

## Decay Time Optimization of YAG:Ce Scintillator for S(T)EM Electron Detector

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The process of optimization of a scintillation electron detector for S(T)EM offers many options such as the optimization of electron collection, electron-photon conversion, photon collection, as well as of photon-electron conversion [1]. In addition to the electron-photon conversion efficiency [2] and to the photon transport efficiency [3], also kinetic properties of a scintillator are of great importance in an Everhart-Thornley scintillation detection system. This is because the decay time of the scintillator strongly influences the detective quantum efficiency (DQE) [4], which is the most important criterion of quality of the whole detector. If the detector is to suit the TV rates, the decay time of the scintillator must be shorter than 100 ns. Kinetic properties of many single crystal scintillators were measured at our laboratory, and single crystals of YAG:Ce, YAP:Ce, and P47 were chosen as the most interesting ones for electron microscope detectors [2]. Of the crystals mentioned, the YAG:Ce is the cheapest one and so its usage is widespread. However, its decay time is often longer than 100 ns, and moreover, its decay characteristic is multi-exponential with afterglow of 2 % at 5 : s after the end of excitation. Two possibilities of decay characteristic optimization of YAG:Ce single crystals are presented in this paper.

As the first approach to the YAG:Ce single crystal decay time reduction, the study of the activator concentration effect has been accomplished in our laboratory. The single crystals were grown using different stoichiometry, and YAG:Ce specimens having the Ce concentration of 0.0013 mol%, 0.029 mol%, 0.13 mol% and 0.32 mol% were obtained. Their decay characteristics have been measured using a fast electrostatic deflection system for excitation and a photomultiplier-oscilloscope arrangement for response detection. It is obvious from FIG. 1 that YAG:Ce single crystals containing the highest Ce concentration are the fastest ones. No concentration quenching of cathodoluminescent emission was recorded for these single crystals. Unfortunately, it is a great technological problem to grow YAG:Ce single crystals resulting in activator concentration higher than 0.3 mol%. If one succeeded in growing such single crystals, then cathodoluminescent responses might approach very fast decays because of a higher probability of direct activator excitation.

Decay time reduction utilizing the activator concentration optimization is interesting particularly for producers of single crystals. However, there still exists another simple possibility of decay time reduction of YAG:Ce single crystal scintillators, which is interesting also for producers and/or operators of electron microscopes. As the second approach to the YAG:Ce single crystal decay time reduction, scintillator surface treatment effect has been studied in our laboratory. After cutting, polishing and cleaning in ethyl alcohol the YAG:Ce scintillator disks were boiled in different solutions and fired in oxidizing and/or reducing atmospheres. It is obvious from FIG. 2 that YAG:Ce single crystals, whose surfaces have been treated under different conditions, show different decay characteristics. Although the specimens boiled in aqua-regia possess high cathodoluminescent efficiency, they have quite poor decay time. Similarly, the YAG:Ce scintillators fired in a reducing atmosphere show better efficiency, but it is impossible to use them at TV rates at the same time. It can be summarized that the YAG:Ce scintillators cleaned in ethyl alcohol and fired in oxidizing atmosphere have the shortest decay time. Unfortunately, this favourable effect is accompanied by some decrease in cathodoluminescent efficiency.

- [1] P. Schauer and R. Atrata, Proceedings of 13th European Microscopy Congress, Antwerp, Belgium 2004, Vol. I, p.69.  
 [2] R. Atrata and P. Schauer, Scanning Microsc. Suppl. 9 (1996) 1.  
 [3] P. Schauer and R. Atrata, Proceedings of Microscopy Conference 2005, Davos, Switzerland 2005, p.55.  
 [4] D. C. Joy, C. S. Joy and R. D. Bunn, Scanning 18 (1996) 533.  
 [5] This work was supported by the grant No. 102/04/2144 of the Grant Agency of the Czech Republic.

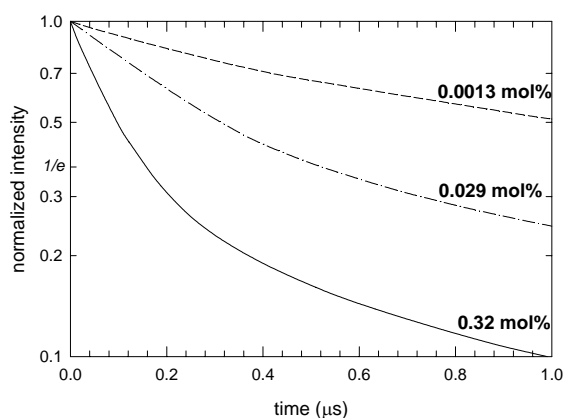


FIG. 1. Cathodoluminescence decay characteristics of YAG:Ce single crystals with different Ce concentrations.

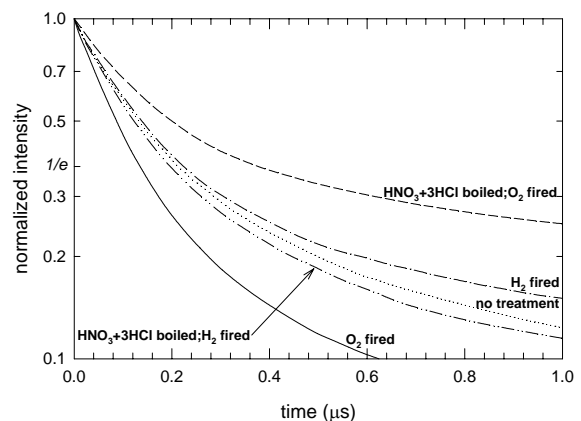


FIG. 2. Cathodoluminescence decay characteristics of YAG:Ce single crystals with different treatment conditions.