Design of a multi-ion/electron beam common axis column

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Various dual ion/electron beam common axis column designs have been proposed in the past in the context of designing better lithography and microscopy instrumentation[1,2]. Recently, a patent was filed on the use of a magnetic sector as a means to deflect an ion and electron beam on to a common optical axis[3], where the electron beam is deflected through 90 degrees. However, no details are given as to how the deflection aberrations of the magnetic sector can be minimized. In this paper, detailed simulation results will be presented on how best to design round stigmatic magnetic sectors for the purpose of combining an ion and electron beams, ones that can act as round lenses for the primary beams that they deflect, thereby greatly reducing their deflection aberrations. It will also be shown that by using two such magnetic sectors, an instrument for combining multiple electron/ions beams can be designed. Extending a previous proposal to provide spectroscopic information by the use of stigmatic magnetic sectors[4], it will be shown that the present instrument can also be also be used for parallel energy and mass spectroscopy detection, in effect, combining Scanning Electron Microscopy (SEM), the Focused Ion Beam (FIB), Secondary Ion Mass Spectroscopy (SIMS), and Auger Electron Spectroscopy (AES). A multi-ion/electron beam common axis column also has obvious attractions for direct write lithography.

Fig. 1 shows a general schematic of the multi-ion/electron beam instrument proposal, while Fig. 2 gives an illustration of the kind of round beam separators (magnetic sectors) that can act stigmatically, that is like round lenses, when deflecting primary ion/electron beams. Beam separator 2 deflects ions of different charge-to-mass ratios on to a common optical axis. Below it, beam separator 1 deflects primary electron beams of differing energies on to the same axis. A transfer lens ensures that all primary beams are focused towards the centre of each magnetic sector in order to minimize deflection aberrations. A special combined electrostatic lens/magnetic immersion lens is used to focus all primary beams on to the sample, the magnetic field adds greater flexibility in the focusing of the electron beam. Beam separator 1 subsequently acts as the first stage of an electron energy spectrometer for the scattered electrons, while beam separator 2 acts as the first stage of a mass spectrometer for secondary ions. The paper will present detailed simulations to show that the design of a multi-ion/electron beam common axis column is feasible.

References

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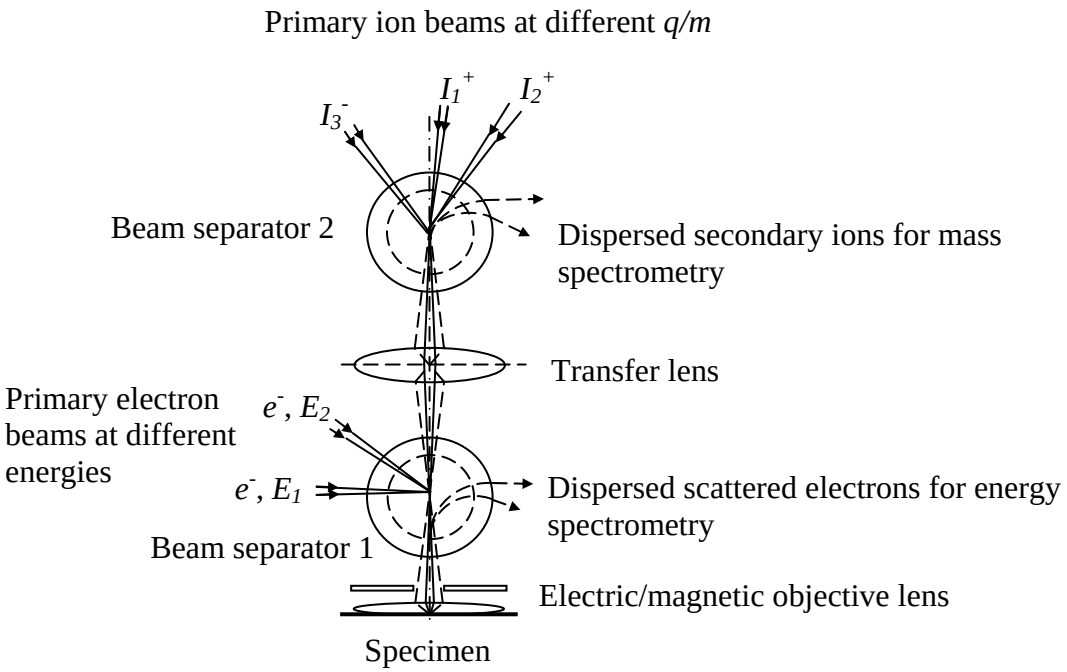

Fig. 1: Schematic for ray paths in a multi-ion/electron common axis column: The primary beam is indicated by a solid line while scattered particles are represented by a dashed line

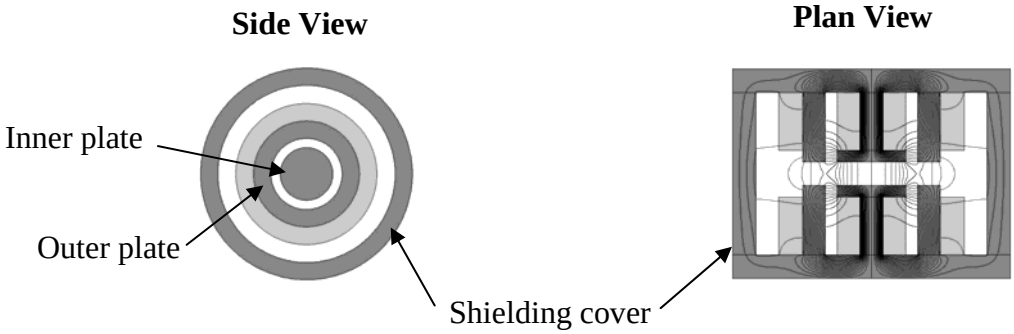

Fig. 2: Stigmatic magnetic sector deflector: Flux lines from a finite element solution are shown in the plan view for an outer diameter of 100 mm.