A Novel STEM Detector System

Introduction

By using a Scanning Transmission Electron Microscopy (STEM) detector, the information limit for the Gemini FESEMs can be extended beyond the nanometer range. A resolution of 0.8nm @ 30kV is now readily attainable and gives additional nanoscale information compared to conventional SAM detectors. The resolving power of the combined FESEM/STEM can be used to save processing time on TEM systems and enables high sample throughput for quality assurance applications and standard type measurements. The transmission mode of the FESEM has the advantages of avoiding chromatic aberration, allowing for a larger aperture to obtain higher transmission, signal to noise ratio and contrast enhancement due to the lower electron energy (10–30kV). The classic STEM detector, used since the SEM was introduced, consists of a single electron detector area positioned under a replica or a thin, electron transparent section. Other STEM detection systems used a conversion plate to produce a converted TE/SE signal. The signals provided are either BF (Bright Field), DF (Dark Field) or most likely the unwanted sum of both signals, which could lead to a loss of information. The newly developed multi-mode STEM detection system enables simultaneous separate BF, DF and orientated DF (ODF) signals, without any need for realignment during imaging.

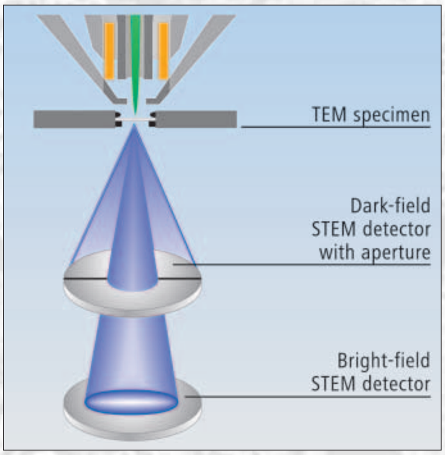

Fig. 1: Multi-Mode STEM priciple

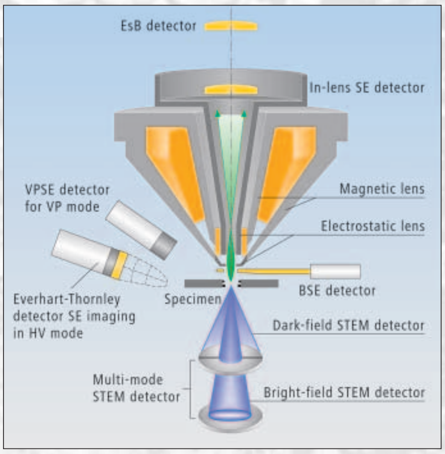

Fig. 2: Detector systems for the FESEM

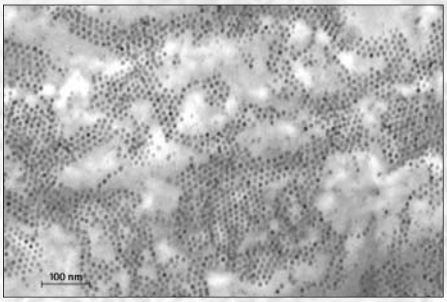

Fig. 3: Magnetic cobalt nano particle in oil aced (olefine). Combined ODF+BF imaging mode, 27 kV

Multi-Mode STEM

The Gemini multi-mode STEM detection system comprises two parallel long-life diode-detector surfaces. The top detector (DF) has been divided into specific areas to allow orientated DF imaging and forms the aperture for the BF signals which are detector by the lower BF detector: Fig. 1. The Transmission Electron Microscopy (TEM) specimens are mounted on a carrousel type TEM grid holder, which can hold up to 6 specimens. The multi-mode STEM detector is mounted on a completely retractable assembly fitted with a high precision adjustment so that optimum alignment can be tained and can be used in combination with all other Gemini detectors: Fig. 2. The combination of the resolving power of the FESEM and the separate BF and DF signal detection capabilities of the multi-mode STEM detection system could replace a classic TEM for a variety of applications.

Even non-conducting specimens, non stained organic material, or ceramics can be imaged in VP mode without any charging effects, see Fig. 6.

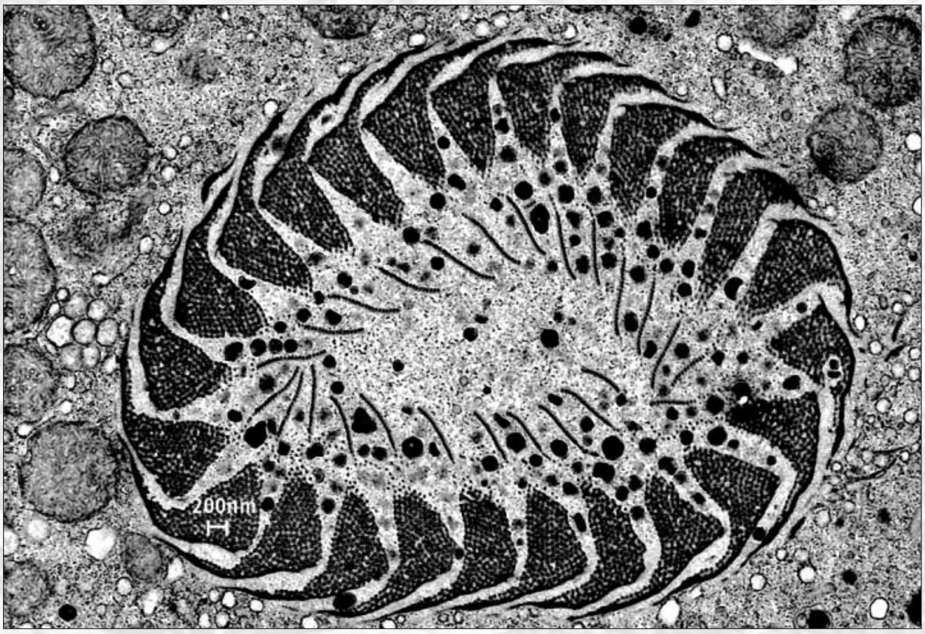

Fig. 4: Cross section of stained ciliate (30kV)

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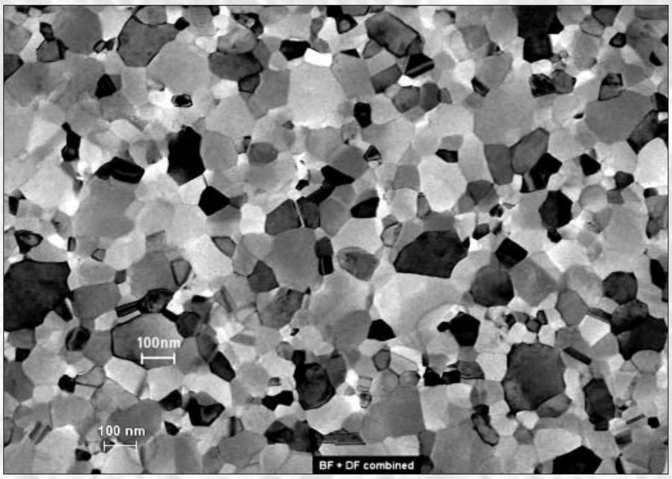

Fig. 5: Combined DF + BF signal of aluminium sample (30kV)

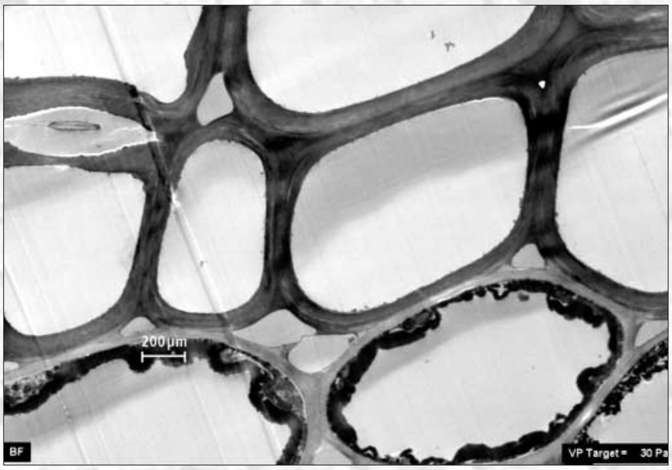

Fig. 6: Cross section of unstained wood (30kV)

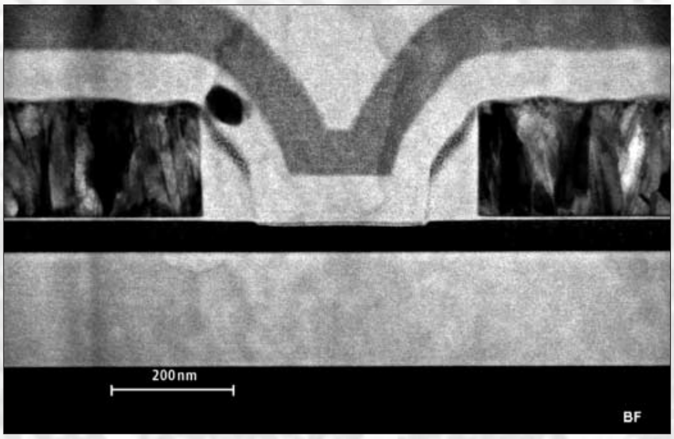

Fig. 7: BF image of semiconductor TEM lamella prepared with the Crossbeam. A very small defect in a layer was exactly hit in the centre and is clearly visible.

Signal Enhancement

Compared to conventional TEM (80–300kV) images, those obtained by the multi-mode STEM detection system show improved signal to noise ratio and enhanced contrast with comparable resolution. This is due to significantly lower electron beam energies used in the FESEM, which result in reduced excited volume and increased electron scattering cross sections at lower accelerating voltages (10–30kV). Thus, subtle contrast mechanism (Fig. 3, 4, 5) may be explored.
The multi-mode STEM detector enables pure BF or DF imaging to achieve optimum contrast and rich imaging details of even unstained thin sections. Moreover, the small excited volume in thin sections of biological materials results in a 10x improvement of the lateral resolution of EDX analysis; accurate analysis of particles down to 30nm is now achievable. Due to parallel detector surfaces and the division of the DF detector, the multi-mode STEM detection system allows 6 distinctive imaging modes:
BF, DF, BF+DF, BF-DF, OD1+ ODF2 and ODF1 - ODF2.

Typical STEM application fields are:

- Materials Analysis (polymer, ceramics, nanoparticles, grain boundaries)
- Life science (histology, pathology)
- Semiconductors (failure analysis, FIB lamellas)

Another new application area for the multi-mode STEM detector is in the Crossbeam, a combined FIB/FESEM system. The Crossbeam enables site specific TEM lamella milling directly out of bulk material, wich can be analysed in-site with the STEM detector: an example is shown in Fig. 7.
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References:

Crawford, B.J & Liley, C.R.W, J. Phys. E 3 (1970) 461 - 462

Golla, U, Schindler, B & Reimer, L, J. of Microscopy Vol. 173 Pt3 (1994) 219–225

Gnauck, P, ET AL, Microscopy & Microanalysis, Vol. 7, Suppl 2, (2001), 880-881

Gnauck, P, ET AL, Microscopy & Analysis (UK), 94 (2003), 11–13

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