Towards high spatial resolutions in electron emission microscopy, application to experimental setups used for PEEM and localised ESCA.

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In order to reach very high spatial resolutions by direct photoelectron emission microscopy, the objective lenses -electrostatic immersion lens- should adjusted with a great care [1-2]. Obviously, such a purpose deserves to pay a particular attention to the selection of their geometrical parameters and excitation conditions. This is here our main goal.

This study mainly associates analytical calculations with optical simulations based on SIMION 7 software for electrostatic systems composed of an acceleration space followed by focusing elements. In the objective output pupil an aperture stop sets variable limits in collection angles, depending on the electron initial energies [3-4]. Even when an energy filter is included to the experimental set up, the surface image implies energy dispersed electron beams. Therefore, any objective lens characterisation should take into account the chromatic behaviour and spherical aberrations simultaneously. Hence, the image quality is deduced from density plots achieved by convolutions of a very large set of electrons paths ejected with random emission angles.

The high acceleration voltages applied over short distances increase the angular limits and consequently the aperture aberrations. Obviously the aberrations could be reduced by using narrow aperture stops. However, it seems more convenient to choose moderate acceleration voltages in connection with a positive bias for the focussing element. Indeed, this bias mode reduces the chromatic and spherical aberrations simultaneously and also to lessen the influence of residual magnetic fields since the electrons keep high energies all along their paths. Even, for the energy band pass of 0-10 eV an aperture stop of 30 µm in diameter convene to distinguish two elements separated by 1 nanometre only. Further, since the object nodal point are removed quite far from the emitting surface, this configuration also reduces misalignments effect caused by local disturbances in electrostatic field at the sample surface level.

Additional studies also concern adjustments in the electrode shapes to induce a further reduction of aberrations coefficients by a factor about 3 and voltage control of insulating substrates by an auxiliary electron beam applied in a mirror like configuration.

References:

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