WIEN FILTER ELECTRON OPTICAL CHARACTERISTICS DETERMINING USING SHADOW PROJECTION METHOD

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Wien filter is suitable for the separation of the primary and the signal electron beams in very low energy scanning electron microscope with cathode lens [1]. We have modified the *two-grid shadow method* [2] to determine experimentally electron optical properties (cardinal elements and aberrations) of the Wien filter, which is not a rotationally symmetric element. We call the modified method the *shadow method with grid and moving screen*. The advantage of the shadow method is its geometrical simplicity allowing the comparison of the experimentally obtained and numerically computed trajectories.

The arrangement of the *two-grid shadow method* is shown schematically in Figure 1(a). The electron beam from the point source passes through horizontally oriented linear grid, next the beam passes through the measured optical element, makes an image of the source, passes through a vertically oriented second linear grid, and casts a shadow upon a fluorescent screen. The inclination tangent of input trajectories can be determined from the point source position and from the known dimension of the first grid. The inclination tangent of the output trajectory can be determined from the shadow image of the first grid and the distance between the screen and the intersection of the trajectory with the optical axis. This distance can be determined from the second grid and its shadow image. Angular magnification can be calculated from these trajectories. Hence, with knowledge of potentials in image and object planes, we can calculate linear magnification. Two measurements at two different geometrical configurations are necessary to calculate the remaining cardinal elements, i.e. the positions of principal planes and focal distances [3]. The calculation of angular magnification from shadow image of two grids is possible only for rotationally symmetric element. Therefore, our modification of the *two-grid shadow method* is necessary to measure electron optical elements without rotational symmetry.

The arrangement of the modified *shadow method with grid and moving screen* is shown in Figure 1(b). The rectangular grid situated in front of the measured Wien filter (outside the filter fields) together with the point source position fully determines the input trajectories. Output trajectories can be determined from the two shadow images taken at two fluorescent screen positions. The advantage of the method remains the use of the grid as a scale, thanks to this the coordinates of the characteristics points are sufficiently precisely determined before the measurement. The grids can be used to calibrate distances on the screen. Additionally, the information about transverse coordinates of the trajectories is contained in one image, so image processing methods can be used to read the coordinates of the characteristic points from the image. Only the determination of the screen position is important.

All the types of aberrations will manifest in the shadow image: geometrical, chromatic, and diffractive, as well as blurring due to finite dimension of the point source. The method is based on reading the coordinates of the characteristic points from the shadow image. The edge blurring caused by the chromatic and diffractive aberrations and the finite dimension of the point source makes the precise reading of the points coordinates difficult. Therefore, deviations in the image caused by the above mentioned aberrations have to be minimized and the deviations in the image caused by the geometrical aberrations have to be maximized. Simultaneously the aberrations must be large enough to be measured. The calculation of the aberration coefficients will be made by fitting of the measured trajectory using the least squares method. The method can be also used for calculation of chromatic aberrations coefficients if the measurements for different electron energies would be made.

The experimental UHV apparatus for measurement of our Wien filter properties have been designed and made. The Wien filter uses eight combined poles-electrodes to produce nearly identical magnetic and electrical field. Schottky thermal field cathode is used as a point source of electrons.

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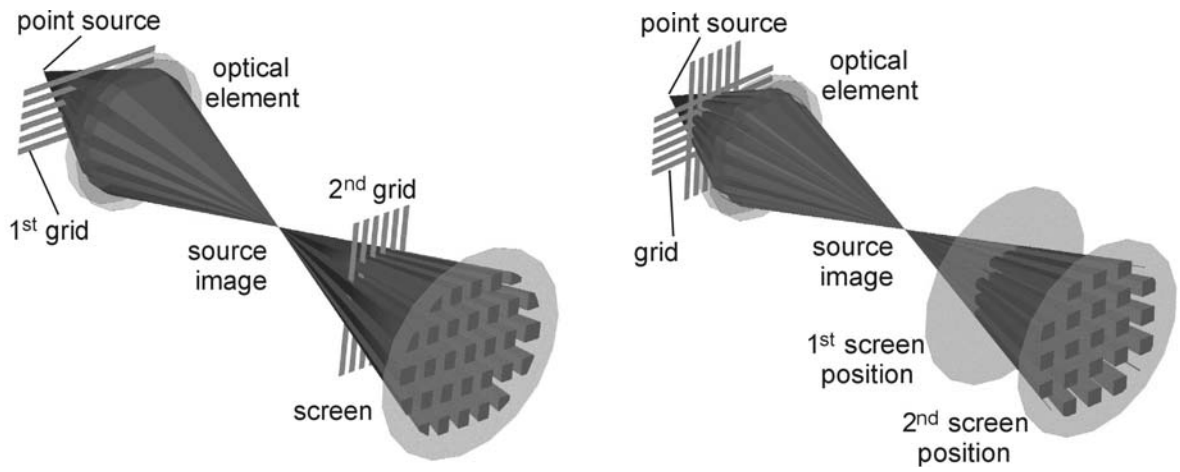

(a) (b)

Figure 1. (a) The arrangement of the two-grid shadow method. **(b)** The arrangement of the modified shadow method with grid and moving screen.