THE DESIGN OF PRE-RETARDATION COLUMN OPTICS TO IMPROVE THE ENERGY RESOLUTION OF ENERGY ANALYSERS

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High resolution electron spectroscopy is a technique utilized in many different fields of physics, material science, chemistry, and even medicine [1]. One of the most popular spectrometers in use is the hemispherical deflector analyser (HDA) [2] also available commercially from many different high tech companies. Currently, modern HDAs are equipped with state-of-the art multi-element zoom lens and position sensitive detector (PSD) and therefore enjoy a very large collection efficiency. The zoom lens focuses the source electrons into the HDA entry, thus increasing the overall collection solid angle. Of outmost importance is also the overall energy resolution of the spectrometer which can be further improved by pre-retardation. The same input lens, can also decelerate the electrons from an initial source energy E_0 down to a much lower energy E just prior to HDA entry, improving the energy resolution by a factor of $F=E_0/E$ within the constraints imposed by the Helmholtz–Lagrange law [3]. An example of direct ray tracing through such an HDA is shown in Fig. 1 for pre-retardation with F=10 [4].

This paper will present a pre-retardation conical electrode design for the second-order focusing 270° deflection toroidal energy analyser for use in scanning electron microscopes (SEM) as an add-on attachment [5]. An example of direct ray tracing through such a design is shown in Figs. 2a and 2b, where 2 keV backscattered electrons emitted with ±2° around a 45° polar angle are retarded to a pass energy of 10 eV through the analyser. These simulations predict that the analyser has second-order focusing optics, and that a 200 μm wide exit slit will capture a 1° emission polar angular spread with an energy width of 0.3 eV, corresponding to an energy resolution of around 0.015%.

The paper will discuss how pre-retardation might be used to significantly increase the energy resolution for SEM applications where high energy resolution is required, such as detecting bulk plasmon peaks on the trailing edge of the backscattered energy spectrum. Comparisons of the energy resolutions attainable in simulations of comparable toroidal and HDA analysers will be presented.

References

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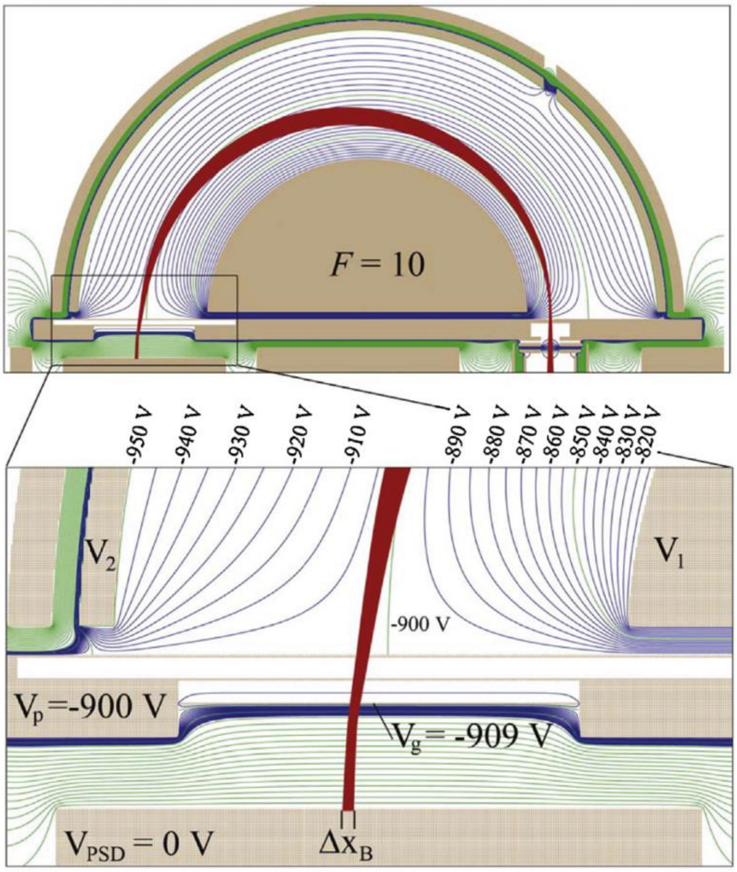
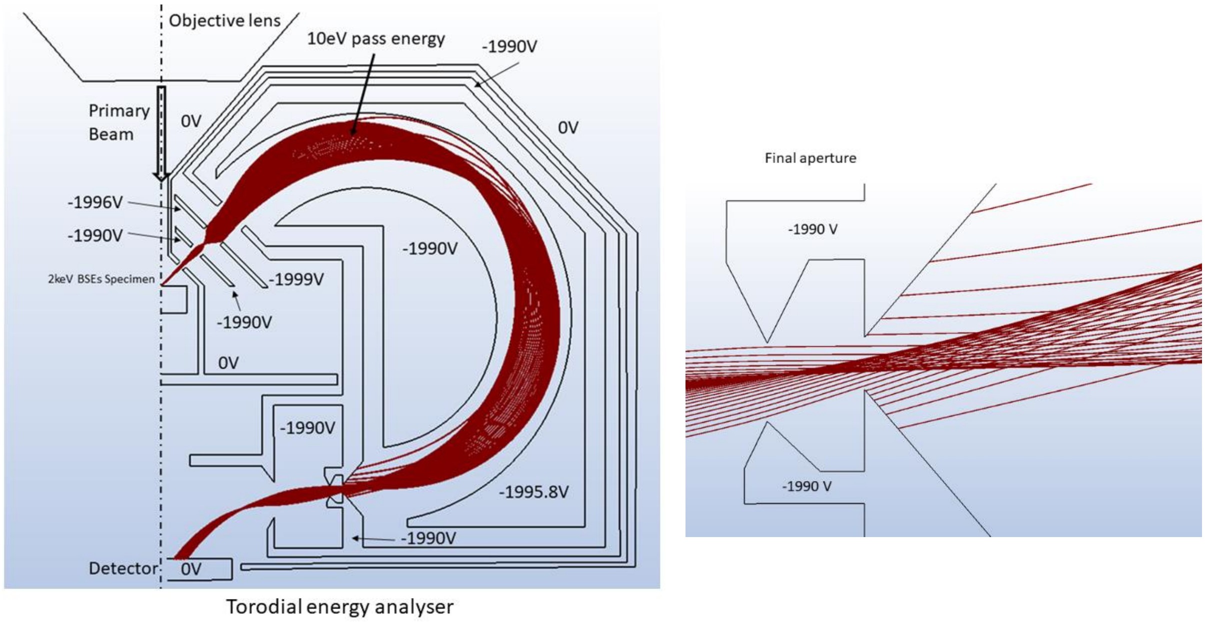


Figure 1. SIMION schematic of HDA electrodes, equipotenttials and trajectories in the symmetry plane showing the position sensitive detection (PSD) region (zoom insert) at the exit of the HDA. Electrons with energy E_0=1 keV enter from the right, where a zoom lens (only partly shown) focuses and retards them down to a central pass energy of E=100 eV (pre-retardation factor F = 10). The source half angular spread is 0.397°. The distance h between the HDA exit plane and PSD is adjusted for optimal beam spot size $\Delta x_{B.}$ The trajectories spread out in the dispersion plane resulting in an improved energy resolution proportional to 1/F. A grid biased to V_g=-909V is used just in front of the PSD to eliminate any spurious electron back-ground (adapted from Ref. [4]).



(a) (b)

Figure 2: Direct ray tracing simulations through a second-order toroidal SE energy spectrometer with pre-retardation optics inside a SEM. 2 keV backscattered electrons emitted with ±2° around a 45° polar angle are retarded down to a pass energy of 10 eV through the analyser for F=200.