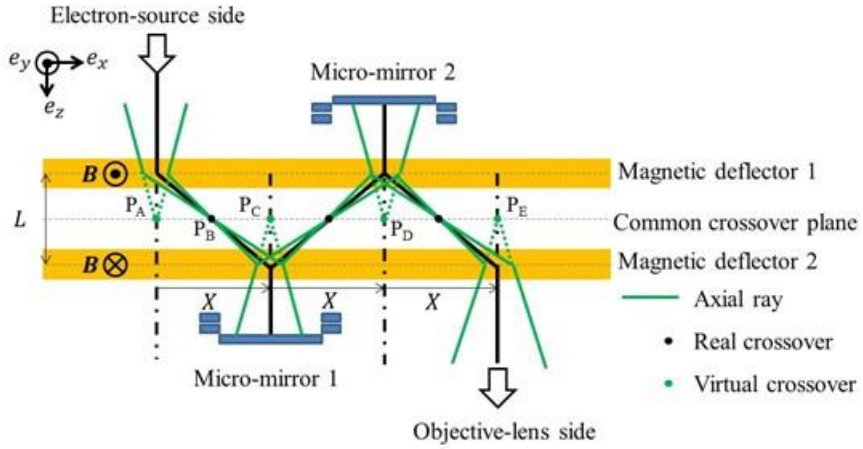
An aberration corrector for scanning electron microscopes using miniature electron mirrors

Kruit, P.[1], Dohi, H.[2] and Kishimoto, T.[2]

[1] Delft University of Technology, Netherlands, [2] Hitachi High-Technologies Corporation, Japan

The resolution of scanning electron microscopes (SEMs) is limited by aberrations of the objective lens, mainly the chromatic aberration. It is well known that both spherical and chromatic aberrations can be compensated by placing an electron mirror in the beam path before the objective lens. The effectiveness of this has been proven in LEEM systems. Nevertheless, this approach has not led to use of these aberration correctors in SEMs, probably because aberrations of the bending magnet can be a serious problem. We have proposed a mirror corrector with two mirrors placed perpendicularly to the optic axis of an SEM and facing each. As a result, only small-angle magnetic deflection is necessary to guide the electron beam around the top mirror to the bottom mirror and around the bottom mirror to the objective lens. The deflection angle is only in the order of 50 mrad, and thus sufficiently small to avoid deflection aberrations. In addition, lateral dispersion at the sample plane can be avoided by the correct choice of deflection fields. In order to keep such a corrector system simple, the incoming beam should pass the top mirror at a distance in the order of millimeters. It is proposed that condition can be satisfied with micro-scale electron optical elements fabricated using MEMS technology. In the proposed corrector system, the micro-mirrors have to provide the exact negative spherical and chromatic aberrations for correcting the aberration of the objective lens. This exact tuning is accomplished by variable magnification between the micro-mirrors and the objective lens using an additional transfer lens or by using a tetrode element mirror.

Extensive optical calculations were performed. Aberrations of the micro-mirrors were analyzed by numerical calculation. Dispersion and aberrations of the deflectors were calculated by using an analytical field model. We concluded that the proposed corrector system could be a candidate for aberration correction in low-voltage SEMs. We have started the construction of a system to be tested in an existing SEM.



Schematic ray diagram of the so-called S-corrector.

Reference:

Hideto Dohi and Pieter Kruit, *Design for an aberration corrected scanning electron microscope using miniature electron mirrors,* To be published Ultramicroscopy 2018.