SCINTILLATION PROPERTIES OF CZOCHRALSKI-GROWN SINGLY-, DOUBLY- AND TRIPLY-DOPED β-Ga_2O_3 SINGLE CRYSTALS

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I Introduction

β-Ga_2O_3 is a wide bandgap oxide semiconductor that has attracted much scientific and technological attention in the last decade. In addition to UV optoelectronics and high power electronics, also detection of nuclear radiation has been found to be fast and relatively efficient in β-Ga_2O_3 [1-5]. As the result, this compound has become an interesting material as an emerging semiconducting oxide scintillator that undergoes initial study. In this communication we present results of pulse height (PHS), scintillation time profiles (STP), as well as radio- (RL) and low temperature thermoluminescence (ltTL) measurements.

II Materials and Experiment

Under ongoing investigation β-Ga_2O_3 serves as a perfect matrix for three different dopants such as Al, Ce, and Si. All the crystals have been grown by the Czochralski method at the Leibniz Institut für Kristallzüchtung in Berlin, Germany, as described by Galazka et al. [6]. The measurements have been conducted at the Institute of Physics, Nicolaus Copernicus University in Torun, Poland.

RL/ltTL measurements :

- Acton SpectraPro 500i monochromator
- Acton SpectraHub
- LakeShore 330 temperature controller
- APD Cryogenics Inc. closed-cycle helium cooler
- Inel XRG3500 X-ray generator (Cu-anode tube, 45 kV / 10 mA)
- Hamamatsu R928 photomultiplier

PHS/STP measurements :

- Excitation source: ^{137}Cs
- Hamamatsu R878 PMT (PHS)
- Hamamatsu R1104 PMT for "starts" and R928 PMT for "stops" (STP)
- Canberra electronics
- Tukan 8K MCA

III Experimental results

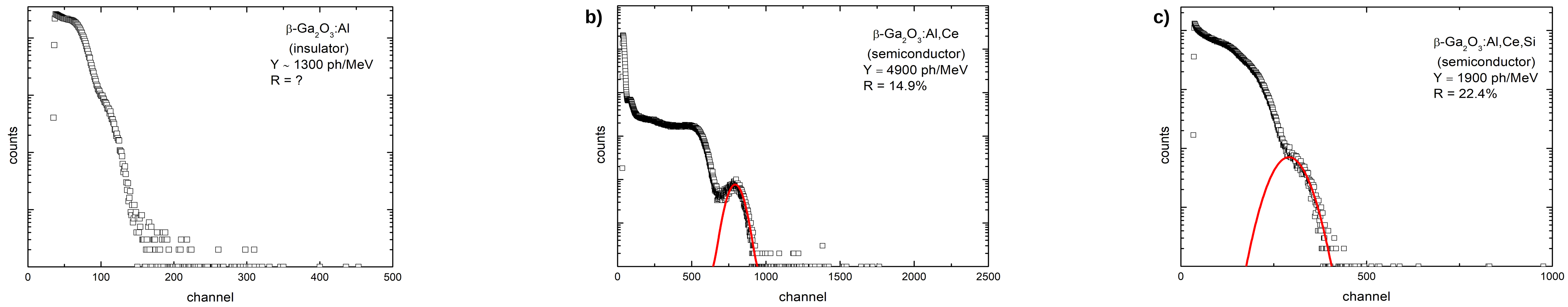

Fig. 1. Pulse height spectra of **a)** β-Ga_2O_3:Al, **b)** β-Ga_2O_3:Al,Ce, **c)** β-Ga_2O_3:Al,Ce,Si.

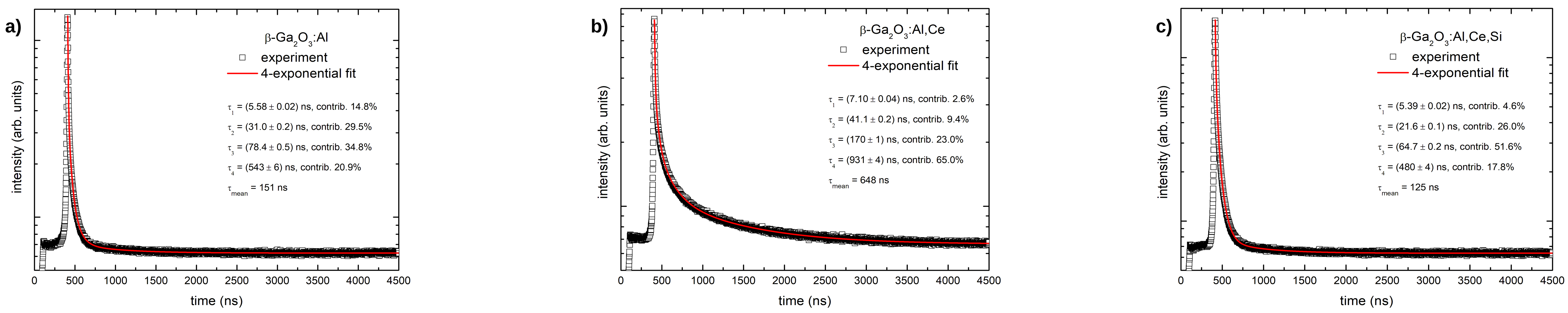

Fig. 2. Scintillation time profiles of **a)** β-Ga_2O_3:Al, **b)** β-Ga_2O_3:Al,Ce, **c)** β-Ga_2O_3:Al,Ce,Si.

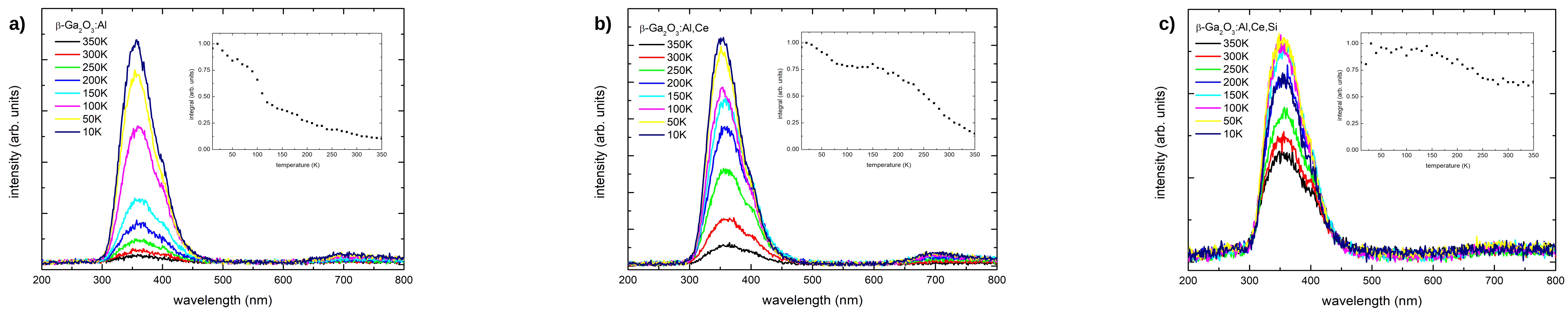

Fig. 3. Radioluminescence of **a)** β-Ga_2O_3:Al, **b)** β-Ga_2O_3:Al,Ce, **c)** β-Ga_2O_3:Al,Ce,Si.

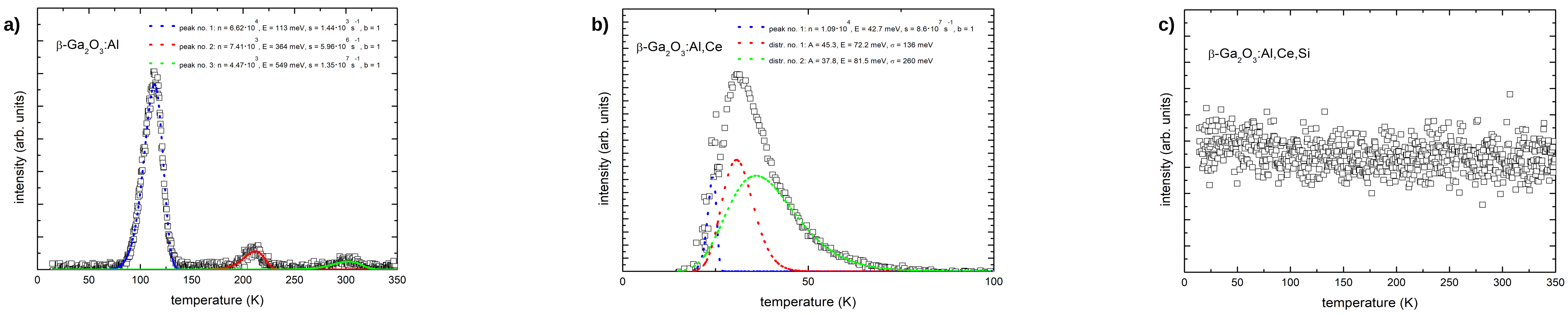

Fig. 4. Low temperature thermoluminescence of **a)** β-Ga_2O_3:Al, **b)** β-Ga_2O_3:Al,Ce, **c)** β-Ga_2O_3:Al,Ce,Si.

IV Conclusions

Considering the mere goal of obtaining a fast and efficient scintillator, the studied series of β-Ga_2O_3:Al, β-Ga_2O_3:Al,Ce, and β-Ga_2O_3:Al,Ce,Si crystals do not break any record compared to the previously reported results [4,5]. The doping with Al, intended to make the bandgap broader, does not result in presence of the Ce^{3+} d-f emission (which can be clearly seen by collating the current RL spectra and in previous communications [4,5]).

Scintillation properties such as light yield, energy resolution, and scintillation decay constants, are more or less comparable with those obtained for crystals without Al. Therefore a conclusion can be drawn that doping with Al is not a proper way to improve the scintillation performance of β-Ga_2O_3. Any further efforts should be aimed at combining the prominent properties of the already examined samples in order to find a composition providing the fastest and the most efficient scintillation.

The next step should be focused at providing a good compromise between light yield and free carrier density for any application that would require both high scintillation light yield and high conductivity. With high free carrier density luminescence/scintillation is being quenched most likely by Auger effect on free or bound electrons.

V References

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