COMPUTER DESIGNED SCINTILLATION DETECTORS FOR SEM

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Two different modes of scintillation detection of electrons are used in SEMs. One (basic) makes use of the Everhart-Thornley (ET) detector, i.e. a base guided signal (BGS) rotationally symmetric system, intended for the detection of secondary electrons. The other makes use of an edge guided signal (EGS) scintillation system, and it is intended for the detection of backscattered electrons. An optimum design of detectors for both detection modes depends on the proper choice of material and geometry of the scintillator and light guide, as well as on the treatment of all surfaces including boundaries. Furthermore, the detector design must comply with the space available in the microscope. Estimation and experimental verification of the properties of such a detection system are very time consuming and expensive and offer uncertain results.

The best way of avoiding inefficient detection systems is Monte Carlo (MC) simulation method for the photon transport through the scintillator and light-guide [1]. Therefore, the SCIUNI computer program suitable for nearly any scintillation detection system for SEM was developed. Version 2.0 has been extended using a new algorithm for the interaction of a photon with scintillator and light-guide surfaces. Thus simulated detector systems may comprise almost all actual surfaces. In addition, the 3.0 version involves new loops for the light-guide shape optimisation. The source code of the program has been written in Fortran 77 and compiled on different computer platforms. At present, versions for the MS-DOS, UNIX, and RTE-A (Hewlett Packard) operating systems are available. The results presented in this paper have been obtained by computing on Iris Indigo (Silicon Graphics) work station under IRIX operating system.

Designing ET (BGS) detection systems is a much easier task than designing EGS systems. In fact, the efficiency of ET detectors is given only by the material and the shape of the scintillator. The results of the MC simulation of the photon transport through ET (BGS) rotationally symmetric systems are shown in Fig. 1. The 3-D graphs illustrate the dependence of the system light-guiding efficiency on the coordinate of the excited point on the surface of the scintillator. It is evident from the Fig. 1 that a cone shaped scintillator is advantageous, if an electron collection system can collect close to the detector axis. Otherwise, a disc shaped scintillator with a matted output surface is better. The efficiency of the ET system is nearly independent of the size of the light guide that is mostly cylindrical.

On the contrary, the efficiency of backscattered (EGS) detection systems is strongly dependent on the size and mainly on the shape of the light guide, even if the material, size and the shape of the scintillator are the same. This is due to the fact that a narrow light-guiding profile has to expand to a wide circular one. The three steps of computer designing a new S 4000 Hitachi

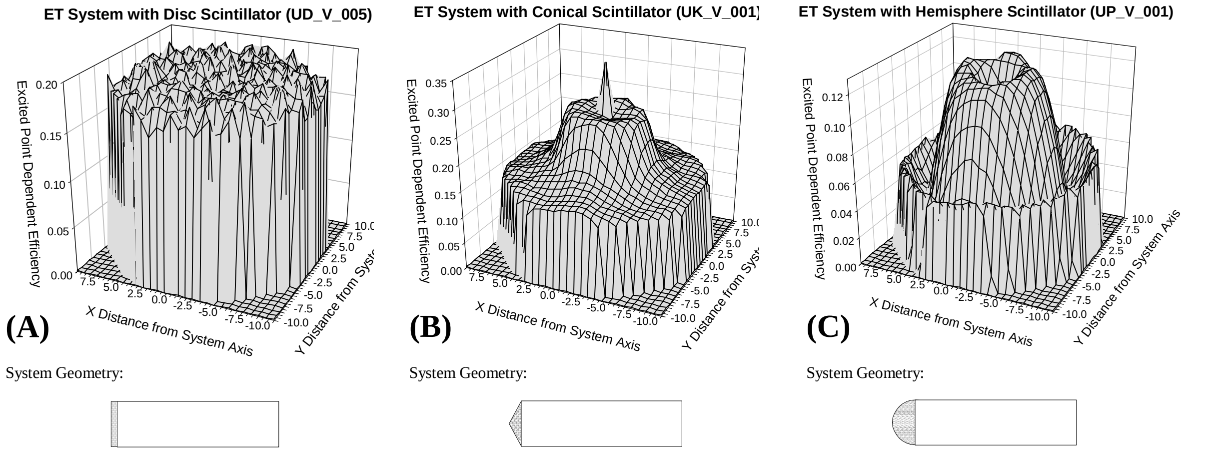

Figure 1. Light-guiding efficiency of rotationally symmetric ET detection systems in the dependence on the coordinates of the excitation point on the surface of the (A) disc, (B) cone, and (C) hemisphere YAG:Ce scintillator. Notice the different scaling of efficiency axes.

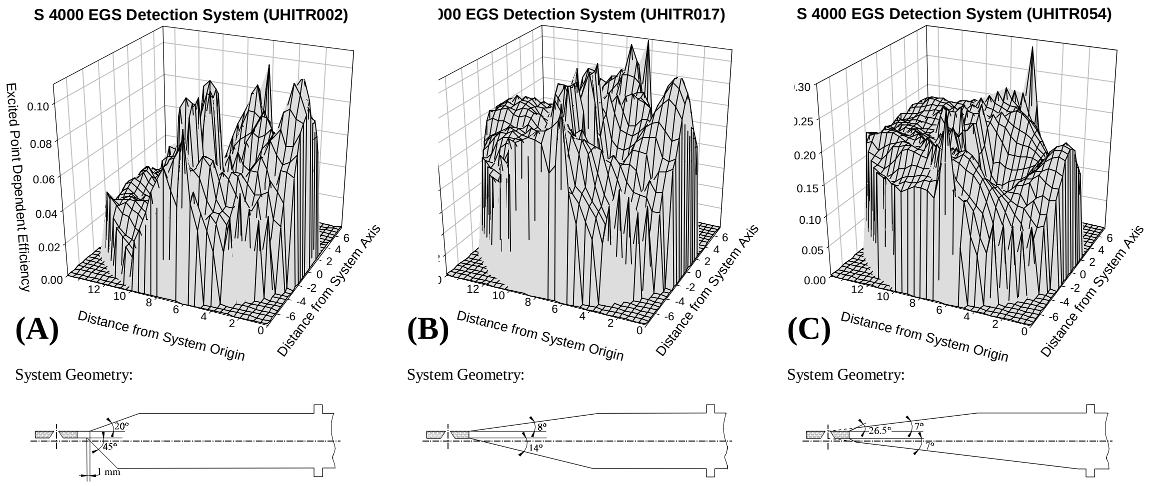

Figure 2. Light-guiding efficiency of the EGS BSE detection system (Hitachi S 4000) in the dependence on the coordinates of the excitation point on the surface of the YAG:Ce disc scintillator with a conical hole. (A) The rough (non-optimized) design. (B) After shifting widening planes and decreasing angles of planes. (C) The final geometry, after reducing slopes and integrating a conical light-guiding ring. Notice the different scaling of efficiency axes.

SEM detector are shown in Fig. 2. The initial (non-optimized) detector design (A) was given above all by the limited space in the specimen chamber, and by the size and position of the PMT window. The simulated mean efficiency of the photon transport through this configuration was about 0.04. After partial computer optimization (B) it has been found, that even only shifting the widening plane and decreasing the angles of planes increase the detector efficiency as high as to 0.11. The light-guiding efficiency for the final refinement (C) with a conical light-guiding ring was about 400 % compared with the initial one.

References

[1] Schauer P, Autrata R, *Scanning* **14** (1992), 325-333.