

Dynamics of Magnetic Electron Lenses

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1 Magnetic electron lenses

Measurements on an experimental scanning electron microscope (SEM) lens system (immersion-type probe forming lens and vacuum chamber) in combination with first principle models and finite element methods have to provide insight into the dynamic behavior of the lens influenced by phenomena as Eddy currents, a nonlinear B-H curve and hysteresis.

For decades the electron microscope has been used as a manual controlled imaging device. For the next generation of microscopes there is a need for automation and calibration. Static characterization of electron optic elements such as magnetic electron lenses is known in detail. However, to reduce the time involved and to increase reproducibility of lens settings, taking into account dynamics is crucial.

Within a SEM an electron beam is focussed into a fine spot which can be as small as 1nm. The spot size is limited by aberrations of different electron optical components. The area which is scanned is in the order of μm . Magnifications in the order of a few 100,000 times are obtained, [1]. A schematic diagram of a SEM is provided in Figure 1.

The focal distance f (1) is related to both the acceleration voltage ($U \in [0.2, 30]\text{kV}$, [1]) and the magnetic field at the optical axis B_z , [2]. Here e and m represent the charge and mass of an electron.

$$\frac{1}{f} = \frac{e}{8mU} \int B_z^2 dz \quad (1)$$

Magnetic electron lenses are controlled by the current running through the lens' coil (about 1,000 Ampere turns). The magnetic field ($\mathbf{B} \in [0, 1]\text{T}$) is shaped by the lens-yoke. Stability demands on both current and the magnetic field are in the order of 10 ppm. The yoke-material is selected such that the best steady state results are obtained.

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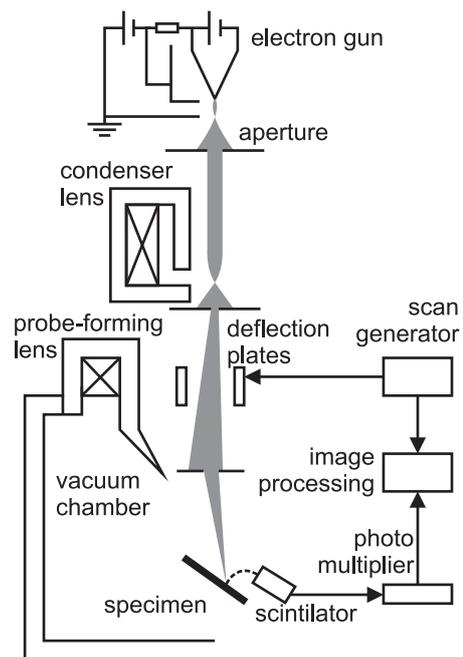


Figure 1: Schematic diagram of a scanning electron microscope.

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References

- [1] FEI Company brochure. "All You Wanted to Know about Electron Microscopy but Didn't Dare to Ask", 2002.
- [2] Ludwig Reimer, "Scanning electron microscopy: physics of image formation and microanalysis", Berlin Springer, 1985.