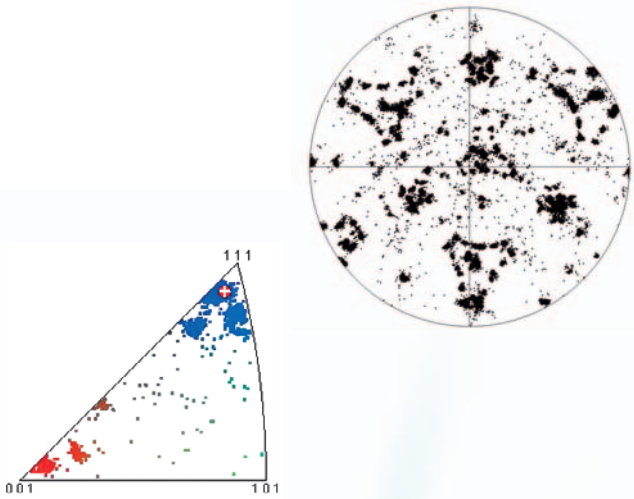
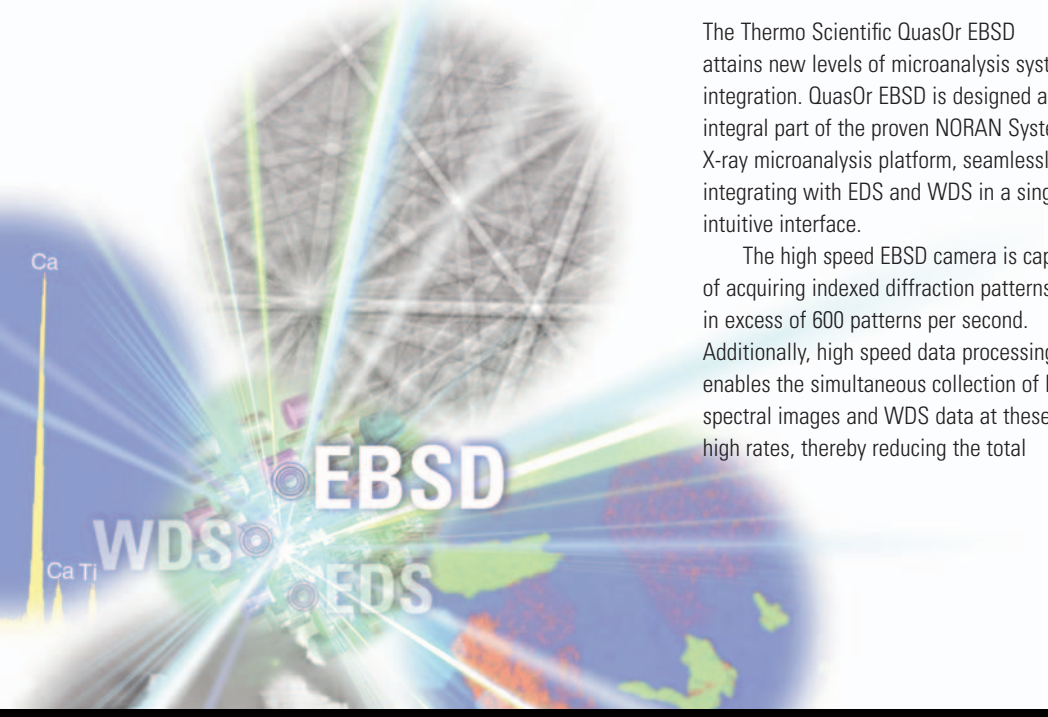
EBSD enables nanostructural analysis in the electron microscope by characterizing the crystalline structures which affect physical properties in a wide range of materials. EBSD is now a common tool in the Scanning Electron Microscope (SEM) laboratory, especially when integrated with other microanalytical techniques such as EDS and WDS.

Thermo Scientific QuasOr

Electron Backscatter Diffraction





The Thermo Scientific QuasOr EBSD attains new levels of microanalysis system integration. QuasOr EBSD is designed as an integral part of the proven NORAN System 7 X-ray microanalysis platform, seamlessly integrating with EDS and WDS in a single, intuitive interface.

The high speed EBSD camera is capable of acquiring indexed diffraction patterns in excess of 600 patterns per second. Additionally, high speed data processing enables the simultaneous collection of EDS spectral images and WDS data at these high rates, thereby reducing the total microanalysis data acquisition time. The EBSD, EDS and WDS data are all stored together in a single project along with the acquisition parameters.

QuasOr EBSD caters to both the novice EBSD user and the expert crystallographer. Guided, flowing setup tabs enable users to adjust camera parameters for acquisition and to automatically calibrate the camera pattern center. Full featured, interactive data displays allow the operators to clearly see all the relevant data in a single interface, without switching between programs.

Camera

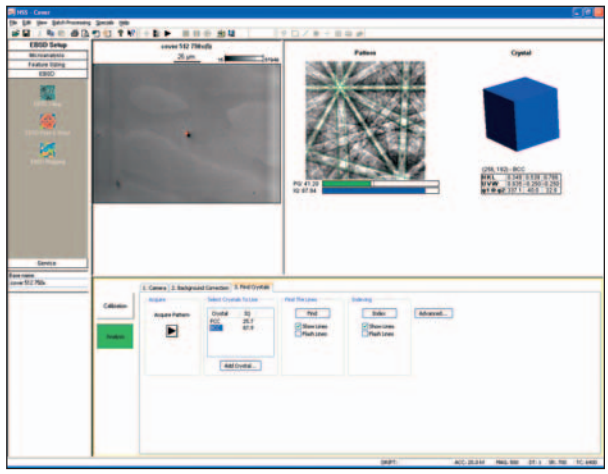
The QuasOr EBSD camera is capable of collecting and indexing at rates in excess of 600 patterns per second. The high speed CCD camera has a resolution of 640×480 pixels with binning up to 8×8. Included is an integrated motorized slide that is fully controllable using software (with detector insert position shown on screen) and/or hardware. The tapered tube design with a 42 mm diameter allows simultaneous EBSD, EDS and WDS acquisitions on many models of electron microscope. In addition, the removable screen holder allows for easy replacement of the phosphor.

High Speed Simultaneous EBSD, EDS and WDS

QuasOr EBSD is capable of acquiring indexed EBSD patterns, full EDS spectral images and WDS X-ray data simultaneously at rates of more than 600 patterns per second. This high speed data acquisition permits full sample characterization in the minimum amount of time. This is particularly important for beam sensitive samples.

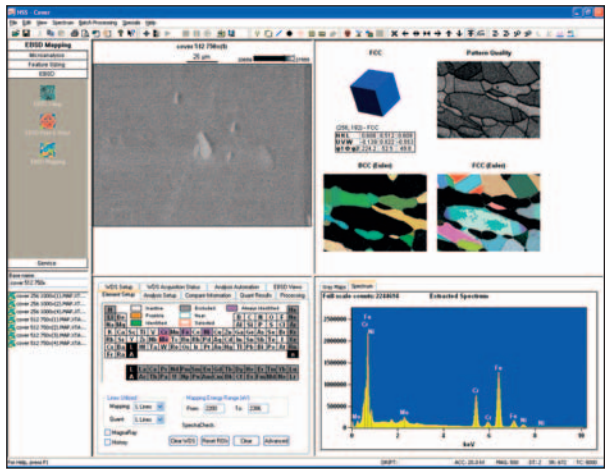
Single Interface

QuasOr EBSD was built from the ground up as part of the NORAN System 7 microanalysis system. As a result the user has a single, intuitive interface to acquire any combination of EBSD, EDS or WDS data. NS7 allows the user to see all elements of the acquisition or processing software at once or to view an operator-chosen selection. Users only need to learn one interface and do not need to switch between multiple programs when performing analyses during the characterization of samples.



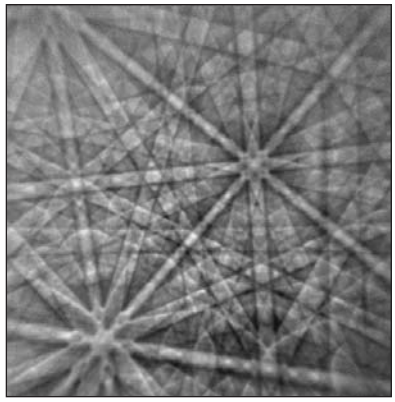
Guided EBSD Pattern Center Calibration and Acquisition Setup

A logical progression of tabs guide the operator through calibration of the camera pattern center geometry, via pattern collection, optimization, background removal, flat fielding, indexing and data acquisition. A three-point pattern calibration allows for a dynamic pattern center adjustment during acquisition for samples where the planar sample surface is not perpendicular to the phosphor allowing for the highest accuracy orientation measurements. Pattern correction for the magnetic fields from immersion lens electron microscopes provides distortion free patterns for accurate indexing.



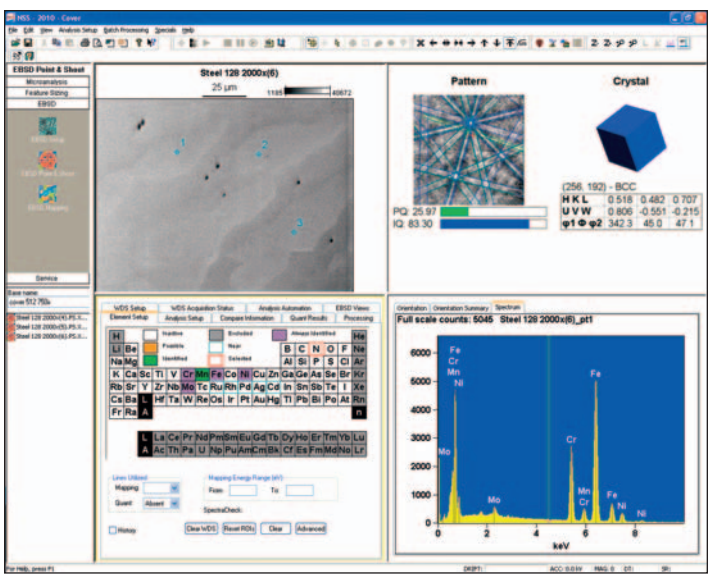
Reanalysis of Stored Kikuchi Patterns

Raw Kikuchi patterns may be optionally stored during acquisition to allow reanalysis under different processing parameters.



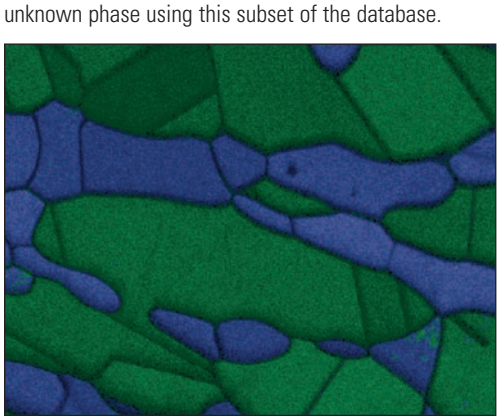
Point and Shoot Analysis

For certain sample analyses, acquisition of complete orientation maps is not the most efficient analysis method. For those samples, simple spot analyses provide sufficient orientation information for characterizing the sample. A complete misorientation summary compares the orientation at each location to a reference location. To aid in the investigation, an EDS spectrum can optionally be collected for each analysis location.



Phase Identification

Users can identify unknown phases using a combination of EDS and EBSD. An EDS spectrum is collected from the unknown phase and the subsequent chemical data is compared against the crystal database to determine the possible phases. Phase identification then finds the best match to the EBSD pattern from the unknown phase using this subset of the database.



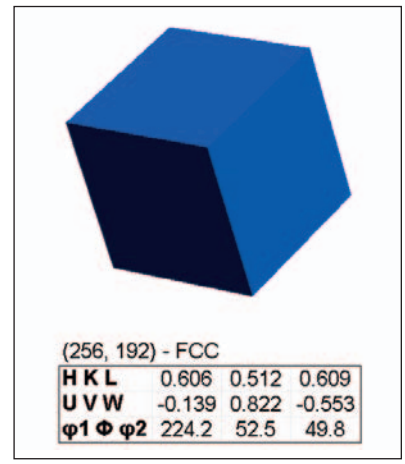
Pattern quality map overlain with a phase map. The green is a FCC phase, the blue is a BCC phase.

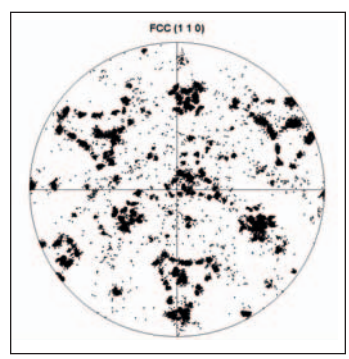
Selected Area Maps

Selected areas within the electron image may be defined for analysis if a complete map of the sample area is not required. Available selections are circle, rectangle, point, user-defined polygon and intensity-filled regions.

Orientation Cube

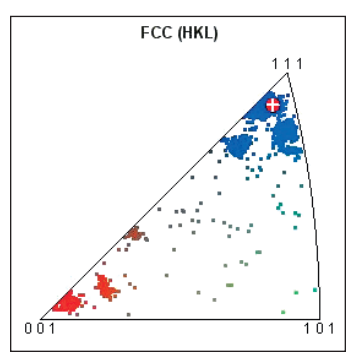
The orientation cube display changes as the cursor is moved in the electron image or map. The title contains the name of the crystal type that best matches the diffraction pattern. The graphic shows the orientation of the unit cell. Below the cell is the location of the pixel in the acquired map with the crystal type name. The table contains two different numeric representations of the orientation.





Pole Figures

Pole figures are important tools for the recognition and interpretation of texture components in crystalline materials. A display is available for each crystal type within a data set. The three highest usage orientations are provided for each crystal symmetry along with a user-defined custom orientation.

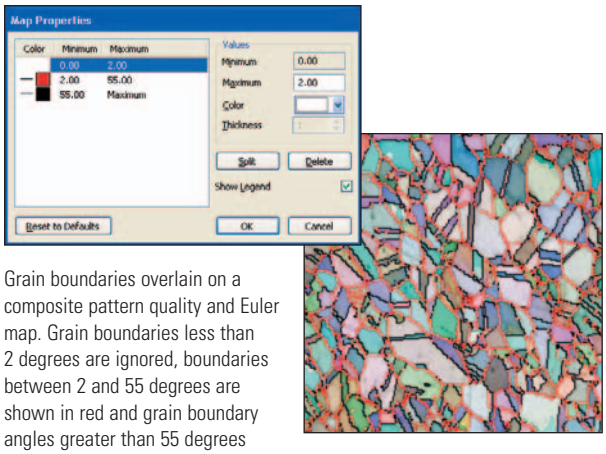


Inverse Pole Figures

Inverse pole figures display orientation data relative to the crystal axes. The pole figures are interactive within QuasOr EBSD, selection of any points on the figure will highlight the corresponding pixel on the IPF.

Grain Boundary Analysis

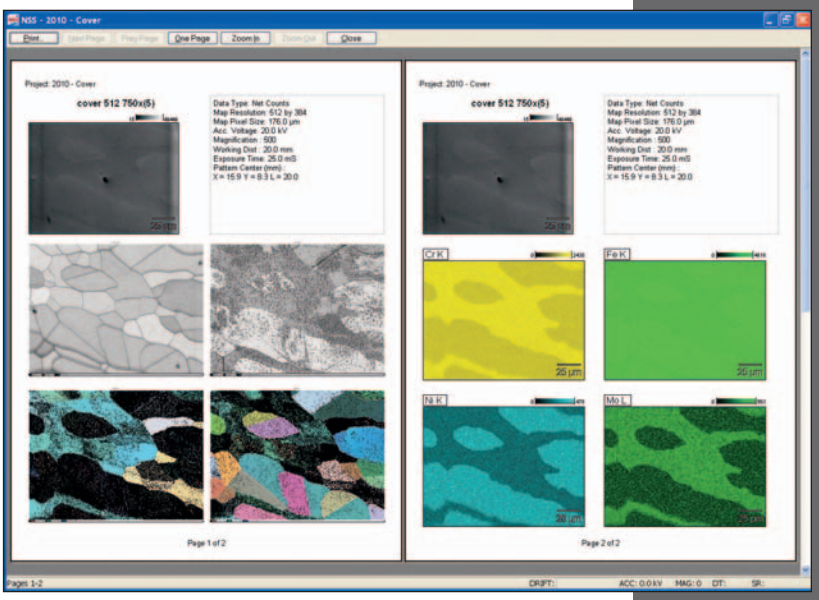
Grain boundary maps can be used to display grain boundary angles, axes and coincidence site lattice (CSL) or special case boundaries. The displays are user configurable for the numbers and ranges of the grain boundary angles, colors and line thicknesses. In addition, histogram plots of the misorientation angle and the grain size distribution across a sample can be displayed.



Grain boundaries overlain on a composite pattern quality and Euler map. Grain boundaries less than 2 degrees are ignored, boundaries between 2 and 55 degrees are shown in red and grain boundary angles greater than 55 degrees are shown in black.

Reporting

QuasOr EBSD has one-click reporting to Microsoft® Word or directly to the printer. Users can define report headers, page layouts and printer settings. All images are reported at native resolution.

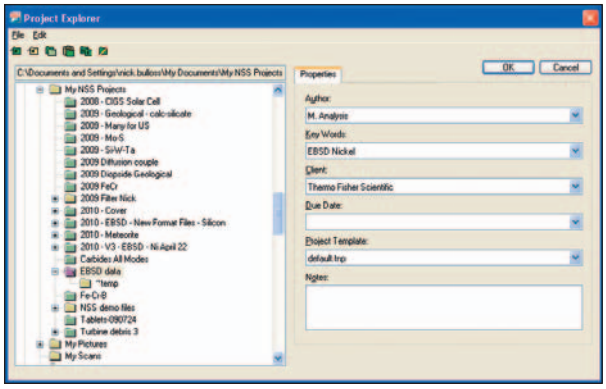


Crystal Database

The QuasOr crystal database and editor uses the standard crystallographic information file (CIF) format.[1] Users can import crystal structural data and edit crystal files in the database.

Data Storage

Data for a given sample or set of samples (EDS, WDS and/or EBSD data) is stored in a single project folder structure. This allows the user to keep track of all microanalysis data for a single project in a single location. Project specific parameters are stored with the project each time it is closed. These settings may be duplicated as templates for future projects. This helps users define routine analytical practices, particularly useful in multi-user laboratories.



Misorientation Line Extract

In many investigations, the orientation of neighboring pixels along a line provides more meaningful information than visual maps. For these investigations, line scan extractions from map acquisitions provide a plot of the misorientation versus distance. The misorientations can be either pixel-neighbor relative or reference-point relative.

Phase ID Acquisition

The crystal structures of typical EBSD samples will be well understood by the analyst before the experiment begins. However, some samples will have regions that have unexpected and possible unknown crystal structures. For these investigations, a phase identification is required to investigate and determine the true crystallographic description of the feature of interest. This task involves collecting a high quality diffraction pattern and an EDS spectrum followed by a comprehensive search against a database containing many potential crystal matches.

Orientation Distribution Function (ODF)

Simple pole figure and inverse pole figures are useful for a vast majority of materials texture analyses. However, detailed texture analyses require the use of the detailed results provided by the Orientation Distribution Function. This analysis provides the texture expert with a complete description of the texture throughout the sample.

Site License

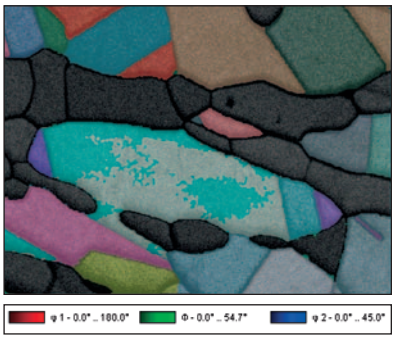
The NS7 and QuasOr EBSD is accompanied by a site license which allows the use of the software on one system connected to a microscope for data acquisition and any number of fully featured offline systems at the same site for data processing. Operators are free to collect data at the microscope then process offline, thereby reducing wasted valuable microscope time.

EBSD Map Displays

EBSD orientation mapping data can be displayed as Euler, HKL, UVW or phase maps.
Data quality calculations are performed and displayed as pattern and image quality maps.

Euler Map

An orientation map that is colored according to the Euler angles is available for each phase type in the analysis. Each of the 3 Euler angles is assigned to a Red-Green-Blue color respectively. This display is useful for indicating the location of unique grains in the analysis.



HKL and UVW Maps

Orientation maps that map the pixel orientation to its location within an Inverse Pole Figure (IPF) are provided for each axis of the sample. The sample axis are designated HKL for the sample normal, and uvw for the sample transverse direction. The coloring of the IPF legend is Red for <100> crystal directions parallel to the selected sample direction, Green for <110> crystal directions and Blue for <111> crystal directions. These displays are useful for indicating similarities and differences of the crystal orientations with respect to the sample and processing geometry.

Strain Map

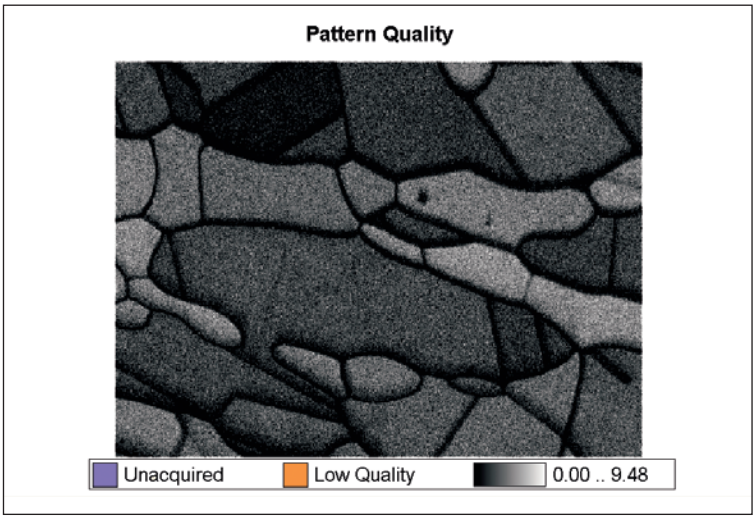
For samples with grains containing many random orientations, subtle misorientations can be masked when using standard orientation colored map displays. When investigating small misorientations, maps displaying only the deviation from the average grain orientation are preferred. These strain displays emphasize the subtle changes in the material that are typically associated with residual deformation.

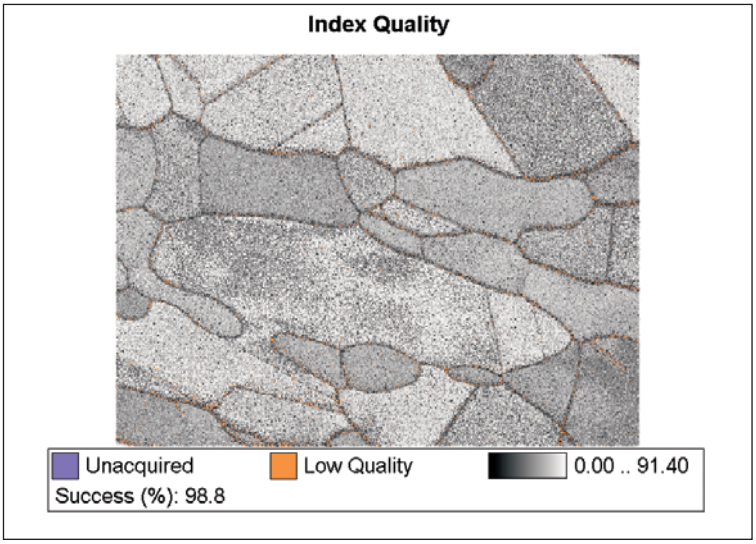
Schmid Map

Understanding the deformation response of a material while undergoing uni-axial stress can lead to enhanced mechanical properties. A Schmid map provides a display of the predicted amount of deformation in the material.

Pattern and Index Quality Maps

Pattern Quality (PQ) and Index Quality (IQ) maps are provided to indicate the quality of the data acquisition and analysis. The PQ is a metric of the sharpness of the diffraction pattern. The IQ is a metric of the fit of the crystal type simulation to the measured Radon lines.





Product Specifications

Hardware Specifications

Camera	CCD
Resolution	640×480
Pixel Binning	1×1, 2×2, 4×4, 8×8
Maximum indexed pattern acquisition rate with simultaneous EDS and WDS	600 indexed patterns per second
Detector tube	Automatic retract on program exit 42 mm with tapered end
Phosphor	Square (27 mm × 27 mm), user replaceable
Operating System Capability	Microsoft Windows® XP, Windows 7

Software Specifications

Feature	Basic Level	Intermediate Level	Advanced Level
Data Acquisition			
SEM image acquisition	✓	✓	✓
Simultaneous EBSD, EDS and WDS	✓	✓	✓
Tilt corrected imaging	✓	✓	✓
Choice of number of Hough lines	✓	✓	✓
Automated pattern center calibration	✓	✓	✓
Dynamic three point pattern center calibration	✓	✓	✓
Guided setup and calibration	✓	✓	✓
Ability to save Kikuchi patterns for later reanalysis	✓	✓	✓
Pattern correction for immersion lens microscopes			✓
Data Processing and Displays			
Index and Pattern quality map	✓	✓	✓
HKL orientation map	✓	✓	✓
UVW orientation map	✓	✓	✓
Euler orientation map	✓	✓	✓
Phase maps	✓	✓	✓
X-ray map	✓	✓	✓
Grain boundary axis and angle maps	✓	✓	✓
Grain size analysis	✓	✓	✓
Grain shape analysis	✓	✓	✓
Grain boundary CSL and special boundary maps	✓	✓	✓
Editable crystal database (CIF format)	✓	✓	✓
Misorientation line scan extractions	✓	✓	✓
Single click reporting to Microsoft Word	✓	✓	✓
Pole figures		✓	✓
Inverse pole figures		✓	✓
Point and Shoot analysis		✓	✓
Strain evaluation (internal misorientations)			✓
Schmid factor display			✓
Phase identification			✓
Orientation Distribution Function (ODF) maps			✓

References

1. Hall SR, Allen FH, Brown ID (1991). The Crystallographic Information File (CIF): a new standard archive file for crystallography. *Acta Cryst* A47: 655–685

Patents: 6326619, 6555817

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