NEW FAST AND EFFICIENT YAP SCINTILLATOR FOR THE DETECTION IN SEM

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Several types of detection system have been designed for detection of signal electrons in SEM. They differ in their components (scintillator – PMT systems, semiconductor systems, channel plate multiplier), in the detection material, geometrical configuration etc. Further, their use depends on the requirement for the detection of certain types of signal electrons (SE, BSE, TE). The energy of signal electrons and their angular distribution, propagation of electrons in the electrostatic or magnetic field, demands on resolution, time characteristics, noise properties and vacuum conditions are some further aspects which decide on the suitability of use of a specific detection in SEM. Comparably among these systems, the scintillation – PMT system, designed in 1960 by Everhart-Thorneley (1), still possesses the best signal to noise ratio and bandwidth characteristics.

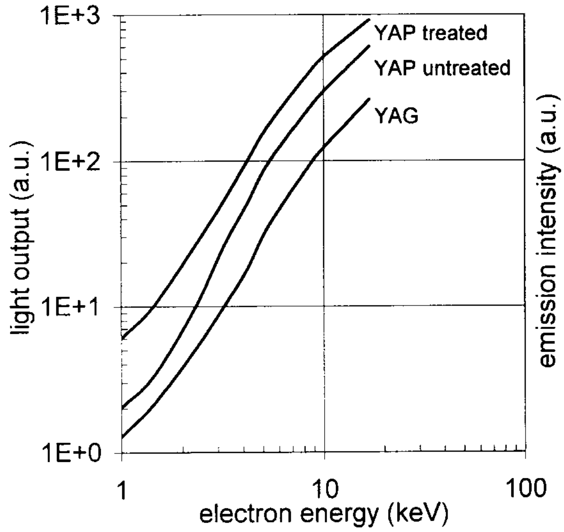
Properties of the scintillation – PMT system depend on the properties of the scintillator and the light guide, for all. Quantum efficiency of the scintillator expressed by number of generated photons after the impact of one electron on the scintillator and the transfer efficiency of photons through the light guide to PMT have the decisive influence on the overall efficiency of the detector. Short decay time and short afterglow of luminescence are further necessary properties of a scintillator in SEM. For these reason, the range of suitable scintilators is restricted to powder phosphor of yttrium silicate (phosphor P47), plastic scintillator (NE102A) and single crystal scintillator based on yttrium aluminium garnet (YAG) (2).

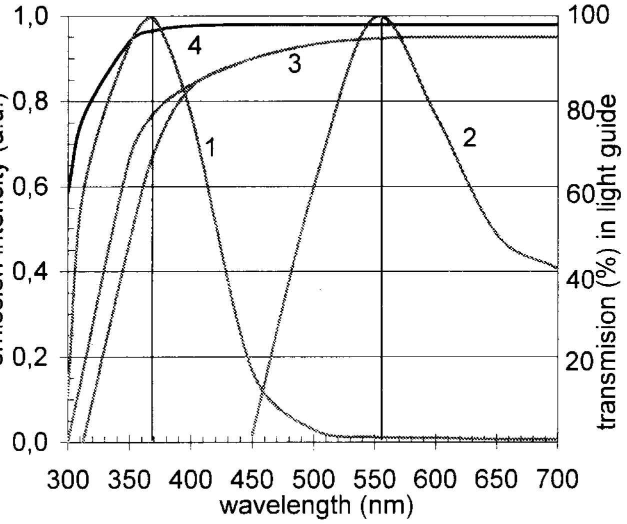
In this contribution, the new single crystal scintillator yttrium aluminium perovskite (YAP) with the improved scintillation properties is presented.

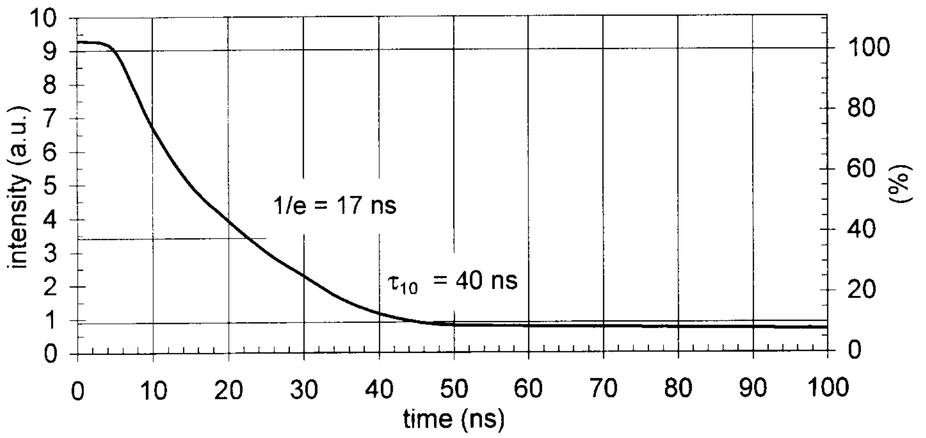
Owing to the additional treatment of the YAP single crystal discs in oxygen or hydrogen atmosphere at a very high temperature, the impurity and colour centers in the YAP crystal lattice have been suppressed. Self – absorption of generated light in 5mm thick YAP single crystal was decreased by one half, to approx. 10%.

It was found that the surface of YAP is contaminated after the polishing process. Micro particles of the polishing material are embedded into the micro-cracks in the depth of some micron units. These impurities 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. (Fig 1).

The short wavelength 370 nm of the emitted light from YAP is its main disadvantage. (Fig 2). A special light guide material which transmits light of 370 nm wavelength must be used. The quartz glass is a suitable material but its brushing and polishing is expensive. Organic glass containing special organic dopants for increasing of light transmission in a short wavelength region of the spectra is available now. Owing to the modified technological process of growing of YAP single crystals and the additional treatment of theYAP discs, the decay time and afterglow of the luminescence event has been shortened (Fig 3). The decay time 1/e is 17 ns for the incident electron energy of 10keV. Afterglow expressed as the decay of the light intensity from 100% to 10% amounts to approx. 40 ns and from 100% to 1% to approx. 200 ns.







YAG single crystal scintillator is widely and excellently used for the detection of backscattered electrons in SEM. (3). Nevertheless, the YAP single crystal, that was developed according to the last technology, can replace YAG and create BSE detector with improved detection properties.

Fig 1. Relative efficiency of single crystals versus energy of incident electrons.
Fig 2. Emission spectra of single crystal scintillators and transmission spectra of the light guides. 1) YAP emission, 2) YAG emission, 3) organic glass standard transmission, 4) organic glass modified transmission.
Fig 3. Time characteristics of YAP. 1/e decay time, τ_{10} = the decay from 100% to 10%.

References
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