EXPERIMENTAL SETUP FOR CATHODOLUMINESCENCE SPECTRA MEASUREMENT

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Scintillators and cathodoluminescent (CL) screens are typical imaging elements in electron microscopes. For their properties evaluation, for the study of new materials, or for the improvement of the original elements, one has to study CL emission spectra. In our laboratory the measurement equipment for the investigation of CL properties of solid specimens has been built [1]. The excitation unit with the electrostatic deflection system is formed by the adapted electron microscope, the light collection part is made up using the bulk UV transmitting light guide, and the detection unit is formed by the fast and efficient photomultiplier tube (PMT). The CL properties of specimens shaped as slim disks can be measured in continuous or pulse modes. So the efficiency, emission spectrum and the rise and decay times can be investigated for 10 keV electron beams. Although the pulse mode was intended for the determination of kinetic properties, it can also be used with advantage for the measurement of emission spectra.

The specimen chambre arrangement of the experimental equipment built is shown in Fig. 1. An investigated transparent specimen (with a transparent substrate if necessary) is positioned at the face of the light guide (inside the Faraday cage), and the blanking diaphragm is placed above the specimen. If required, the specimen can be heated by the ceramic element at the bottom of the Faraday cage, and the temperature can be measured by the built in thermocouple element. The Faraday cage is used to the beam current measurement and to the consequential Wehnelt control to have the excitation beam as stable as possible during the whole spectral region measurement. The electron beam is deflected by deflection plates situated above the diaphragm using a pulse generator.

The layout of the control and measurement bus is shown in Fig. 2. Contrary to the direct measurement of the efficiency or decay characteristics, at the spectral measurement the CL emission is guided to the entrance slit of the mirror monochromator (Carl Zeiss Jena SPM 2), and the PMT (EMI 9558B) is positioned at the output slit of the monochromator. The measured narrow spectral lines are attenuated very strongly, and so the signal to noise/background ratios are very small. Therefore, it is necessary to measure the CL emission in a synchronous mode using the modulated beam and a lock-in nanovoltmeter. The reference pulse is taken from the triggering output of the beam modulating generator. The monochromator hand shift of the wavelength was replaced by a small unit with the electromotor controllable by a personal computer (PC) using the D/A converter. The wavelength shift is grabbed using a revolution sensor. After application of wavelength calibration functions and after signal corrections for the photocathode sensitivity the emission spectra can be displayed on the monitor of the control PC. The individual instruments are connected to the general purpose interface bus (GPIB, known as IEEE-488 standard), and the measuring apparatus is controlled by the PC, that also processes the obtained data. The GPIB is driven using the high performance PCI card Agilent 82350A.

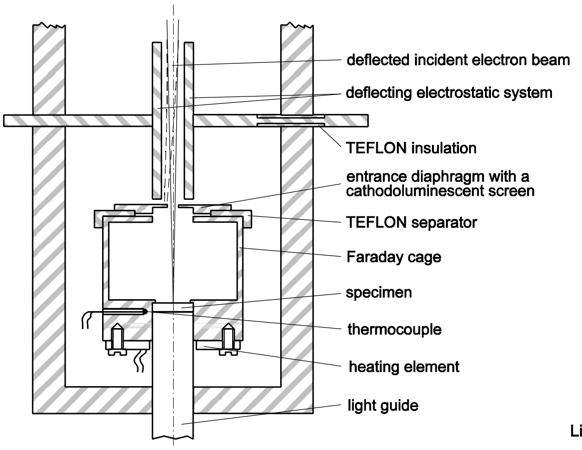

Fig. 1. Specimen chambre arrangement of the CL experimental equipment.

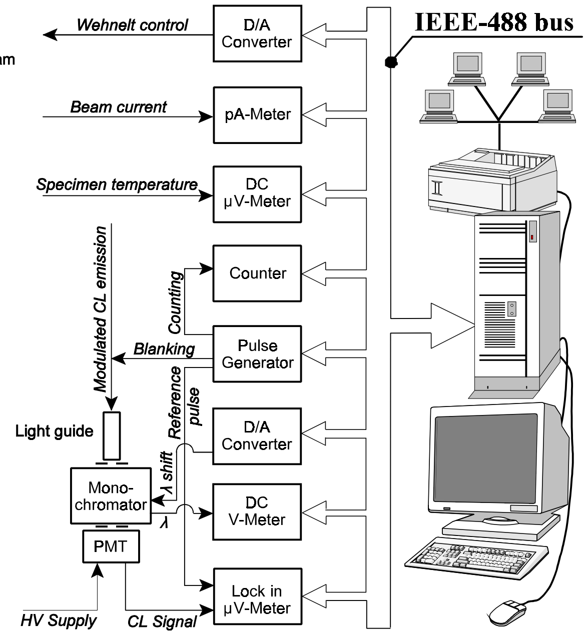

Fig. 2. IEEE-488 bus layout for the control of the CL emission spectra measurement.

Utilising drivers for the MS Windows, it is possible to control the data flow through the bus connected to the Agilent 34970A data acquisition switch unit, Agilent 34401A multimeters, and other IEEE-488 equipped instruments. The PC is connected to the ethernet network, therefore remote operations are available. The data measuring and processing software (including corrections) was written alternatively in the Borland Delphi, the Spectra Publishing PowerBasic, and in the Agilent VEE language using the Agilent IO Libraries.

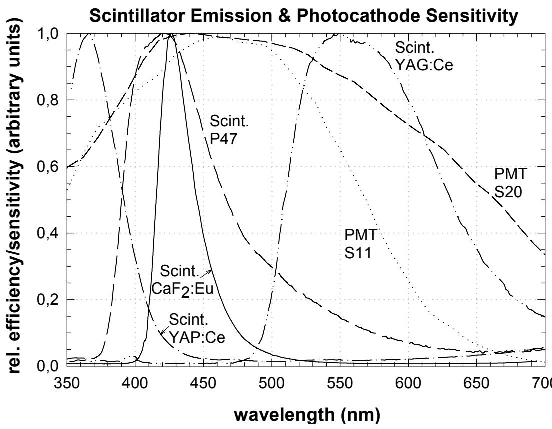

Fig. 3. Normalized CL emission spectra and spectral sensitivities of some scintillators and PMT photocathodes, respectively.

The CL emission spectra of some scintillators (YAG:Ce, YAP:Ce, P47 and CaF_2:Eu) measured using the described experimental setup, corrected for the spectral sensitivity of the PMT used, and normalized to the maxima of each curve are shown in Fig. 3. Using the inbuilt interpretative program, the positions of the peaks wavelength and the full width of the half maxima (FWHM) can be obtained for each specimen immediately. Utilising the same experimental equipment, spectral sensitivities of PMT photocathodes can be measured as well. These curves normalized to their maxima are plotted in Fig. 3, too.

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References

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