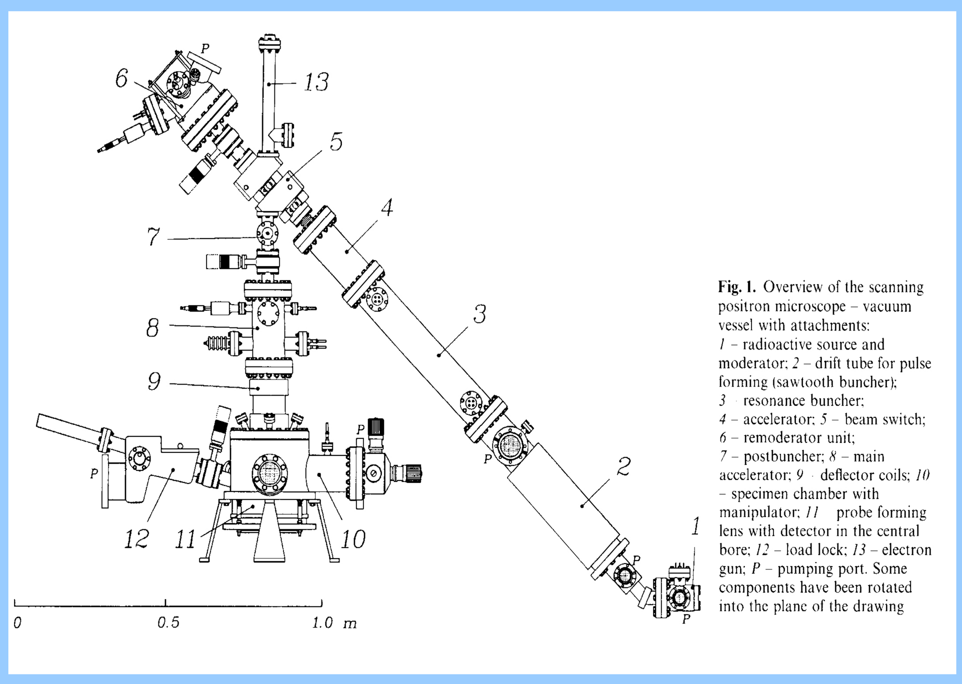

Fig. 3. Overview of the scanning positron microscope in Munich.

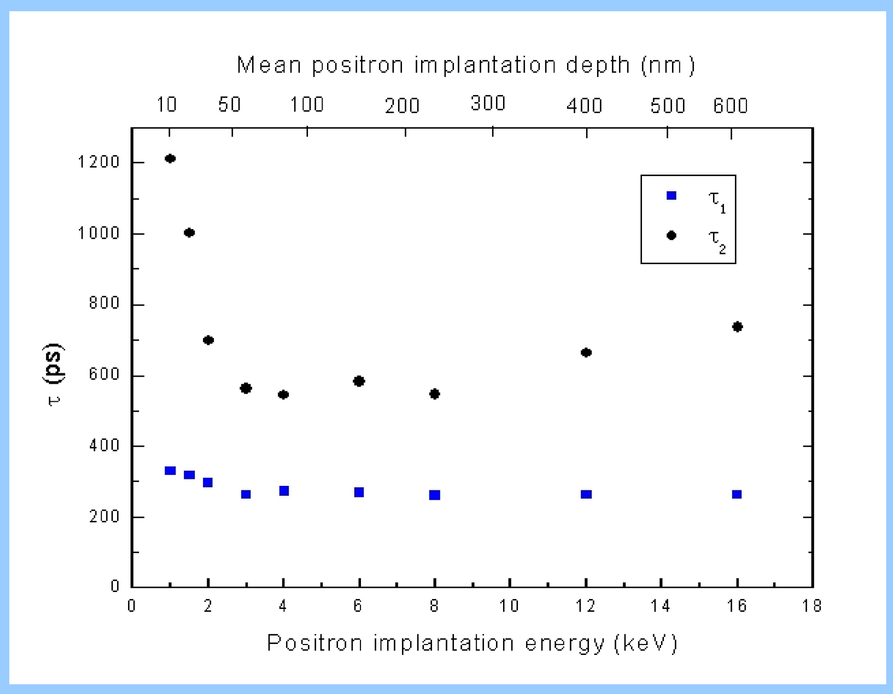

Fig. 4. Positron lifetimes as a function of positron implantation energy.

Table 2. Positron lifetimes for ZnSe measured in Munich.

Positron implantation energy [keV]	τ_1 [ps]	I_1 [%]	τ_2 [ps]	I_2 [%]	variance
1	329	93.5	1211	6.5	1.03
1.5	317	94.8	1003	5.2	1.08
2	296	94.0	698	6.0	1.01
3	262	94.9	562	5.1	1.01
4	272	90.5	545	9.5	1.01
6	266	93.8	582	6.2	1.01
8	260	95.5	547	4.8	1.02
12	261	97.7	663	2.3	1.05
16	262	98.3	736	1.7	1.03

Doppler broadening measurements were performed with variable energy (50 eV - 20 keV) positron beam in Trento [4]. The S-parameter for a given compound does not show big variations with the implantation depth and is essentially determined by the anion. Surface layers differ somewhat from the bulk, with the S-parameter increased.

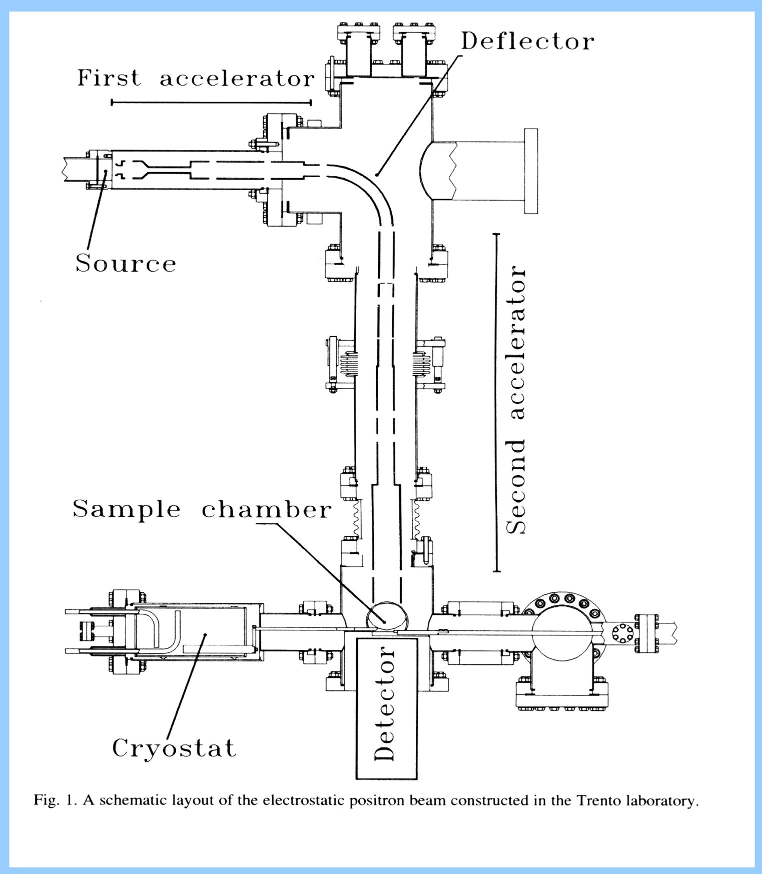

Fig. 6. The scheme of positron beam in Trento.

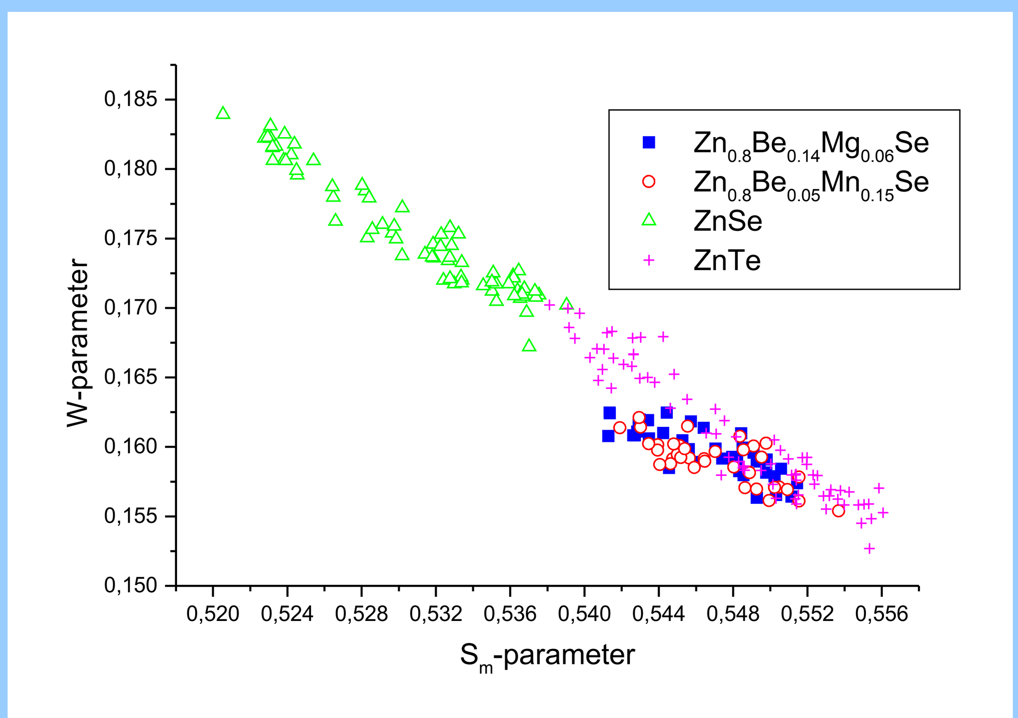

Fig. 7. W parameter vs. S parameter for samples: ZnSe, ZnTe, $Zn_{0.8}Be_{0.14}Mg_{0.06}Se$ i $Zn_{0.8}Be_{0.05}Mn_{0.15}Se$

References:

[1] J. Z. Wang, P. J. Huang, Y. S. Huang, F. Firszt, S. Łęgowski, H. Męczyńska, A. Marasek and K. K. Tiong, J. Phys.: Condens. Matter 19 (2007) 096216.
[2] A. Karbowski, J. D. Fidelus, G. Karwasz, Testing an ORTEC Lifetime System, Materials Science Forum, 666 (2011) 155.
[3] F. Plazaola et al. J. Appl. Phys. 94 (2003) 1647.
[4] R. S. Brusa, G. P. Karwasz, M. Bettonte, A. Zecca, Applied Surface Science 116 (1997) 59-62.