X-ray microscopy with 100nm resolution and 3D imaging of the objects internal microstructure by microCT attachment for SEM.

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A standard SEM image displays the surface of an object as a two-dimensional flat picture. An inexpensive microCT attachment for any SEM has been developed to add a new imaging modality for X-ray microscopy microtomography - visualization of the true 3D microstructure inside the object without any physical cut or sample preparation [1,2].

Fig.1 shows a block-diagram of the microCT attachment for SEM. The objective lens of the SEM (1) focuses the electron beam (2) on the surface of a metal target (3). The target produces X-ray radiation (4) which passes through the object (5) and is collected by an X-ray camera (6). To acquire different angular projections the sample is mounted on a the precision rotation stage. X-ray magnification can be adjusted by changing the target-sample distance using an integrated motorized linear stage. All parts of the system except of X-ray camera are combined in one microscanner, which can be easily installed in the SEM instead of standard object stage. The X-ray camera uses a deeply cooled CCD for direct X-ray detection. The microCT attachment doesn't require any connection to the SEM electronics and works completely independently.

Using a bulk metal target allows X-ray imaging and micro-CT reconstruction with a spatial resolution down to 0.7-1.2 microns (dependent on the target material). In this case the spatial resolution is limited by the X-ray generation volume inside the target. Switching to a thin layer target (200nm Au) allows improving the spatial resolution down to 100nm. Fig.2. shows an X-ray image of a star test pattern with a clear modulation at the 100nm level.

During scanning a computer controls the object rotation and acquires a number of X-ray angular shadow projections of the object's internal microstructure. The reconstruction program back-projects in the computer memory all acquired images and creates a set of virtual slices through the object. The results can be displayed as a slice-by slice movie or rendered to a realistic 3D model. A specially developed software allows calculating numerical parameters of internal morphology in 2D and 3D. For micro-CT reconstruction the spatial resolution is limited not only by the spot size of the X-ray emission point, but also by the accuracy in object rotation. Our reconstruction software includes an iterative alignment procedure for compensation of mechanical inaccuracies in the object rotation.

Fig.3 shows an application of the microCT attachment for SEM: non-invasive reconstruction of the internal structure of the leg of a mosquito. There are three orthogonal virtual slices with 490nm pixel size.

The developed microCT attachment for SEM opens new possibility for non-destructive 3D imaging in wide range of applications using any conventional SEM.

1. J. Cazaux et al. Journal de Physique IV **03**, C7 (1993) C7-2099-C7-2104
2. A Sasov, Journal of Microscopy, vol.147, pt.2 (1987), pp.169-192.

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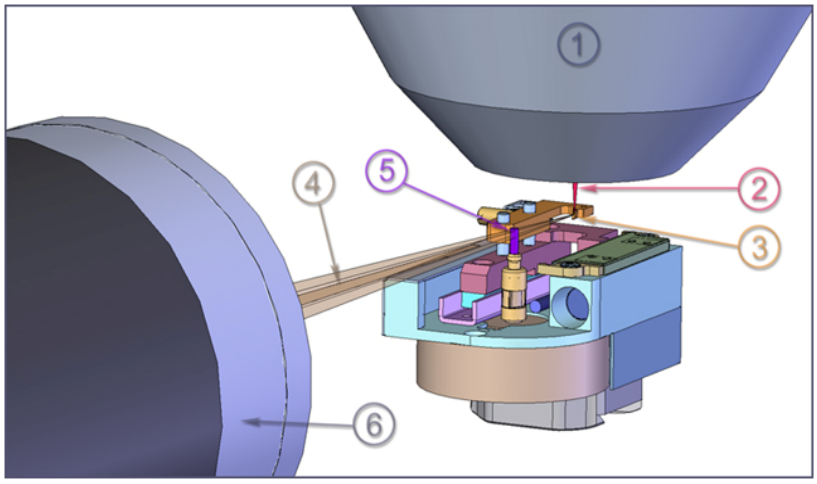

Figure 1. Block-diagram of the microCT attachment for SEM :
1 - SEM objective lens
2 - electron beam
3 - metal target
4 - X-ray beam
5 - object
6 - X-ray camera

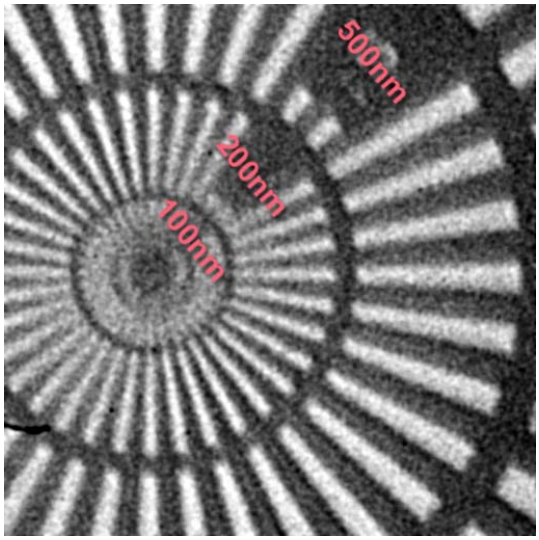

Figure 2. X-ray image of the test pattern (NTT-AT type ATN/XRESO-50HC, Japan). Central ring contains pattern with 50nm features (cannot be resolved) and following rings with 100nm, 200nm, 500nm strips correspondingly.

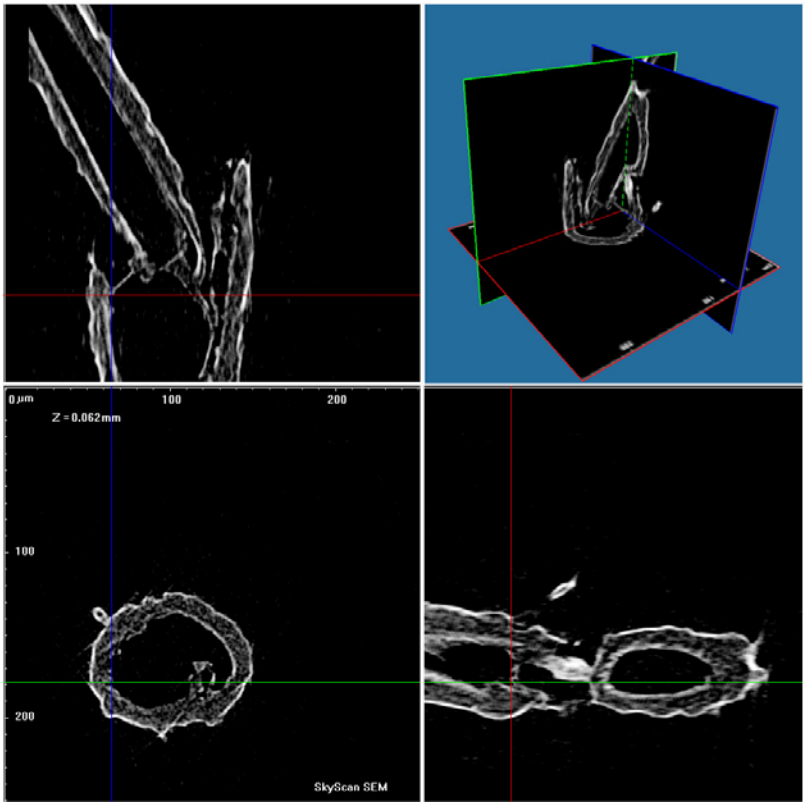

Figure 3.
MicroCT reconstruction of the internal microstructure of the leg of a mosquito: three orthogonal virtual slices with 490nm pixel size.

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