High Throughput Imaging in the Delft Multi Beam SEM

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Multi-Beam Scanning Electron Microscopy can dramatically increases the throughput in high resolution imaging [1 2 3]. To form a 3D image of a 400µm*400µm*1000µm brain volume, a single beam SEM, needs in more than 400 days[4]. Our MBSEM should reduce this to 2 days.

The MBSEM that we developed has a 14x14 array of focused beams with resolution and current in each beam comparable to a state of the art single beam SEM[1 2]. We have designed imaging systems for the parallel detection of both Transmitted Electrons (TE) and Secondary Electrons (SE).

The TE imaging system is built using an in-vacuum high resolution light microscope, developed for in-situ correlative microscopy[5], as shown in figure 1. The SE imaging system is realized by introducing a retarding lens to focus the primary electrons on the sample and directing the secondary electrons to separately focused spots in the detection plane near the variable aperture of the SEM, as shown in figure 2. The pitch of the primary beams at the sample is in the range of 0.5~4 µm.

We will discuss the design principle and technological challenges in these 2 imaging systems, give an update on recent experimental TE imaging results with better resolution than shown before at EIPBN and using different samples (figure 3). Furthermore we will demonstrate that all SE beams are focused and well separated in the detection plane with good resolution (figure 4). A new detection system with high speed camera and FPGA for real time data processing will be discussed as well.

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[1] A. Mohammadi-Gheidari, P.Kruit, Nuclear Instruments and Methods in Physics Research A 645 (2011) 60

[2] A. Mohammadi-Gheidari, C. W. Hagen and P. Kruit, J. Vac. Sci. Technol. B28, (2010) 1071

[3] A.L.Eberle, S. Mikula, R. Schalek, J.W. Lichtman, M. L. Knothe Tates and D. Zeidler, Journal of Microscopy (2014) , pp 1-7

[4] K,L.Briggman and D.D.Bock; Current opinion in neurobiology 22 (2012), pp 154-161

[5] A.C. Zonnevylle, R.F.C. van Tol, N. Liv, A.C. Narvaez, A.P.J. Effting, P. Kruit and J.P. Hogenboom; Journal of Microscopy, (2013) , pp 58-70

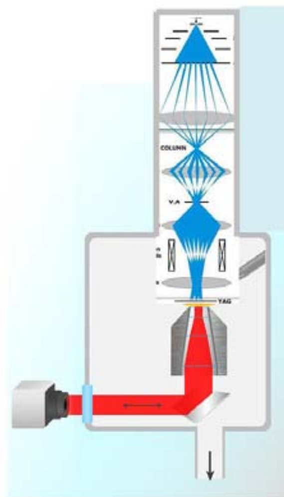

Figure 1

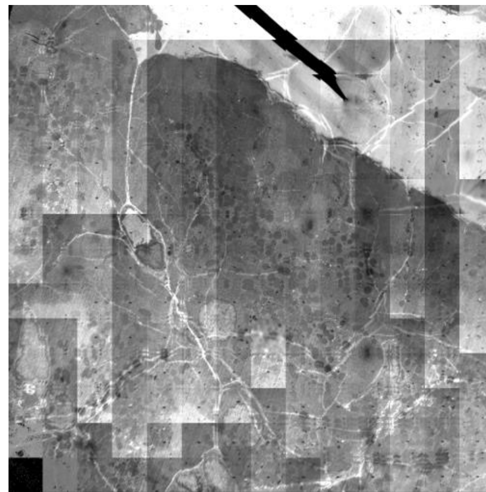

Figure 3

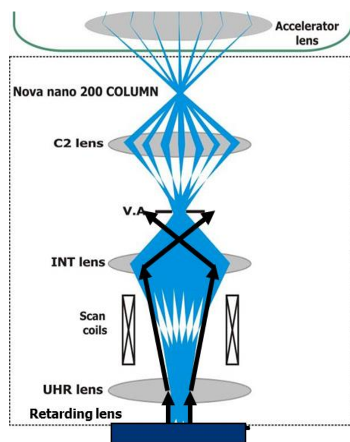

Figure 2

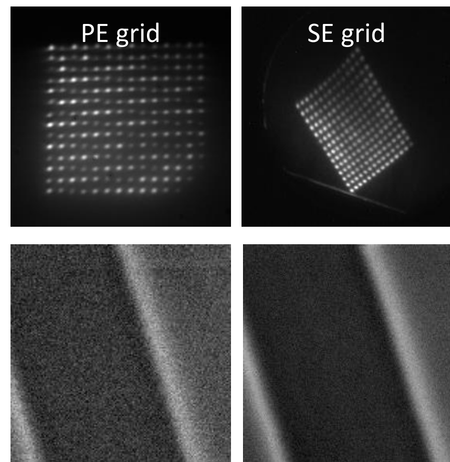

Figure 4

Figure 1: Multi-Beam Scanning Electron Microscope (MBSEM) with transmission electron detection using a high resolution light microscope situated below the sample;

Figure 2: Multi-Beam Scanning Electron Microscope (MBSEM) with secondary electron detection by introducing a retarding lens to focus primary beams and SE beams simultaneously;

Figure 3: TE-image of a biological test sample formed by 14*14 sub-images;

Figure 4: upper left and right show a primary beam grid with pitch 2.7µm on the sample and the corresponding SE beam grid with pitch 138 µm at the SE detector; the lower 2 images are SE images of line patterns. The field of view is 0.8 µm. They were captured in different experiments with the Delft MBSEM.