QUANTAX EBSD

The fastest and most sensitive EBSD system ever

Innovation with Integrity

QUANTAX EBSD – with a new revolutionary core technology

Step into the future of materials characterization with the QUANTAX EBSD analysis system, powered by a new pixelated sensor designed for EBSD. Engineered by Bruker using a first principles approach, the new Wide ARea Pixelated (WARP) sensor combines direct electron detection and CMOS technologies to create eWARP, the fastest and most signal efficient EBSD detector ever. Paired with Bruker's ESPRIT software suite and its newly enhanced pattern processing algorithms, eWARP delivers significant improvements in analysis speed, spatial resolution and data quality.

eWARP – Enter a new era of EBSD

eWARP is a pioneering new EBSD detector for SEM powered by a Bruker-engineered direct electron detection camera. This unique design vastly boosts speed, signal acquisition and processing performance, elevating the EBSD technique to new levels.

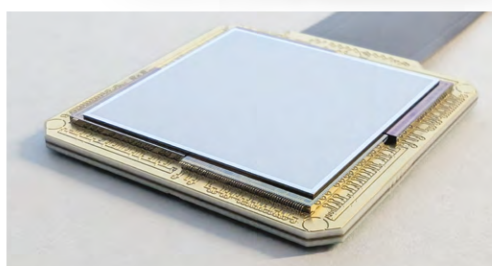
The unprecedented signal efficiency of eWARP is the result of its uniquely high collection rate, enabled by the wide area pixels, and its outstanding conversion rate given by a silicon sensor optimized for low electron energies typically used in SEM.

Figure 1
eWARP detector.

CMOS sensor with binning capability

The first ever CMOS device with patented on-chip binning capability is the core of eWARP. The sensor can acquire up to 350,000 patterns per second when operated in binned mode. This lightning-fast operating mode can be used to simultaneously acquire five ForeScatter Electron (FSE) images showing various mix levels of orientation and topographic contrast (see page 6 for details).

Additionally, eWARP's unique binning capability holds a huge potential for future development of new imaging capabilities.



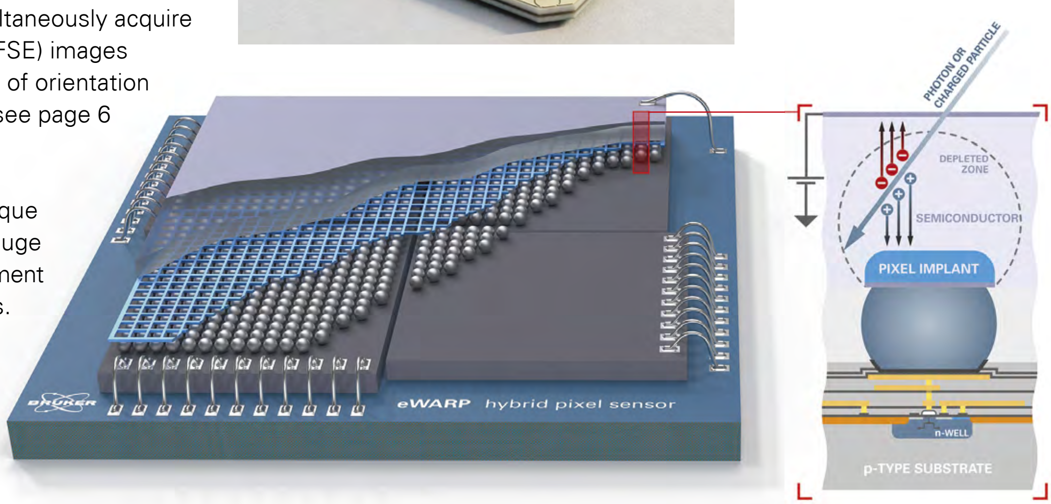


Figure 2
Picture and schematic representation of Bruker's hybrid pixel sensor technology, a.k.a. **W**ide **AR**ea **P**ixelated (WARP) sensor.

Ultrafast measurements with low beam requirements

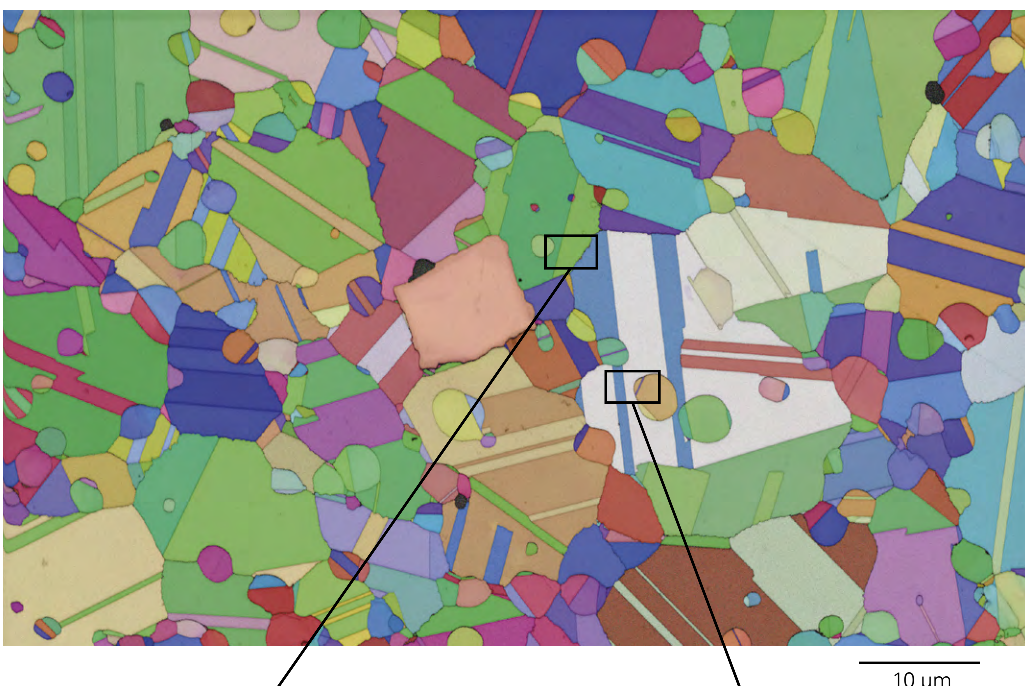
High productivity and high spatial resolution

eWARP requires only moderate electron beam settings, e.g. 10 kV accelerating voltage and 12 nA probe current, thanks to its unprecedented signal efficiency, even when used at its maximum speed of 14,400 patterns per second.

The patterns produced with these low beam conditions have high enough quality to be analyzed by the ESPRIT software suite with indexing rates above 99%.

In comparison with conventional EBSD maps obtained at 20 kV, the spatial resolution can be enhanced by a factor of two due to the reduced accelerating voltage. In other words, eWARP enables EBSD mapping at extreme speed with at least 25 nm resolution and excellent indexing rates.

The incredible speed and spatial resolution delivered by eWARP will have a major impact on most EBSD applications. In particular, large area mapping, 3D EBSD, and in-situ experiments will experience groundbreaking advances.



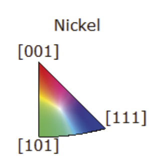


Figure 3
Ni superalloy sample measured at 10 kV and 12 nA.
Speed: 14,429 fps
Map size: 7.6 Mpixels, 84 x 56 µm^2
Map time: 8:46 min
Step size: 25 nm
Indexing rate: 99%

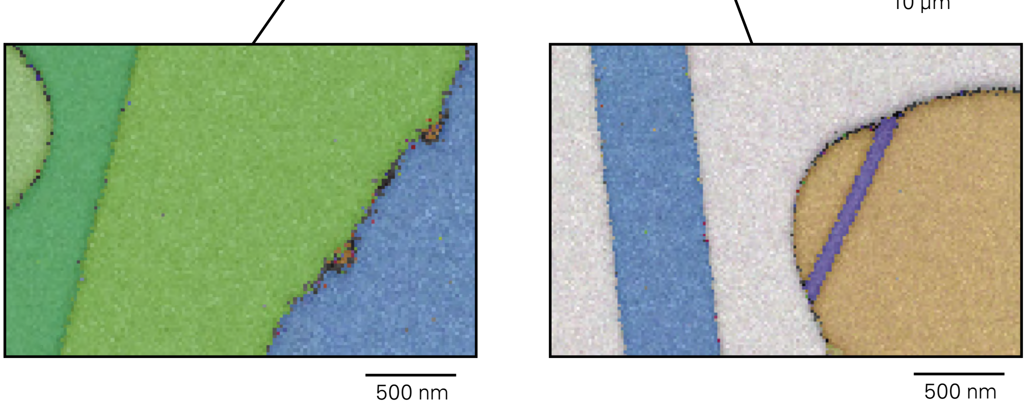


Figure 4
Insert showing 50-100 nm intergranular precipitates (left) and perfectly resolved annealing twin just 100 nm wide (right). Please note that results shown here have not been cleaned and that the map was acquired with a step size of 25 nm.

10 kV is the new norm

Improved statistics, productivity and spatial resolution for advancing NCM battery research

Thanks to its exceptional signal efficiency, eWARP facilitates low-kV EBSD without any disadvantages, leading to unprecedented improvements in spatial resolution and indexing quality. These innovations enable the use of EBSD as a quantitative analysis tool in previously inaccessible fields and materials. Battery materials research and production is an emerging field where EBSD demonstrates exceptional potential. The grain size and the shape as well as the fraction of high-angle boundaries impact several performance factors of batteries such as capacity, charging speed, lifetime, and safety. Figure 5 illustrates a large orientation map of a Lithium Nickel Cobalt Manganese (NCM) battery, showing the detection of even the smallest grains. The map contains around 12,000 grains. The inset in Figure 5 provides a detailed view of the fine microstructure of an NCM cathode particle.

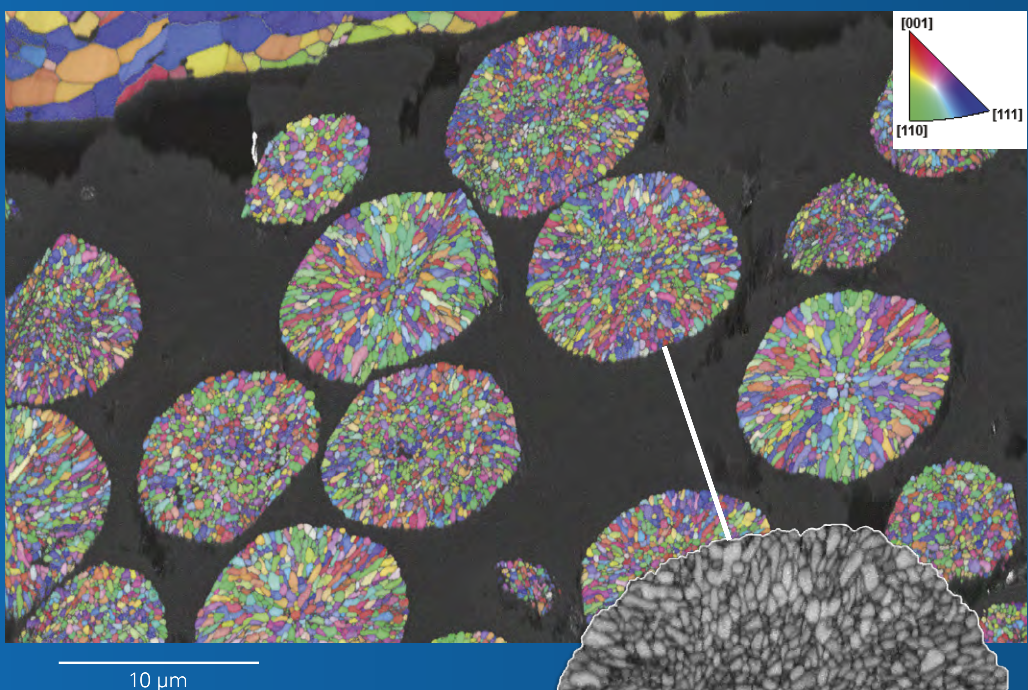


Figure 5
High-resolution EBSD map of a NCM (nickel-cobalt-manganese) battery measured at 10 kV and 12 nA.
Speed: 3,300 fps
Step size: 25 nm
Map size: 3.8 Mpixels
Map time: 19:20 min

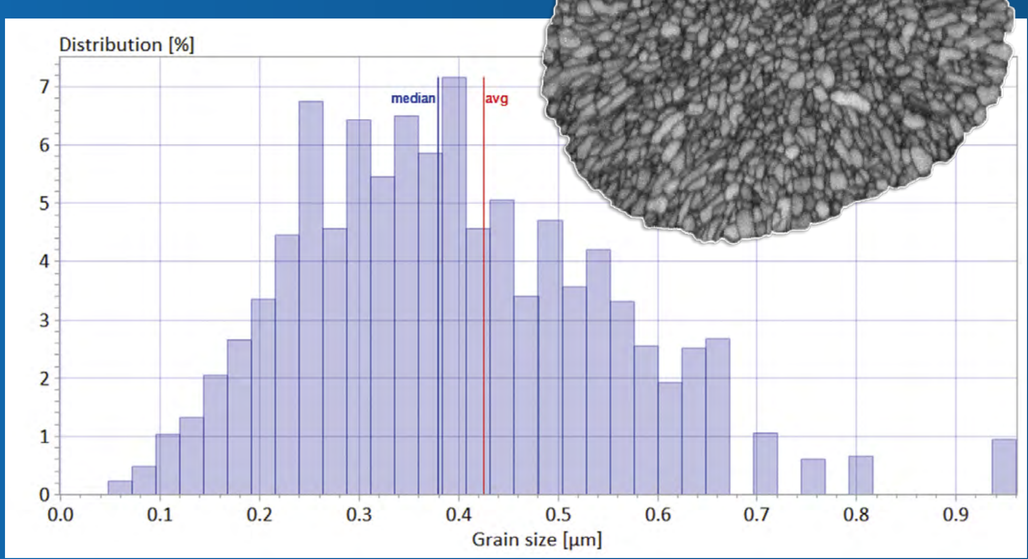


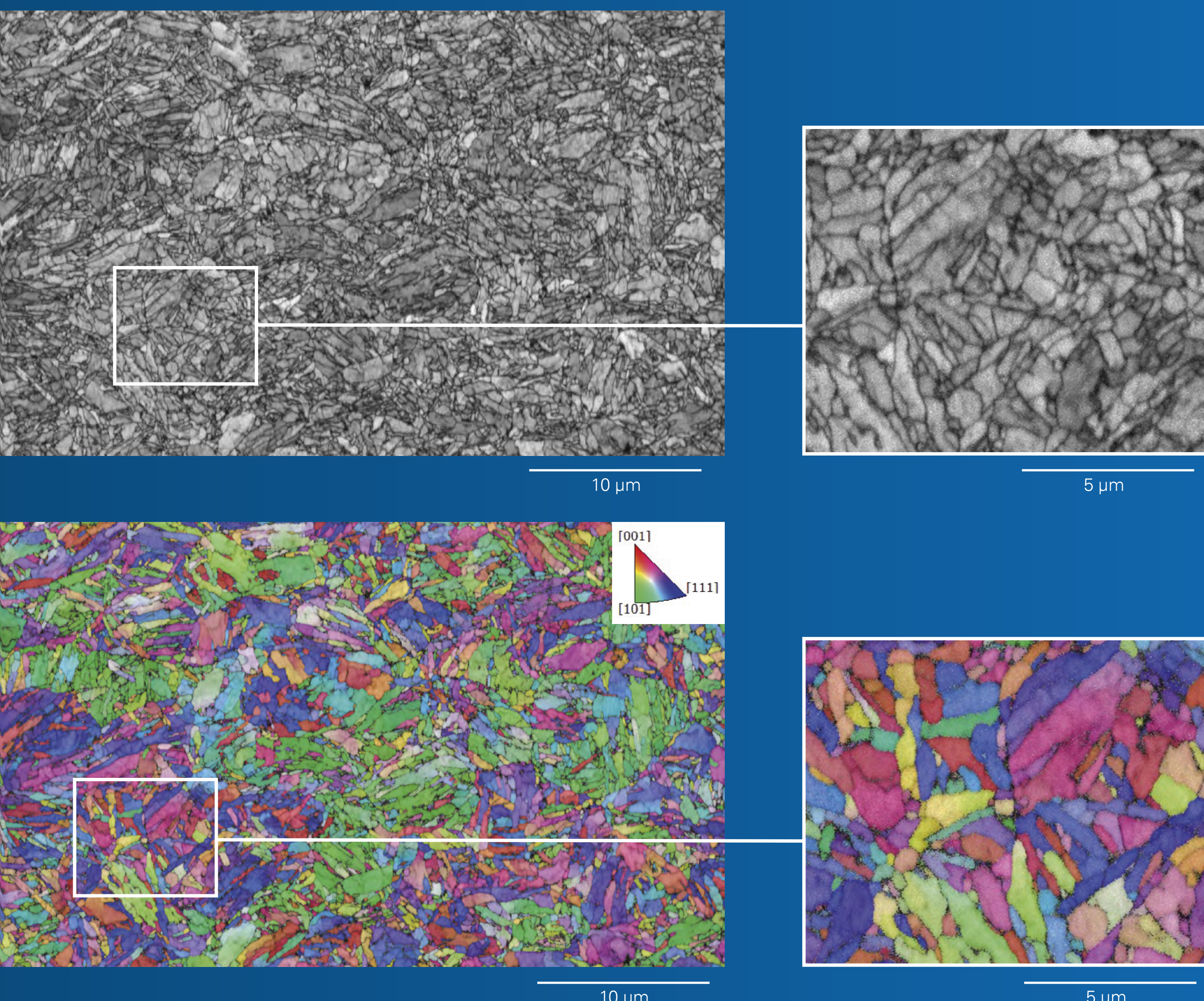
Figure 6
Grain size distribution histogram corresponding to the single cathode material particle shown in Figure 5. The particle contains more than 1,000 grains with an average diameter size of 428 nm.

20 nm resolution for difficult materials

Resolve challenging materials such as martensitic steels

One significant advantage of 10 kV EBSD is especially evident for the characterization of martensitic structures in steels and titanium alloys. The lower accelerating voltage minimizes the interaction volume, positively impacting both spatial resolution and the contrast in Kikuchi patterns. More visible bands result in higher probability of a correct indexing, thereby improving data quality, which is crucial for successfully correlating EBSD results with material properties. Figure 7 presents EBSD data obtained from a martensitic stainless steel sample prepared by conventional mechanical polishing method. The pattern quality map (top) reveals a typical Martensite lath structure with a resolution of 20 nm. The corresponding crystal orientation map (bottom) clearly shows the high indexing quality in the raw data without applying data cleaning.

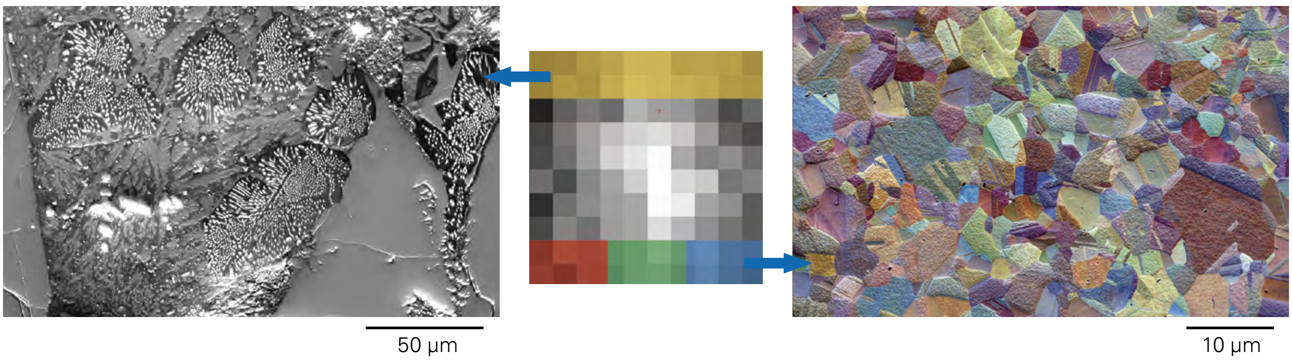
Figure 7
EBSD results acquired from a martensitic steel sample measured at 10 kV and 12 nA.
Speed: 3,327 fps
Step size: 20 nm
Map size: ~ 3 Mpixels
Map time: 14:49 min



Augmented ARGUS™ with 100 "eyes"

The augmented ARGUS™ imaging system provides various key features and benefits:

- **Lightning fast FSE/BSE imaging**
- **New! Virtual FSE imaging**
- Orientation, topographic and phase contrast
- 1 Mpixels in just 3 seconds
- 5x images acquired simultaneously
- Color coded or grey scale
- Ideal for automated continuous acquisition during in-situ experiments



eWARP's patented binning technology is central to the new ARGUS™ imaging system, enabling superfast FSE imaging at up to 350,000 pixels per second and providing 80 times more signal per pixel compared to native resolution mode. This results in faster and higher quality FSE images (see Figure 8).

Additionally, ESPRIT now includes the capability to create Virtual ForeScatter Electron (VFSE) images automatically during EBSD mapping, without compromising speed or signal integrity. Figure 9 shows a set of five VFSE images from a duplex stainless steel.

Figure 8 (top)
FSE images acquired using the ARGUS™ augmented system and showing phase/ average z number contrast in a rock sample (left) and orientation contrast in a steel sample (right). The center image is a typical image/signal produced by the eWARP sensor operating in 9x9 binning mode.

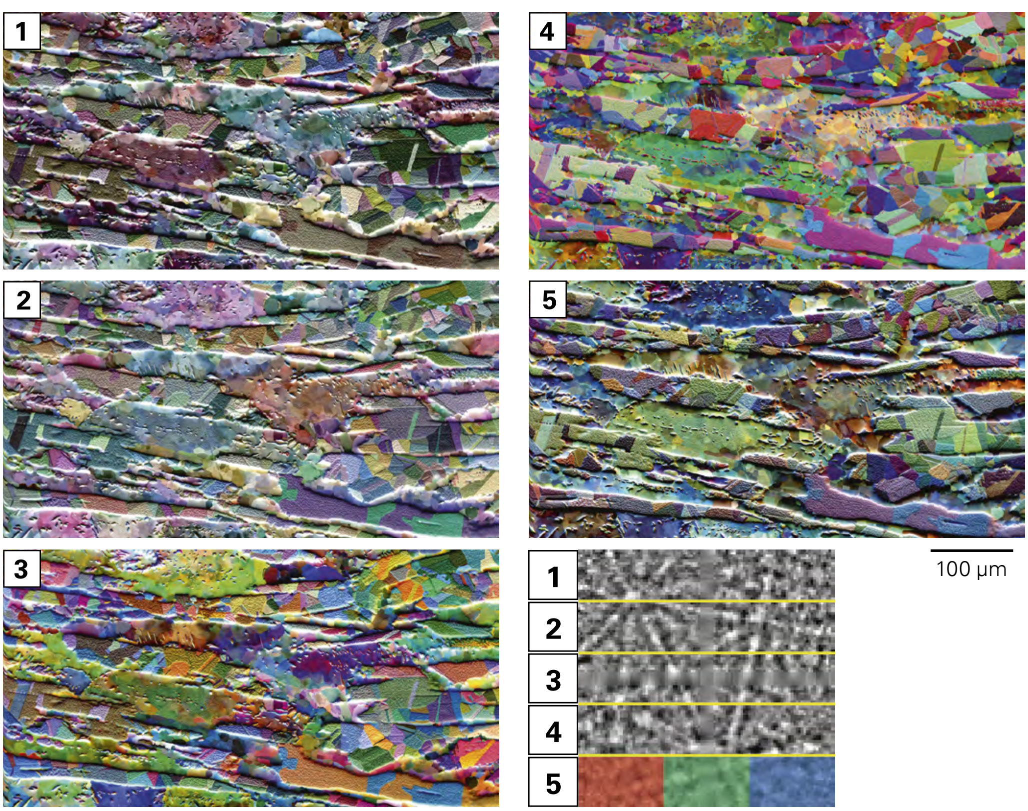


Figure 9 (left)
VFSE images showing orientation and topographic contrast in a duplex stainless steel sample. Each image is created by a different area of the sensor.

ESPRIT Software

ESPRIT is Bruker's intuitive software for microstructural and elemental analysis. In addition to providing the capability for in-depth EBSD analysis, ESPRIT can also integrate elemental data from EDS.

Data processing superpower

The ESPRIT pattern analysis engines have been completely redesigned to match the massive jump in speed brought by eWARP EBSD detector. More than 20,000 patterns per second can now be analyzed (band detection and indexing) thanks to its new algorithms combined with a 24 core Intel processor. Offline reindexing of EBSD maps can be done at speeds that can reach up to 100,000 points per second.

The quantum leap in ESPRIT's speed performance is essential for boosting productivity and will fundamentally transform the use of the EBSD technique in advancing science and technology.

Easy to use, flexible by choice

The ESPRIT user interface was designed for ease of use while maintaining flexibility. The software automates all tasks that can be handled without compromising speed and data quality. For experienced users who wish to experiment with specific parameters, ESPRIT offers the necessary tools to do so.

Advanced data post processing tools

The ESPRIT software provides a wide array of options for offline processing and interpretation of EBSD data. Standard post-processing tools, such as crystal orientation distribution representation, grain reconstruction, misorientation maps, and texture component maps, are enhanced by robust subset creation and processing capabilities. This suite of post-processing tools enables the quantification of microstructures and the correlation of these results with material properties or the processes to which samples are subjected.

One platform, endless possibilities

The two different but complementary techniques, EBSD and EDS, are fully integrated in the ESPRIT software suite allowing the operator to execute different analytical tasks without constantly switching between programs. Simultaneous acquisition of EBSD and EDS data is one click away and it provides the best of each technique in a single dataset, i.e. each pixel in the map contains an EDS spectrum and the EBSD data.

Both techniques combined on the same software platform lead to increased productivity and improved data quality. Processing and understanding results is much easier now.

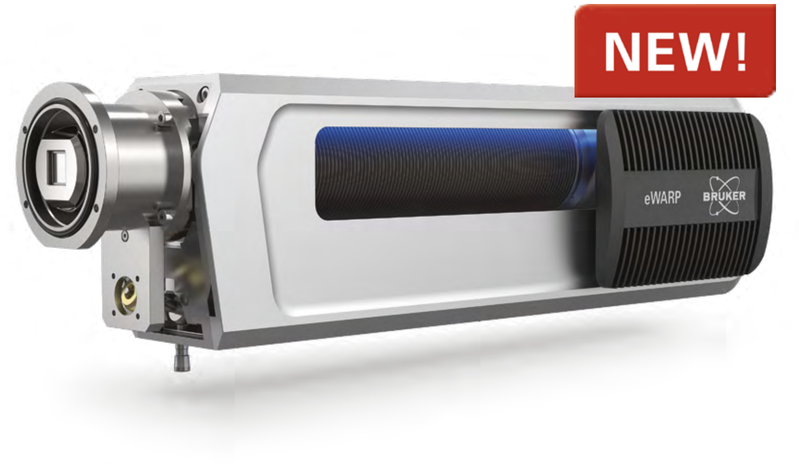
Export with ease, report with impact

ESPRIT software enables the export of EBSD and EDS data in various formats, such as HDF5, facilitating the exchange of both results and raw data among researchers. Additionally, templates can be created and utilized to automatically generate reports.

Operational benefits

- **On-site firmware upgrades** for
  - Enhanced performance
  - Improved user experience
- **Detector monitoring** for predictive maintenance (with customer permission)
- **On-site sensor module replacement** to maximize uptime
- **EBSD mapping at 10 kV** as the new standard – eliminating radiation damage

eWARP – Electrons only



Technical Data

Chip technology	CMOS/ Pixelated sensor
Detection method	Direct electron detection
Active area/sensor material	16 x 16 mm^2 / silicon
Pixel size/ pitch	160 x 160 μm^2
Dynamic range	15 bit (91db)
Operating beam conditions	Accelerating voltage range: 5 kV – 30 kV Standard/ recommended accelerating voltage: 10 kV, typical probe current required to reach 99% hit rate on an austenitic steel sample at 10 kV accelerating voltage: ~12 nA
Pixel resolution	Native: 100 x 100 pixels Binned: 10 x 10 pixels (9x9 binning – Patent EP 3605 044 B1 / US 1166 5441 B2)
Minimum integration time/ frame time	2.6 µs / 69 µs
Radiation hardness - expected lifetime	At least 10 years (40 hours/ week) at 10 kV accelerating voltage
Cooling system	Active - Peltier
Offline band detection and indexing	Up to 20,000 patterns per second
Offline reindexing	Up to 100,000 patterns per second

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