Investigation of the influence of light illumination on the characteristics of CdZnTe detectors

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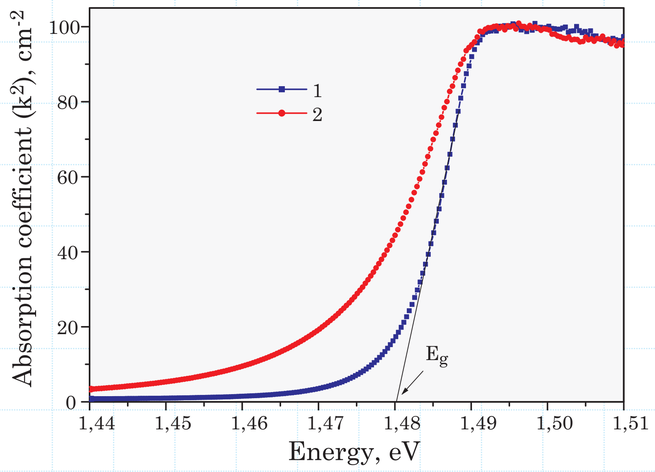
Near IR transmission and luminescense spectra, spectral response of spectrometric characteristics, output signal shapes and leakage currents of CdZnTe detectors with plane parallel electrodes under illumination by IR light within wavelength region of 400 - 1100 nm were investigated. IR transmission spectra and detector's IR stimulation were carried out using Double Beam Spectrophotometer LABOMED Spectro UV-VIS UVD-2800. For luminescence spectra measurements as the excitation source the YAG:Nd laser (266 nm; 8 ns pulse duration) was used. The close cycle helium cryostat with copper cold finger was used for sample cooling up to 12K. The luminescence was detected by Hamamatsu photomultiplier H8259-02 through monochromator MDR-3. The spectral resolution was $5*10^{-3}$ eV. The luminescence measurements were carried out with photon counting board with time bins 250 ns. The spectra were detected in time gate 125 ns.

Spectral dependencies of the square of the absorption coefficient of IR photon energy.

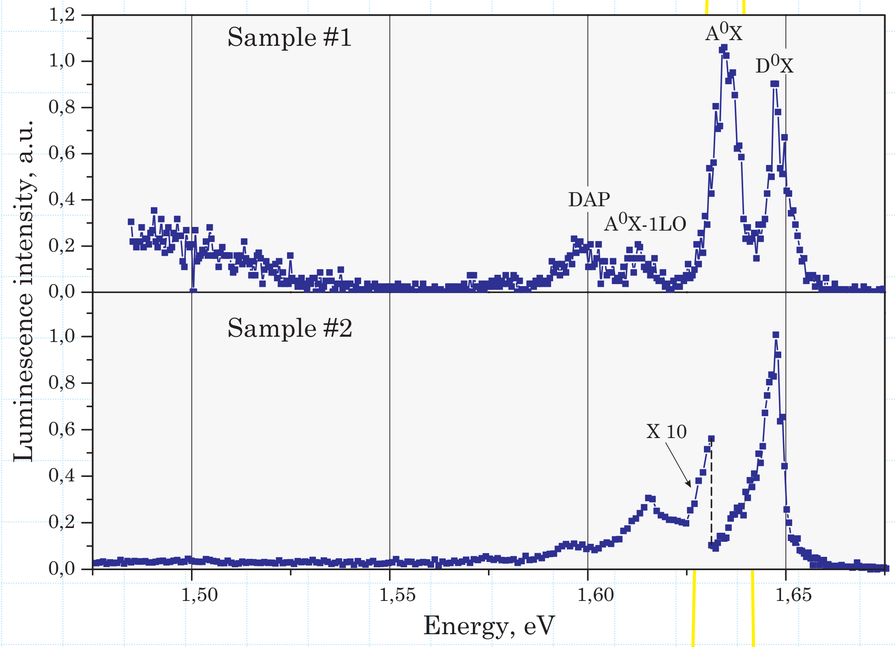
1- samples with short tail in the below band gap region

2 - samples with long tail in the below band gap region



Estimated values Eg lies in a region of 1.473-1.511 eV. Of samples with the long tail (2) in the below band gap region gamma-radiation detectors with a poor spectrometric performance were fabricated.

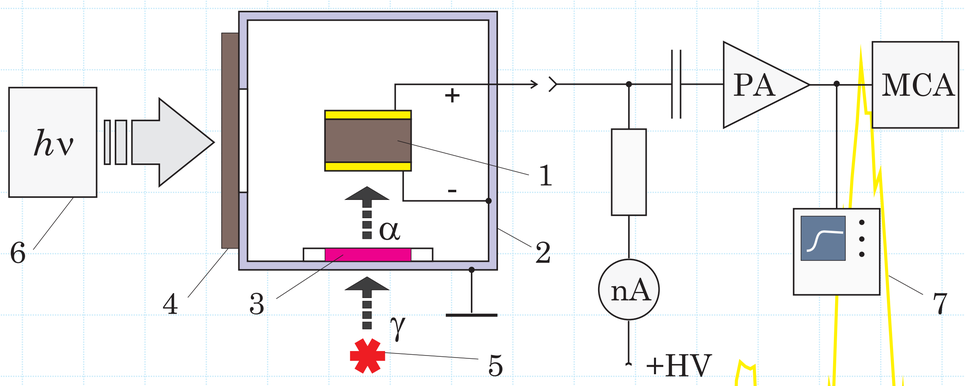
Luminescence spectra of "bad" sample #1 and "good" sample #2



Gamma-radiation detector made of the "Good" sample has energy resolution better then 2% and "bad" detectors have energy resolution worsen that 3.5% at 662 keV.

In the luminescence spectrum of the "bad" sample #1 the surface defects broad band, the intensive A^0X band, the DAP luminescence and LO replica of A^0X are detected.

Experimental setup for the spectral response of planar detectors spectrometric characteristics measurement

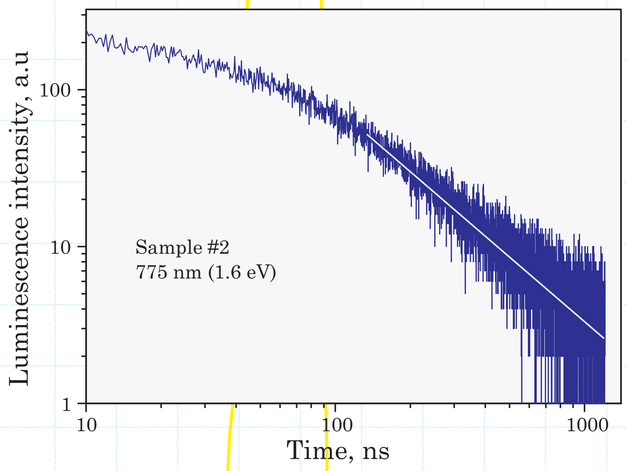


1 - CdZnTe detector, 2 - Detector holder, 3 - Source of alpha-particles ^{238}Pu (5.5 MeV), 4 - Entrance window, 5 - Gamma-radiation source ^{137}Cs, 6 - Tunable monohromator, 7 - Digital oscilloscope, PA - Charge sensitive preamplifier, MCA - Multichannel analyzer.

Luminescence peaks interpretations

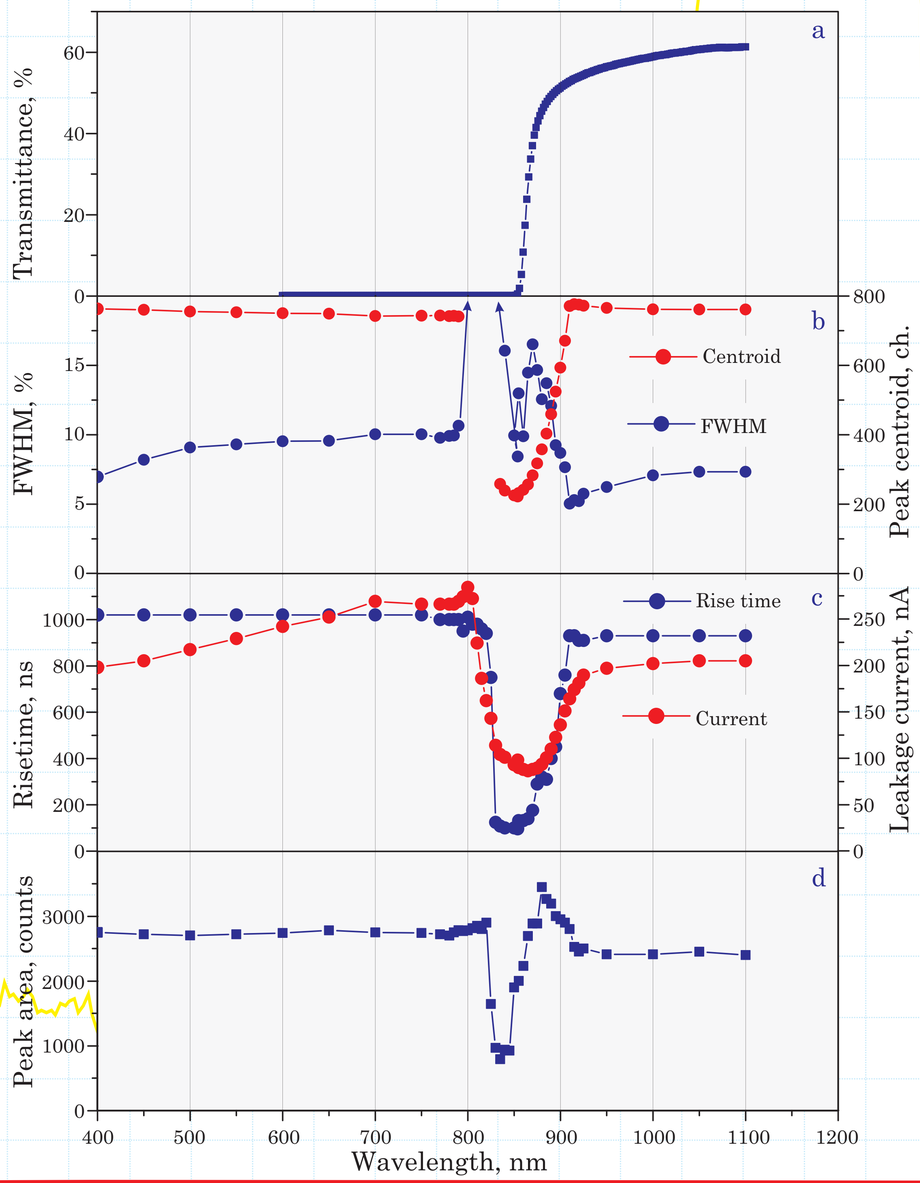
№	Peak position, eV	Luminescence model
1	1.40-1.55	Surface defects
2	1.598	Donor-acceptor pair (DAP)
3	1.613	Longitudinal optical photon replica (A^0X-1LO)
4	1.635	Exciton bound at neutral acceptor (A^0X)
5	1.639	TET? (for sample #2)
6	1.647	Exciton bound at neutral donor (D^0X)
7	1.649	Upper polariton (Xup)

Luminescence decay kinetic for 1.6 eV band confirms the origin of the DAP luminescence

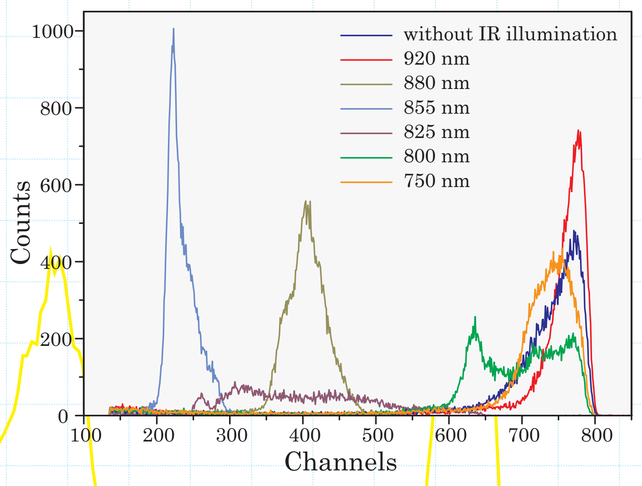


Spectral responses of IR transmittance (a), alpha-peak centroid and the relative energy resolution (FWHM) (b), output signals rise time at alpha particle registration and leakage current (c) and number of pulses in a gamma-peak (662 keV) area (d) measured with planar detector

IR light radiant power of measurement was about 800 nW



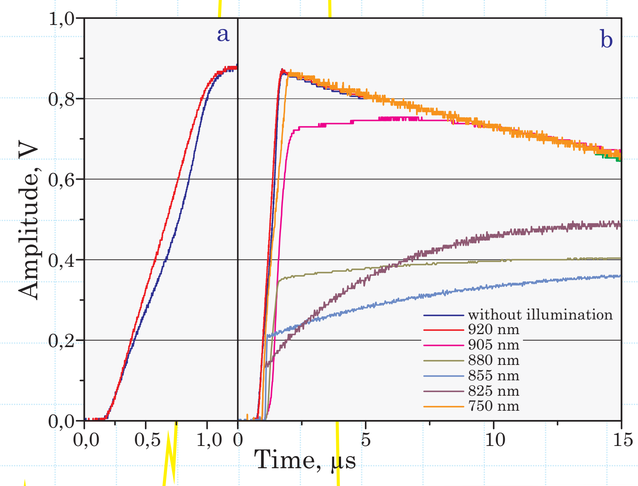
Alpha-spectra measured at different IR illumination wavelengths



Output signals waveforms at different illumination wavelengths

a - pulses leading edge (fast component)

b - pulses trailing edge (slow component)



Main results:

☑ Practically all tested gamma-radiation detectors with poor performance were fabricated from samples having the long tail in the below band gap region.

☑ In the luminescence spectrum of the "bad" sample there are broad band donor-acceptor pair associated with surface defects (1.4-1.5 eV), the intensive excitonic A^0X (1.635 eV) peak and the DAP (1.598 eV) transitions peak.

☑ IR illumination by wavelengths slightly above the fundamental absorption edge (910 nm - 920 nm) improves charge collection in planar detectors. Illumination by wavelengths from 910 nm to about 800 nm a greatly reduces the charge collection efficiency and worsens energy resolution. Charges in the charge collection are primarily due to changes in the electric field distribution.

☑ Significant quenching of leakege current by IR light in the region from 910 nm to about 800 nm is observed.

☑ Degree of IR illumination influence depends on an illumination intensity. Even a very low intensity of IR illumination ~ 10^{-8} W can cause noticeable changes in charge collection.

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