Microcolumn with Variable Axis Lens for Large Scan Fields

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The ongoing miniaturization of structures in electronics and storage calls for new production and examination methods. The desired structures can be generated and inspected by a low voltage scanning electron beam. For increased efficiency, it is desirable to miniaturize these electron optical systems and operate them in parallel [1]. Most microcolumn designs up to now have been dedicated to achieve small beam sizes for lithography or microscopy purposes [2], usually exhibiting rather small working distances and scan fields. This work takes a different approach by aiming the design of the microcolumn geometry at a large number of addressable pixels while keeping the pixel size, i.e. the beam size, as small as possible. Our previous design [3] for this task has been altered and extended by a variable axis lens (VAL) realized within a microcolumn for the first time.

The new design features a large working distance in the 40 mm range and therefore magnifies the effective electron source into the final spot. About 1 cm^3 in size, the electron optical system employs a microfabricated pre lens double deflector and a VAL operated in accelerating mode. The VAL consists of two apertures and three identical octupoles and is optimized to correct the 3[rd] order coma and transverse chromatic aberrations. 5[th] order simulations for 1 keV electrons from an electron source of 10 nm in size and 0.5 eV energy spread predict an increase in beam size from 75 nm on axis up to about 900 nm for a beam deflected 5 mm off axis (Fig 1). Within a 3 x 3 mm^2 scan field this microcolumn could address over 1 Gigapixels of less than 100 nm in size.

Tests of this design were performed using the electron probe of an XL30 SEM as the electron source. Fig 2 shows the ability of the microcolumn to scan field sizes of more than 6 x 6 mm^2 once dynamic correction of focus and distortion is implemented. Besides the enhanced scan field with a VAL configuration resolution towards the edges of the scan field is deteriorating much less than with conventional lenses as ca be seen in Fig 3. The design methodology, experimentally evaluated performance and comparison with simulations will be presented.

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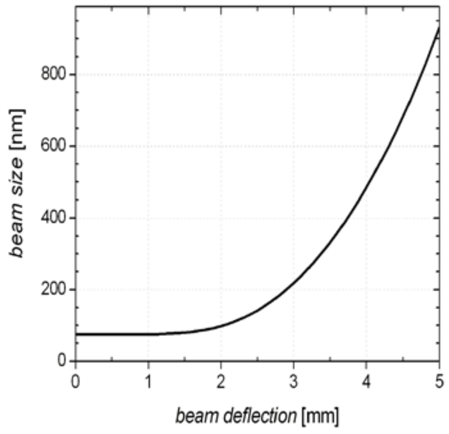

Figure 1: Calculated size of a 1 keV beam at 40 mm working distance versus deflection presuming a 10 nm source and 0.5 eV beam energy spread.

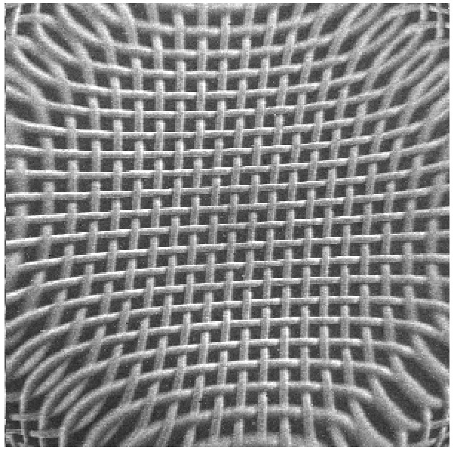

Figure 2: Scan of a mesh with 0.5 mm period at a working distance of 38 mm and 1 keV beam energy. Field curvature and distortion are not corrected.

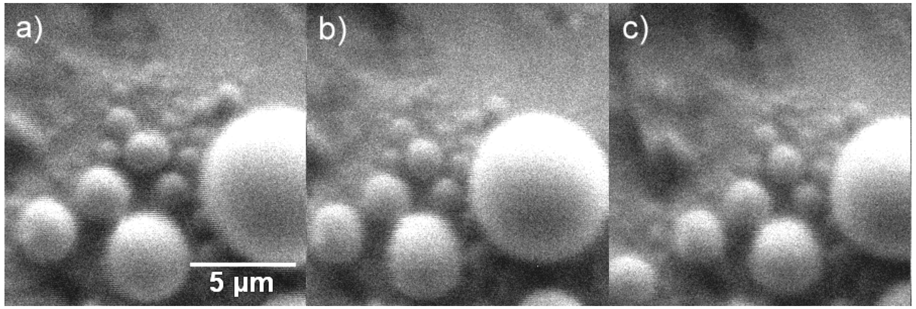

Figure 3: Images of tin spheres. Image a) was taken by the microcolumn with the beam scanning the structure on axis while for scans b) and c) the structure was positioned 3 and 5 mm off axis, respectively. Focus and astigmatism were readjusted for scans b) and c). Working distance was 38 mm. The graphs show the little decrease in resolution with beam deflection caused by the VAL configuration.