AZtecHKL

EBSD Acquisition and Analysis

TKD IPF map of strained Cu. Step size 4 nm
Courtesy: Saritha Samudrala and Kevin Hemker.

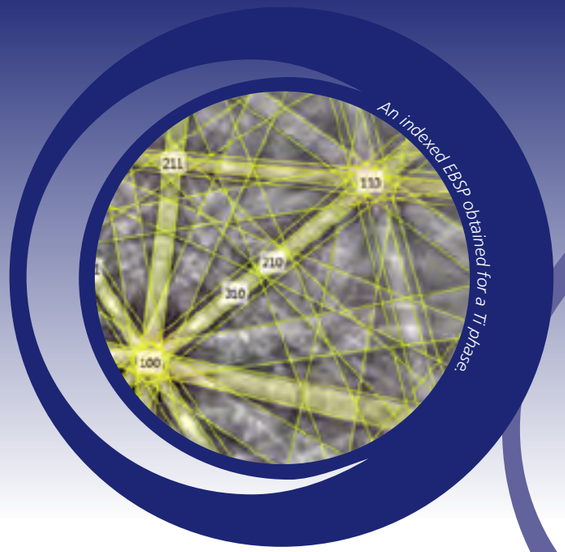
Right Results in Real Time...

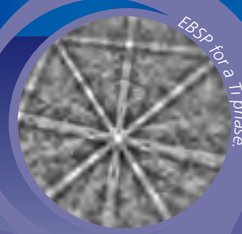
OXFORD INSTRUMENTS

The Business of Science®

AZtecHKL

The ultimate EBSD system





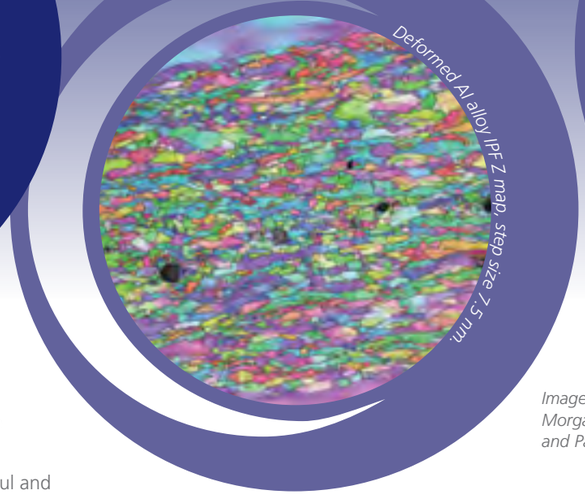


Image courtesy Morgan Tort and Pat Trimby.

AZtecHKL combines the speed and sensitivity of the **Nordlys** EBSD detectors with the superior analytical performance of **AZtec®** software to create a powerful and versatile tool for Electron Backscatter Diffraction (EBSD) and Transmission Kikuchi Diffraction (TKD) analysis.

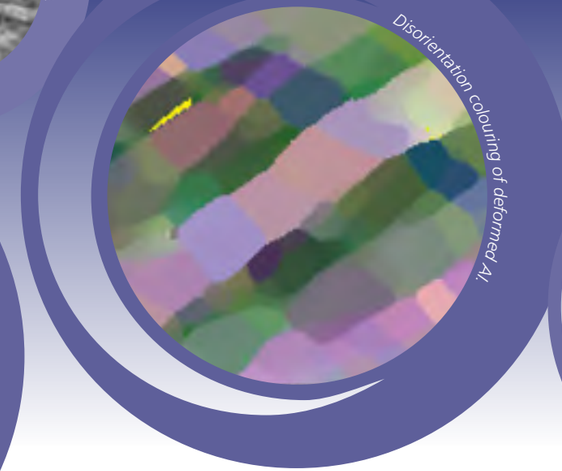
For the expert, **AZtec**HKL contains innovative technology that delivers unparalleled accuracy and flexibility when working at the frontiers of EBSD. For everyday applications, the guided workflow leads through data acquisition and analysis, so achieving high quality EBSD results becomes routine.

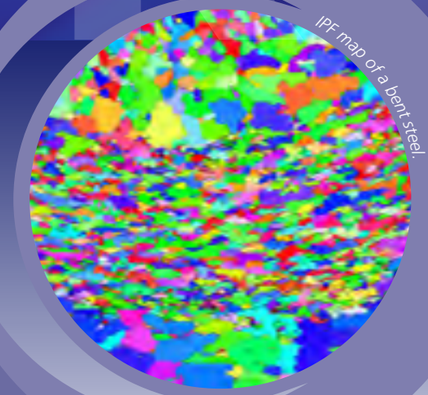
EBSD and TKD analysis can be integrated with Energy Dispersive Spectrometry (EDS) through **AZtec**Synergy. This enables microstructural and compositional data to be analysed, interrogated and interpreted interactively. **AZtec**Synergy is the ultimate materials characterisation system.

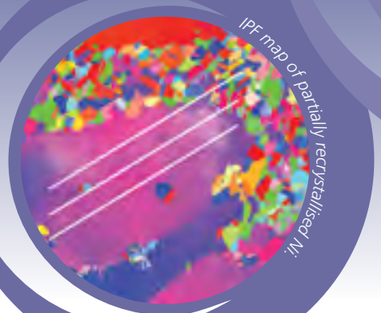
Unmatched in breadth and accuracy, **AZtec**HKL is a must for anyone serious about EBSD analysis...

AZtecHKL

At a glance...







Fast and powerful

- Unleash the latest generation of **Nordlys** EBSD detectors for high-speed and high-sensitivity data acquisition
- Acquire, process and display high-speed data in real-time
- Interact with your data during acquisition using 64-bit processing power and multitasking software

Easy to use

- A guided workflow for system set-up and data acquisition ensures that everyone gets the right results every time
- Intelligent tools, such as automatic background correction, ensure accurate results on all samples

Flexible

- Experts can adjust settings to solve difficult applications
- Optimise data post-acquisition using powerful re-analysis tools
- Present data and results in customisable reports

Innovative

- Unique Tru-I® algorithms achieve the highest number of accurately indexed EBSPs
- Simultaneous EBSD and EDS analysis, including using EDS data to differentiate similar crystal structures
- Refined accuracy indexing* delivers an outstanding angular resolution of 0.05°
- Powerful tools included as standard, e.g. a TKD optimised indexing routine and modules for advanced data analysis

** Patent pending*

PRODUCTIVITY

Ease of Use

EBSD with built-in intelligence - as standard

Images of a geological sample collected from each of the forescatter diodes. Sample courtesy of Dr. Elsabetta Mariani, University of Liverpool.

Intelligent EBSD

Optimising the system for data acquisition and analysis is easier and more automated than ever. Intelligence built into the system means that operators can change acquisition conditions and still collect EBSD patterns with ease.

- **AutoCalibration** - a sophisticated correction routine that automatically calculates calibration parameters based on geometry changes (i.e. working distance and detector distance). In addition, this technique compensates for beam movement at low magnifications.
- **Automatic detector exposure** - optimises the detector settings to maximise the EBSP signal to noise ratio for a given binning level.
- **Dynamic background corrections** – a pattern-by-pattern correction routine compensates for changing conditions. It corrects for changes in signal strength resulting from variations in atomic number and automatically masks any screen imperfections.
- **Detector control** within the user interface eases set-up and operation.
- **Interactivity** - change SEM conditions, such as kV, probe current, magnification, or specimen tilt without recalibration - and still collect optimised EBSD data with ease.
- **Step Note** - provides on-screen help and can be tailored to incorporate user-defined procedures into **AZtec** - ideal for novices or those needing to follow a set routine.

Microstructure imaging

Incorporating up to 6 forescatter diodes (FSD), the **Nordlys** detector can collect forescatter and backscatter images to help visualise orientation and compositional information.

Individual images, collected from each diode simultaneously, are mixed and customised as required.

Now everyone can achieve reliable results

Image registration

All **AZtec** images and maps can be used for specimen navigation and relocation.

Images are automatically registered during collection and **AZtec** can drive the microscope stage to relocate a point of interest.

Specimen navigation and relocation becomes quick and easy, allowing more time for data acquisition. Manually registering images also enables specific areas of a sample to be investigated further at a later date, even on another SEM.

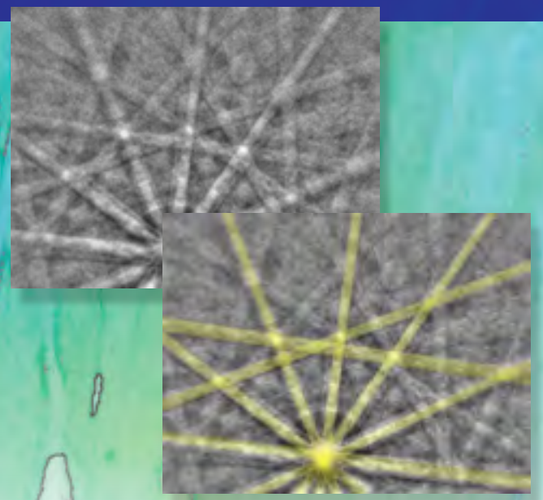
Reporting

AZtec will help you present the reports you need in the format you want.

- Fast: reporting directly from the interface - a simple right click and data can be e-mailed direct to your customer
- Flexible: a dedicated application enables you to export your data in the format and resolution you want
- Structured: a comprehensive list of report templates tailored to each application enables you to print a professional report with a single click

Indexing

Intelligent indexing, superior accuracy



Patterns from an intermetallic phase in a stainless steel. With a tetragonal structure and large lattice parameter, the bands are narrow and are more difficult to detect accurately. AZtec automatically detects the bands correctly.

Intelligent band detection

An intelligent band detection routine determines which of the Kikuchi bands are best used for indexing. This automatic routine applies both the intensity of the band and its position in the EBSP to pre-process the patterns before Tru-I Indexing.

Improvements in band detection leads to a higher hit-rate. This is especially important in materials exhibiting indistinct bands, or where the pattern quality is low.

Tru-I indexing

Oxford Instruments' Tru-I indexing engine ensures that EBSD patterns are solved accurately, reliably and automatically.

AZtec class indexing uses groups of four Kikuchi bands to form the foundation of the indexing routine. This routine achieves the highest validated hit rates without the need for extensive data clean up.

- Excellent grain boundary resolution
- This method is robust to operator selected settings, such as the number of bands and reflectors

Magnetic field correction

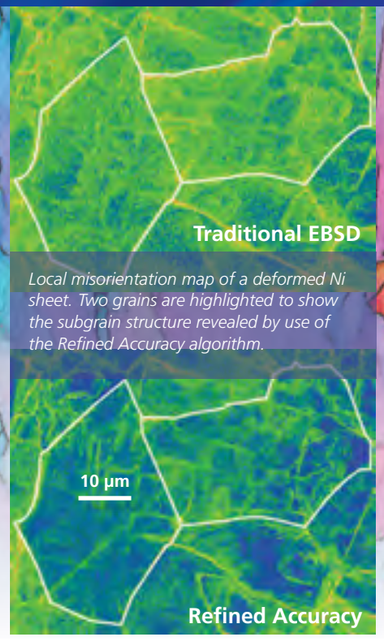
Microscopes with immersion lenses can generate a magnetic field that distorts the EBSPs and shifts the pattern centre. **AZtec** includes unique, patented technology to automatically correct this problem.

Phase databases

- **AZtec**HKL includes the ICSD and the HKL database as standard
- NIST and American Mineralogist databases are available as additional options

Application specific routines

Powerful, sophisticated, and all provided as standard



Local misorientation map of a deformed Ni sheet. Two grains are highlighted to show the subgrain structure revealed by use of the Refined Accuracy algorithm.

A deformed Al alloy, showing the inverse pole figure Z direction on top of the pattern quality image. Step size 10 nm. Image courtesy of Morgan Tort (University of Melbourne) and Pat Trimby (University of Sydney).

Refined accuracy

This innovative algorithm, included as standard, extends traditional EBSD analysis to deliver unrivalled accuracy.

- Refines the Kikuchi band position after indexing to achieve the most accurate orientation measurements
- Delivers best-in-class measurement accuracy
- Works in real-time
- Provides 0.05° angular resolution
- Enhances grain boundary characterisation and identifies subtle subgrain structures

Phase discrimination

AZtec correctly identifies phases with similar crystal structures.

- By grouping phases, and comparing the band width, **AZtec** will differentiate phases with similar crystal structures
- This technique can be applied to crystal structures where the similarity in lattice parameters make phase differentiation with traditional indexing impossible

TKD

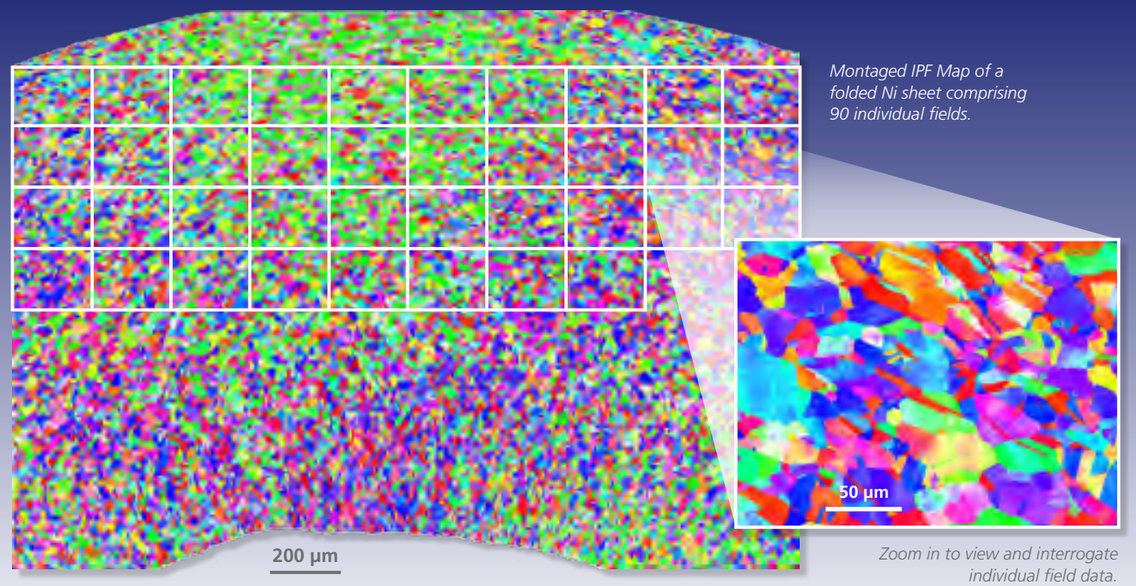
AZtec is the system of choice for TKD analysis. It includes an optimised TKD mode as standard for acquiring the most accurate maps - even at the nanometre scale. EBSPs collected in transmission mode have a gnomonic distortion and this innovative technology detects the bands in these patterns more accurately, ultimately delivering a higher hit rate.

- No extra **AZtec** hardware or software required
- Dedicated sample holder available

AUTOMATED

Routine analysis

Point analysis, linescans, mapping



Montaged IPF Map of a folded Ni sheet comprising 90 individual fields.

Zoom in to view and interrogate individual field data.

Point analysis

Quickly characterise a new sample and ensure that optimum settings are used. Point analysis gives an image-centric overview of the sample and the grain orientations. It is useful where full field mapping is not appropriate, e.g. non-conducting samples, or samples with a very large grain size.

- Position the SEM beam and collect EBSPs from specific points
- Review EBSPs, refine solutions, and measure orientations
- Calculate misorientations between selected points

LineScan

Study linear variations within a grain or across a sample.

- Define line scans in arbitrary directions
- Specify either the step size or the total number of patterns to collect
- Acquire multiple linescans automatically
- Visualise data in real-time, both as a line scan and a data table

EBSD Mapping

Visualise the spatial distribution of phases and grain orientations as a key to understanding microstructure.

- **AZtec** EBSD maps are acquired with high speed and accuracy
- Results are displayed in real-time
- An interactive map calculator tool helps to set-up the analysis area, the step size, and predicts the time to completion

MapQueue

Schedule the acquisition of multiple images, maps and linescans.

- Different areas of a sample, or different samples, are queued for automatic acquisition and analysis
- Multiple data sets can be collected using different acquisition settings
- EBSD and EDS data acquisition can be queued together

Large Area Mapping (LAM)

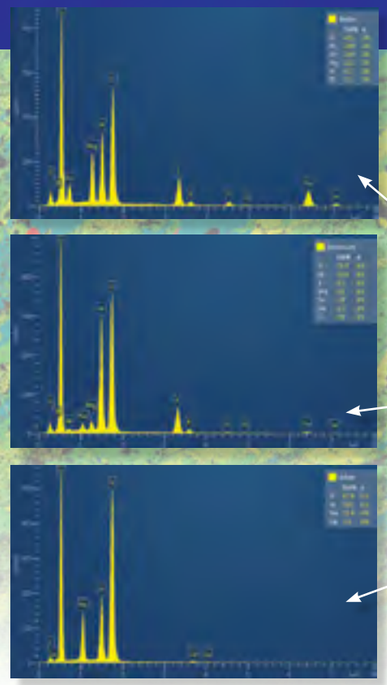
AZtec enables the unattended collection of high resolution electron images, and EDS / EBSD maps from large specimen areas. Up to 1500 fields can be collected at 8k image resolution and 4k EBSD resolution: these are automatically aligned in real-time to create a seamless dataset that can be analysed as a single site of interest.

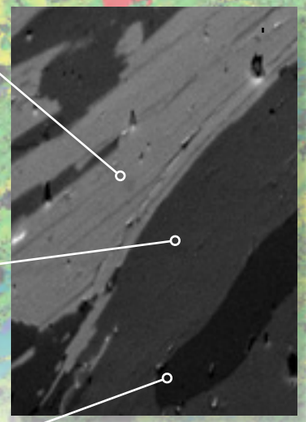
- A set-up wizard guides users through the process, making the acquisition of large area maps routine
- Fully interactive during acquisition: view all the data and zoom into detail
- EBSPs at each pixel can be saved and extracted post-acquisition, either from individual fields or the montaged data
- Montaged Euler, phase and inverse pole figure (IPF) maps can be generated for the entire area, or selected areas of interest

POWERFUL

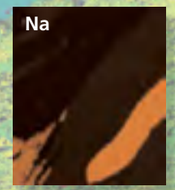
Integrated EBSD and EDS analysis

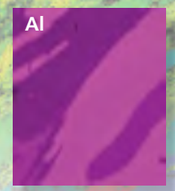
AZtecSynergy





Combined FSD image.

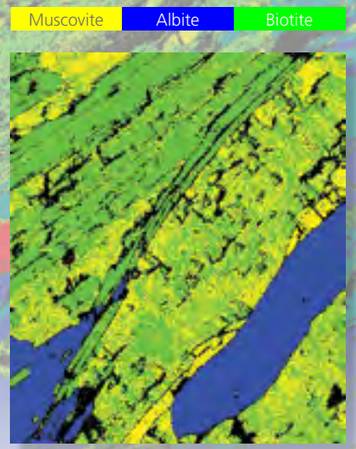




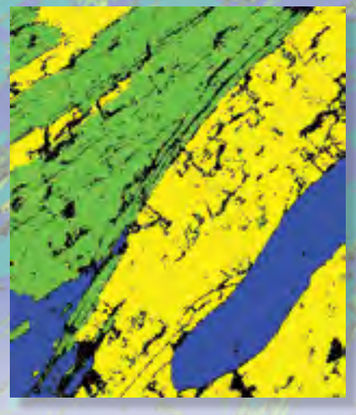
Associated element maps

Geological sample, courtesy of Dr. Elsabetta Mariani, University of Liverpool.

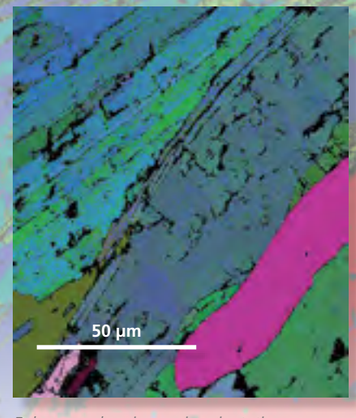
The power of *intelligent* integration



Phase map acquired using traditional EBSD. Biotite and muscovite mica are poorly differentiated due to their very similar crystal structures..



...by applying EDS insights, TruPhase automatically differentiates the two mineral phases.



Euler map showing grain orientation.

AZtecSynergy

The simultaneous acquisition of EBSD and EDS data allows accurate phase identification and enables integrated datasets to be collected from the same area of a sample with ease and speed.

By combining **AZtec**HKL (EBSD) and **AZtec**Energy (EDS), **AZtec**Synergy creates the ultimate materials characterisation system.

PhaseID

Identify unknown phases by combining the power of EBSD and EDS.

- Simultaneously collect an EDS spectrum and an EBSD pattern from a single phase on a sample
- Identify candidate phases based on chemistry using a powerful and fast phase search tool
- Accurately determine phases using Tru-I and Tru-Q algorithms
- Apply to previously acquired maps to identify an unknown or missed phase

Synergy mapping

A true and complete characterisation of the sample in real-time, EBSD and EDS data are collected simultaneously, and at the fastest speeds.

- Collect and visualise integrated data using a single interface
- Acquire integrated data simultaneously with no loss of performance
- View EBSD and EDS

TruPhase mapping

A sophisticated mapping tool for accurately indexing phases where there is a distinct compositional difference but very similar crystal structure.
By using statistical correlation of EDS spectra, the correct EBSD solution is selected.

- Apply TruPhase in real-time as data are acquired
- TruPhase can also be applied post acquisition or to previously acquired data

AZtecSynergy LAM

The power of large area mapping is easily extended to acquire integrated EBSD and EDS data.

- View all the data in the large image and zoom into the fine detail
- Mine the collected dataset to extract:
  - X-ray maps, EDS layer maps, AutoPhaseMaps
  - IPF, Euler, and phase maps
  - Individual EBSPs and spectra

AutoLock

Drift correction is essential for the highest resolution mapping. AutoLock is an integrated drift correction tool that corrects EBSD and EDS data simultaneously. It combines unique predictive and reactive drift correction algorithms.

- Applies to both tilted and untilted samples
- Corrects both EBSD and TKD data
- Shows the corrections that have made as the analysis proceeds

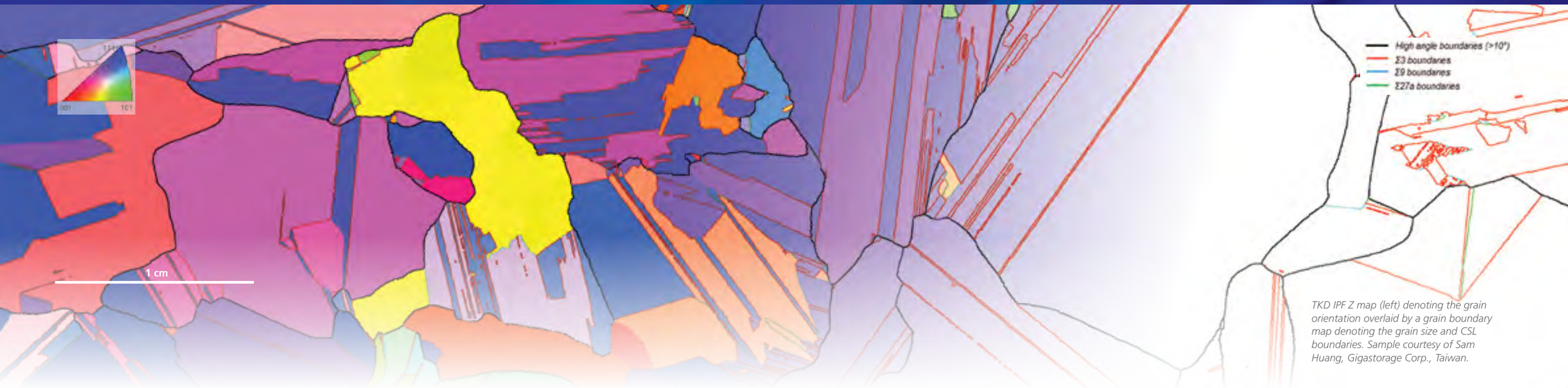
FLEXIBLE

Re-Analysis

Reprocess your data away from the SEM

Data processing

Extensive data processing tools aid data interpretation



TKD IPF Z map (left) denoting the grain orientation overlaid by a grain boundary map denoting the grain size and CSL boundaries. Sample courtesy of Sam Huang, Gigastorage Corp., Taiwan.

Re-Analysis

A powerful and flexible tool for data reprocessing: data sets with stored patterns can be re-analysed online or offline. Optimise settings, add or remove phases, and reprocess the data - without acquiring additional data.

- **Phase ID** – acquire data without identifying all the phases in the sample. Post acquisition, extract EBSP and ED spectrum from any point.
- **Optimise Settings** – review and revise the pattern solver settings after data acquisition. Optimise parameters:
  - number of bands and reflectors
  - Hough resolution
  - region of interest of the EBSP
  - Refined Accuracy algorithm for the highest orientation accuracy
- **Remapping** – maps can be re-analysed with optimised settings or a different phase list. Alternatively, selected regions can be re-analysed to build up a more detailed picture and decrease re-analysis times.
- **TruPhase** – apply to acquired data as if they were collected live

On-line processing

- **Euler, Inverse Pole Figure (IPF) and Phase Maps** – are generated in real-time: data can be visualised and interpreted during acquisition.
- **Pole Figures and Inverse Pole Figures** – are generated, either from a full dataset or a subset, for all 11 Laue groups. Data can be visualised in user-defined displays to examine crystallographic orientations.

The resulting maps and images can be easily annotated and exported, either on their own or in a customised report.

Post-processing

AZtec includes a powerful software suite to perform an in-depth microstructural characterisation. Large data sets with up to 64 million data points, can be analysed with full functionality.

- Characterise grains
- Calculate misorientation profiles
- Produce a wide range of EBSD maps, including orientation, phase, texture and local misorientation
- Calculate contoured pole and inverse pole figures
- Display data in Euler space as orientations (ODF) or misorientations (MODF) in 3D view and/or serial sections

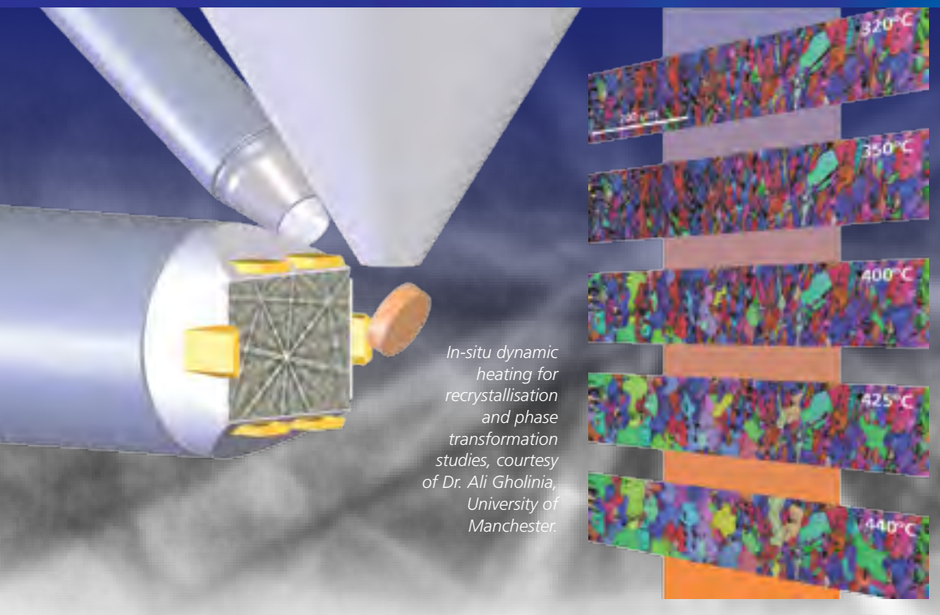
Mine the data for the information you need

FAST SENSITIVE

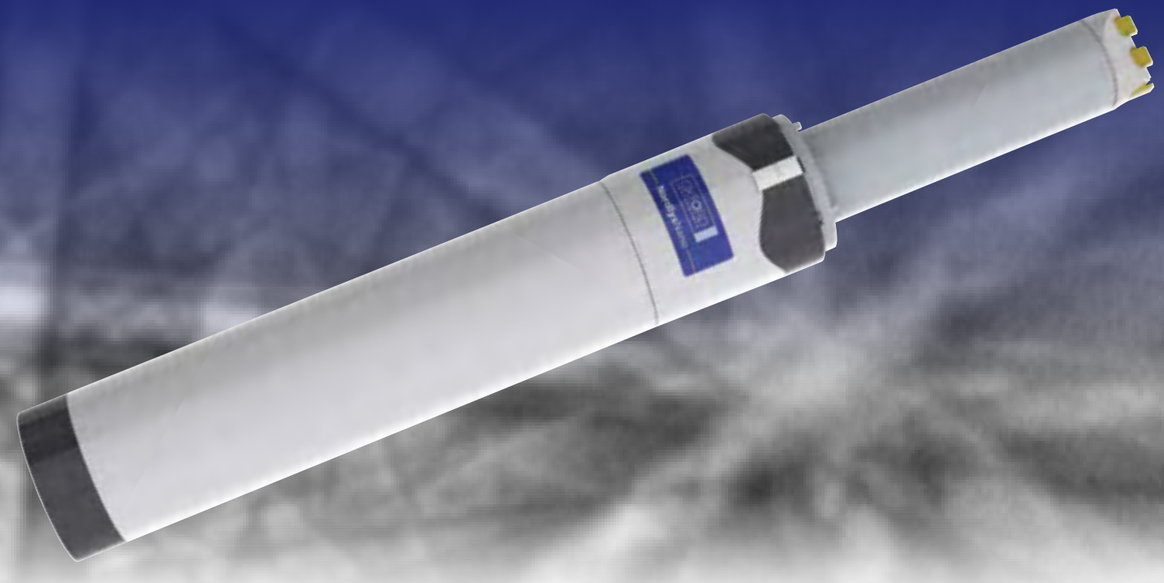
Nordlys EBSD Detectors

Superior hardware design

...optimum system performance



In-situ dynamic heating for recrystallisation and phase transformation studies, courtesy of Dr. Ali Gholinia, University of Manchester.



Optimised EBSD hardware

Oxford Instruments' **AZtec** EBSD system combines superior Nordlys hardware and innovative **AZtec** software to create the best EBSD solution available.

- The tapered nose design maximises the potential of integrated EBSD and EDS analysis, optimising the collection geometry for simultaneous EDS and EBSD acquisition
- Optimised optical design eliminates pattern distortion
- World-leading performance over all application regimes

Optimised for speed - **Nordlys**Max^3

NordlysMax^3 meets the demand to collect more data in a shorter time, and is optimised to acquire data accurately at the fastest speeds, even at lower beam energies.

- **Nordlys**Max^3 enables the fastest data acquisition
  - Performance is maintained down to 5 nA beam current
  - No loss in performance when simultaneous EBSD and EDS data are collected
- Designed for dynamic studies, where high speed acquisition is critical. The unique design incorporates an integrated infra red filter for data acquisition during in-situ heating experiments. This solution delivers high sensitivity compared to conventional high temperature phosphor screens.

Optimised for the nanoscale - **Nordlys**Nano

NordlysNano addresses the growing requirements of nanoscale applications: EBSPs are imaged with the best sensitivity, lowest optical distortion, and highest resolution.

- Optimised for high spatial resolution EBSD
- Effective at low kV data acquisition for the best spatial resolution analysis of nano materials
- Requires only 100 pA to operate, ideal for: Tungsten or LaB6 SEMs operated in high spatial resolution mode, or cold FE SEMs and thermal FE SEMs that operate with low probe current
- Optimised for high pattern resolution EBSD, it uses the full 1344 x 1024 CCD array to digitize EBSPs. The acquisition of higher resolution patterns is crucial for certain applications:
  - difficult to index, lower symmetry materials, where higher pixel resolution can aid in phase identification
  - cross-correlation techniques, for example, elastic strain analysis
  - pseudo-symmetric materials with c/a ratios as low as 2%

Characterise microstructures with accuracy, sensitivity and speed

OISERVICE

Global Customer Support

Accredited, experienced, responsive, dedicated

Oxford Instruments recognises that your success requires not just only world-class products, but also world-class service and support. Our global service team is renowned for delivering outstanding service to customers and microscope vendors:

- Hands-on and theory classroom training
- On-site training tailored to your specific needs
- Web-based courses and training videos
- Consultancy and application support
- Multi-layered maintenance and service contracts

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