EBSD and BKD

The Fast EBSD System

Our FastEBSD system consists of the dedicated hardware detector NORDIF 1000UF and two separated programs which control the digital beam scan of the SEM as well as pattern store and off-line indexing and interpretation of the backscatter Kikuchi patterns (BKP). The patterns, after binning to 100x100 pixels on the sensor chip, are stored on the hard disk as a sequence of bitmap images with 256 graytones rather than a reduced data set such as Hough peaks in order to enable the access to the original raw data at any time.

The detector contains a high sensitive CCD camera with GigE vision interface to the computer. Thus a high speed is obtained. GigE vision is an economic camera interface because no frame-grabber is required. A standard fast Ethernet board and a CAT-5 patch cable are sufficient. The detector can be placed up to 100 m remote from the SEM. Since lately USB3 offers a high speed at low costs as well.

Some advantages of *off-line* over conventional *on-line evaluation* of the diffraction patterns are:
+ Dwell time per pattern is constant whereas time for indexing depends on the current grain orientation and phase.
+ No artifacts which may occur with on-line indexing when synchronization between the acquisition and interpretation of patterns is missing.
+ The extremely high speed of acquisition is only limited by the sensitivity of the camera and speed of storing the patterns on the hard disk.
+ A high acquisition speed is favorable for fast *in-situ* dynamic experiments.
+ A high acquisition speed is economic since the turn-around of the SEM is short.
+ Cold field emitters with typically low stability are accommodated.
+ No compromise is made between speed and reliability of indexing.
+ Pattern indexing and interpretation can be repeated at any time by using the original data.
+ The parameters of the indexing program can be optimized after the acquisition session.
+ Enables thorough check for reliability of indexing and *a priori* unknown phases.

In 2015, when we terminated FastEBSD, the acquisition speed exceeded 1000 patterns per second. Speed of indexing pattern sequences was up to 2000 patterns per second on a PC with QuadCore Intel® CPU.
Some advancements of FastEBSD, in particular concerning combined analytical methods such as EBSD&EDS and EBSD&Phase-Sensitive Imaging, can be found on www.ebsd.de (*in German*).

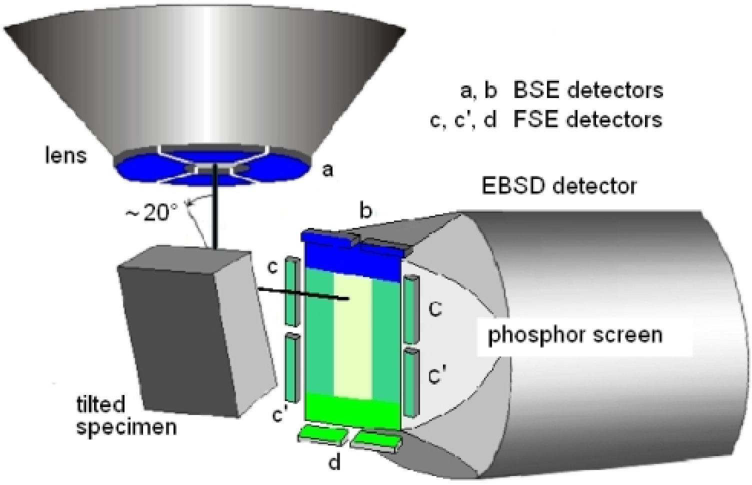
Download presentation at EBSD Meeting in Zürich, 14 - 15 June 2007 (*in German*, 0.5 MB pdf file).

Download R.A. Schwarzer: A Fast ACOM/EBSD System: Archives of Metallurgy and Materials 53 (2008) 5-10

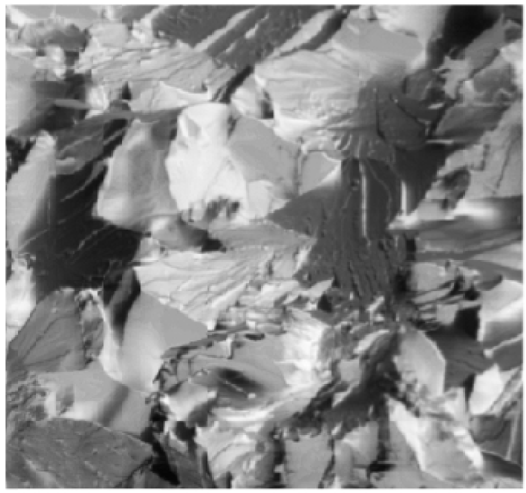
The Multi-Array Image Detector

In scanning electron microscopy, backscattered electrons (BSE) can be used, as a complement to secondary electrons (SE), for imaging bulk sample surfaces.

If the SEM sample is steeply tilted, as is for example the case in EBSD measurements to render subtle topographical contrast more visible, to reduce the penetration depth of the primaries, or to perform a Burgers vector analysis on dislocations, the usual BSE detectors on the bottom side of the probe-forming lens are ineffective. Therefore, special backscatter or forward scatter semiconductor diode detectors are occasionally employed, mounted for instance on the margins of the EBSD phosphor screen. [1]



Solid state BSE detectors in an EBSD setup



Fracture surface of a steel sample acquired with the multi-array image detector 20 µm

The EBSD detector by itself, however, can be used as a BSE detector for conventional imaging [2]. In our FastEBSD set-up acquisition boxes can be interactively set and (re-)adjusted on the phosphor screen by tracking with the mouse, at deliberately selected positions and sizes, to optimize contrast [3, 4]. In this way the EBSD detector is employed as a multi-array BSE image detector. High topographical and channeling contrasts and, if applicable, atomic number (Z) contrast is so obtained in the images by evaluating streamed pattern sequences, depending on the sizes and positions of the acquisition boxes. Unlike special semiconductor detectors, the multi-array BSE detector does not further restrict the free space in front of the sample. The images are directly superposable and aligned to EBSD orientation maps and are so ideally suited to digital image processing. The technique is fast, convenient, and inexpensive.

The intensity distributions (" EBSD patterns") need not be indexed, therefore BSE imaging by using an EBSD system is applicable to non-crystalline and bioscience materials as well [5, 6].

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[1] D.J. Prior, P.W. Trimby, U.D. Weber, and D.J. Dingley: Orientation contrast imaging of microstructures in rocks using forescatter detectors in the scanning electron microscope. Mineralogical Magazine 60 (1996) 859-869
[2] X. Tao and A. Eades: Another way to implement diffraction contrast in SEM. Microscopy Today 11 (March/April 2003) 36, 38.

[3] Download R. Schwarzer, J. Sukkau und J. Hjelen: Imaging of topography and phase distributions with an EBSD detector in the SEM. Microscopy Conference, Kiel 2011, Poster LBP M.P007.
[4] R. Schwarzer: Orientation microscopy using the analytical scanning electron microscope. Practical Metallography 51 (2014) 160-179.

[5] Download R. Schwarzer and J. Hjelen: The EBSD camera - a multi-array image detector. Oral presentation at AK EBSD Düsseldorf 2014.
[6] R.A. Schwarzer and J. Hjelen: Backscattered electron imaging with an EBSD detector. Microscopy Today 23 (2015) 12-17
http://www.microscopy-today.com/jsp/print_archive/print_archive.jsf# click on Current Issue Article PDFs in the bottom line.