Multi-Beam Scanning Electron Microscopy (MBSEM) at 0.5 TB/s ?

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Introduction

The Scanning Electron Microscope (SEM) is a powerful tool and widely used for the inspection of biological and semiconductor samples with high resolution. However for large area or 3D imaging, SEM imaging is a time consuming process. As an example, mapping a 1 mm cube of tissue with a pixel size of 4 nm will result in almost 16 petabytes of data and data acquisition at 20 MHz (typical for SEM) would require a total acquisition time of almost 25 years without overhead time. Multi-beam scanning electron microscopy (MBSEM) [1, 2] is developed to reduce the acquisition time by scanning multiple pixels at the same time. But as we work on the multiple beams and pixels we need a powerful algorithm for the imaging and data acquisition.
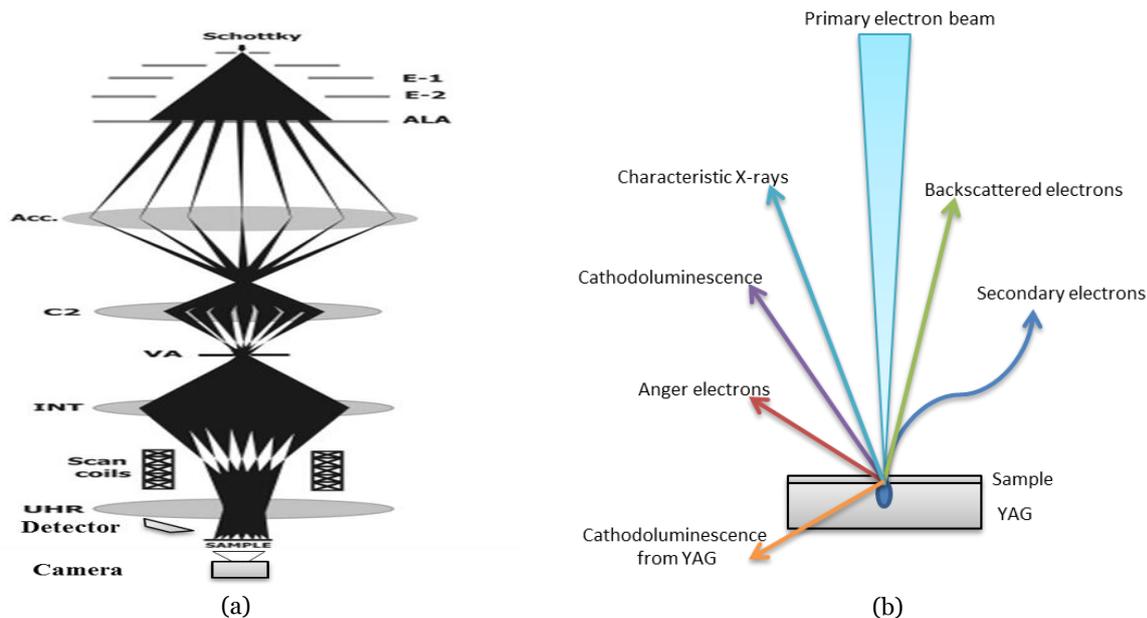

(a)   (b)

Figure 1 Detection Principle (a) Schematic overview of electron optical configuration of the MBSEM (b) Signal in SEM

Material and Method

Figure 1 shows a schematic overview of the imaging set up of the MBSEM at TU Delft. The MBSEM uses a 14 x 14 array of beams simultaneously, the signal from the 14 x 14 beams is captured on a camera which reads out the position and intensity for each beam on the sample. So achieving the speed and keeping the resolution as achieved from the multiple beam scanning is the big challenge. Using MatLab and LabView we developed an algorithm which can acquire data and create images from each beam separately and generate the final stitched image for the scanned area of the sample. At present we are using the 14 x 14 array of beams acquiring camera images while we scan in x and y

directions in the system to generate the beam images from the microscope (Figure 2). Typical camera image uses 13 x 13 pixels per beam "Blob".
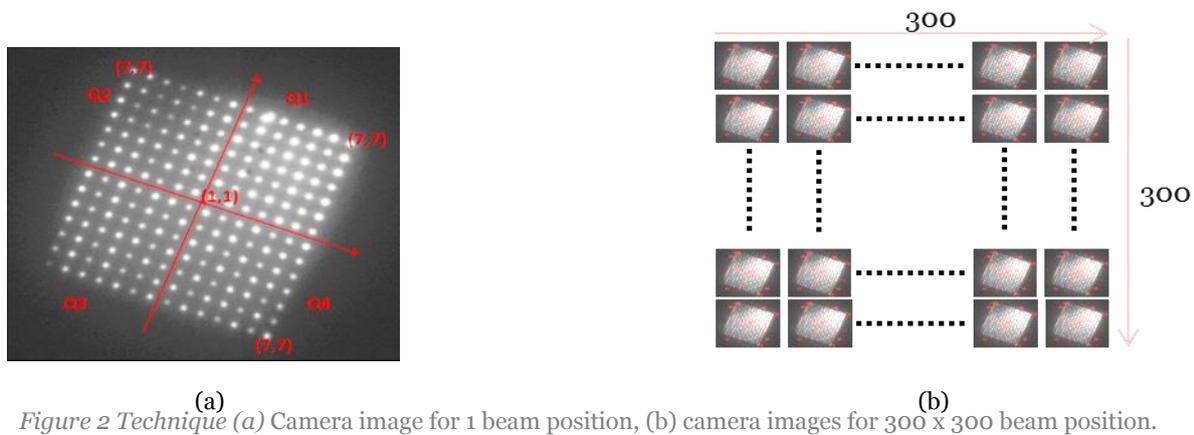

(a)   (b)

Figure 2 Technique (a) Camera image for 1 beam position, (b) camera images for 300 x 300 beam position.

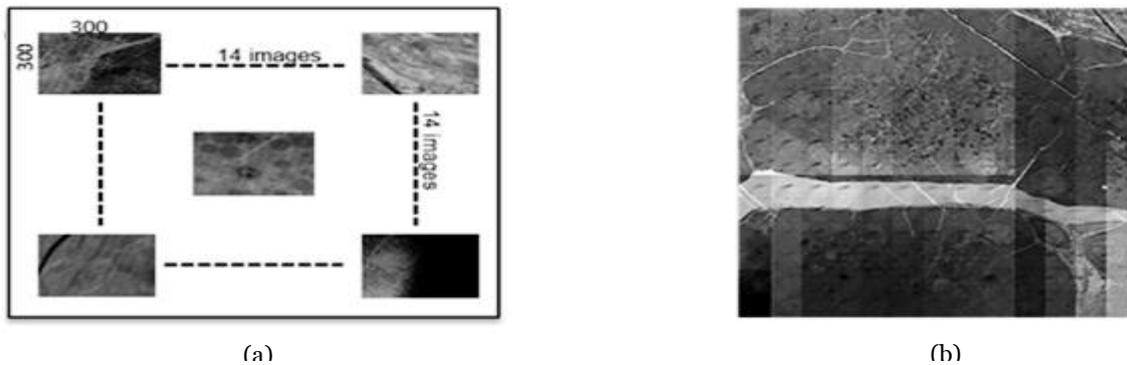(a)   (b)

Figure 3 Result (a) Generated each beam image *(b) full image (14x14) result .*

In our algorithm we follow several steps to reduce the processing time and divide the work over several processes. The first step converts all the images into blob tables (Beam) with information (position (x, y) and intensities (I)). The second step is to read all the information and create individual beam images for all the 196 beams with intensity and contrast setting for each beam image (figure 3 (a)). The third and final step is to stitch all the beam images with the overlap criterion to gives us a complete sample image(figure3 (b)).

Result and Discussion

By setting the sub frame resolution of 14 x 14 beams at 300 x 300 beam positions, capturing all images with the frame rate of 600 FPS and a camera resolution of 220 x 220, we generate 90000 beam images for the scanned area. With the help of above algorithm steps we get the complete scanned sample image.

Conclusion

At 600 FPS we deal with 29MB/s. Our aim is to go to 10^7 FPS and thus about 0.5 TB/s.

References

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