IMPROVEMENT OF SINGLE CRYSTAL SCINTILLATOR PROPERTIES IN SEM DETECTORS

Autrata R., Schauer P.

Institute of Scientific Instruments ASCR, Brno, Czech Republic,
e-mail: autrata@isibrno.cz

Properties of the scintillation – PMT detection system in SEM depend on the properties of the scintillator and the light guide, for all. Efficient energy transfer electron-photon, very short decay time of luminescence and an efficient transfer of photons in the light guide to the photomultiplier are the decisive properties for the efficient detection system.

A variety of the scintillation materials have been proposed for the detection of signal electrons in SEM. Nevertheless, the range of the suitable scintillators is restricted to powder phosphor of yttrium silicate (phosphor P47), plastic scintillators (NE 102 A) and single crystal scintillator based on yttrium aluminium garnet (YAG) and perovskite (YAP) [1]

YAP single crystal has not been used for the detection of signal electrons commercially until nowadays. Relatively short light emission maximum wavelength of 370 nm was a very serious limitation for commercial using of YAP because the light transmission of 370 nm wavelength is very low in organic glass light guide. Quartz glass is more suitable material but relatively expensive [2].

Further problem was very high self-absorption of the generated light emission itself. (20% in 5 mm thick single crystal).

Another problem was found in the polishing process of the YAP surface. The surface is very easily scratched and these cracks contain certain amounts of impurities from mechanically polishing material.

Firstly, a special light guide material which transmits light of 370 nm wavelength was developed. This organic glass contains special organic dopants for the increasing of light transmission in a short wavelength region of spectra (Fig 1). The light from YAP is transmitted to 95 % in the light guide rod 150 mm of the length and 20 mm of the diameter.

Secondly, owing to the additional treatment of the YAP single crystal discs in oxygen and hydrogen atmosphere at very high temperature, the colour centers in the YAP or YAG crystal lattice have been suppressed. Self-absorption of generated light was decreased by on half to approx. 10 % in YAP.

Thirdly, owing to the modified technological process of growing of YAP single crystals and the additional treatment of the YAP discs, the decay time 1/e has been shortened from the older value of 30 ns to the new value of 17 ns, for the incident electron energy of 10 keV (Fig 2.)

Fourthly, the polishing process of the YAP surface causes penetration of polishing microparticles into the surface microcracks. They can be removed by a washing process only, in a special mixture of acids at a suitable temperature. The smoothness of the YAP surface is decreased by this treatment but the relative efficiency of the electron-photon transfer is increased. Schema of the surface relief is shown in Fig.3 A,B.

All these technological steps enable to improve the scintillation properties of single crystal scintillators, namely of YAP, which has the shortest decay time from all single crystal scintillators. Its wavelength is spectrally well matched to all alkaline photocathodes, so that there is no problem regarding the choice of PMT. The short wavelength light transmission of newly developed light guide from organic glass ensures to achieve high efficiency of the light transfer from YAP to the PMT photocathode.

New YAP is now very efficient single crystal scintillator ,suitable for all types of the detectors in SEM. It can replace YAG single crystal scintillator in the BSE detector, used up to date.

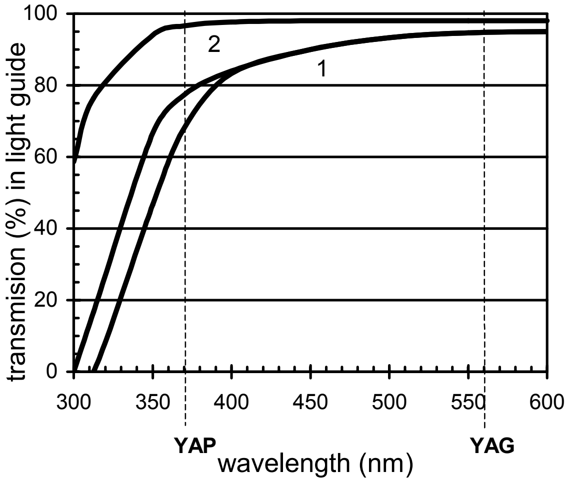

Fig. 1.

Figure 1. Transmission spectra of the commercial standard organic glass (1)and newly modified organic glass (2).

Figure 2. Time characteristics of YAP and YAG ($1/e_{YAP}$ = 17ns, $1/e_{YAG}$ = 70 ns).

Figure 3. Schema of the relief of single crystal surface after the polishing process A and after the additional treatment B.

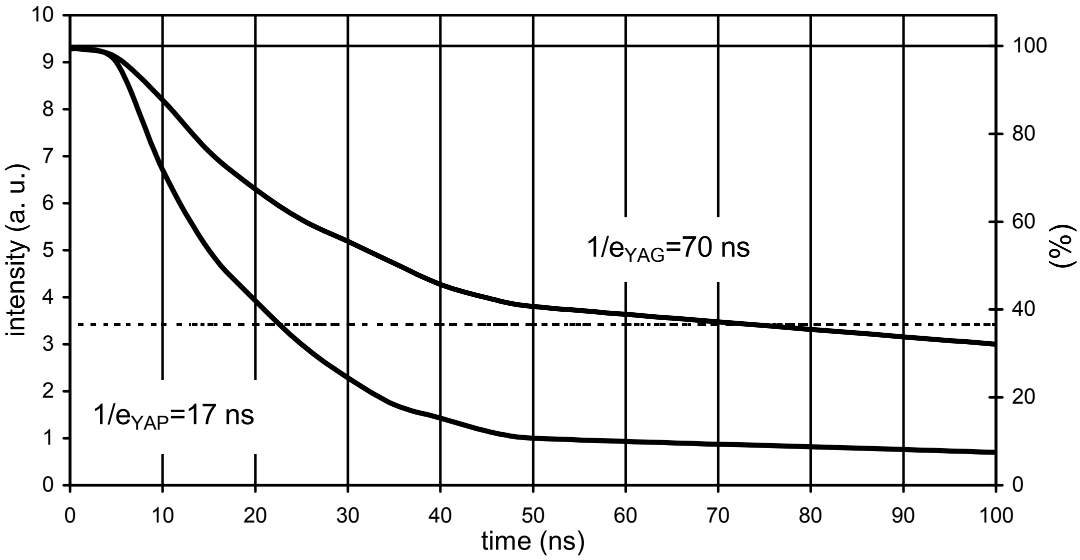

Fig. 2.

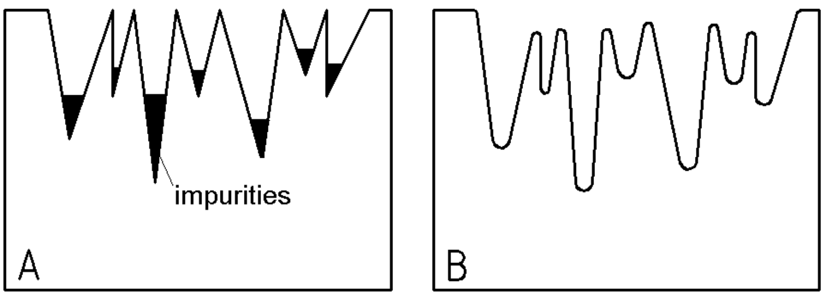

Fig. 3.

This work was supported by the grant of the Academy of Science of the Czech Republic No: S 2065107.

References:

[1.] Autrata R. European microscopy and analysis 3 (1996) 9–11
[2.] Autrata R. Scanning Microscopy Supplement 9 (1995) 1–12