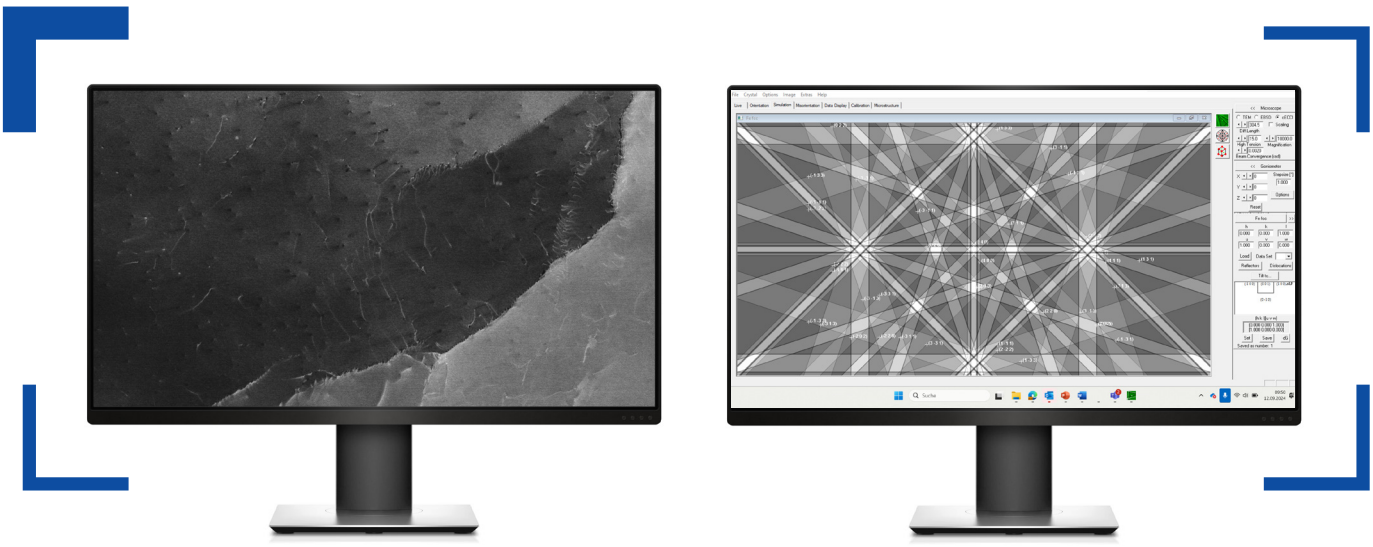
TEM-like Defect Imaging in Bulk Samples on Your SEM



cECCI for ZEISS FE-SEM

Controlled Electron Channeling Contrast Imaging on ZEISS GeminiSEM

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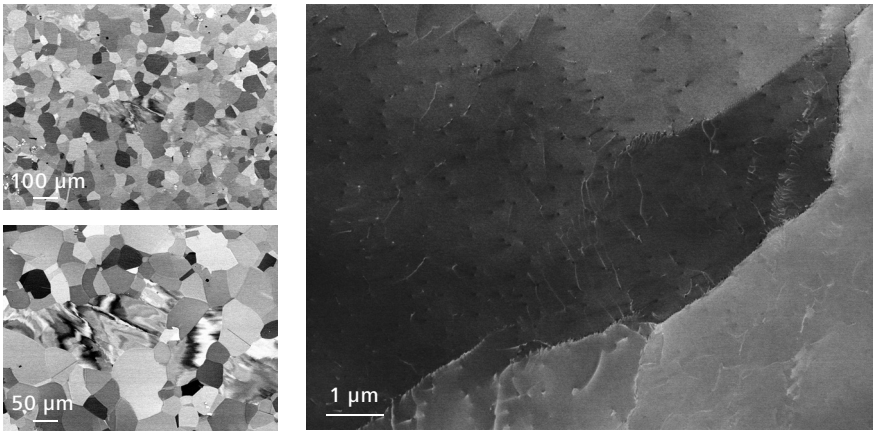
Seeing beyond

cECCI for ZEISS FE-SEM

TEM-like Defect Imaging in Bulk Samples on Your SEM

Image crystallographic defects and characterize deformation in your bulk samples quantitatively without the need for a TEM[1]. Use Controlled Electron Channeling Contrast Imaging (cECCI) in a cutting-edge ZEISS FE-SEM[2] to acquire excellent images of defects in bulk samples with ease and minimal sample preparation.

Add cECCI to your ZEISS GeminiSEM that comes with innovative electron optics ideally suited for the analyses of lattice defects. Combine it with TOCA[3], the analysis software that enables your ZEISS FE-SEM to produce TEM-like images of defects such as dislocations or stacking faults with superior image quality and contrast.



Ni-based superalloy. Overview of all the equiaxed grains in a nickel based superalloy sample (top left). A second slightly zoomed in image focuses on a deformed grain (bottom left). The detailed image, acquired using cECCI, shows that the grain of interest is in channeling condition and clearly reveals several dislocations within (right).

Open up the world of defect imaging and benefit from:

- Qualitative and quantitative defect characterization by cECCI on your GeminiSEM.
- Access defect analysis in bulk samples or additionally combine analysis with *in situ* experiments.
- Go beyond the one-shot analysis approach; save time through less demanding sample preparation as you can now skip the TEM lamella preparation step.

[1] Transmission electron microscope
[2] Field emission scanning electron microscope
[3] Tool for Orientation and Crystallographic Analysis

What is cECCI?

- A technique for the quantitative characterization of deformation structures in SEMs
- Utilizes the relative orientation of a crystalline lattice and incident electron beam to influence back scattered electrons (BSE).
- Delivers perfect imaging conditions for ECCI through precisely simulated electron channeling patterns.
- Controls the illumination of the crystal lattice by "educated" tilting to achieve a perfect electron channeling condition.
- Delivers superior quality SEM images of defects such as dislocations, stacking faults and twin boundaries crucial to materials science research
- Enables the visualization, measurement, and quantitative analysis of the imaged defects.

How does cECCI work?

- Configure your ZEISS FE-SEM for cECCI with a sensitive backscatter detector, precise 6-axis stage, EBSD analytics and the TOCA[3] software.
- Perform a 4-step workflow: first find your defect and acquire an EBSD map, second simulate a channeling pattern in the TOCA software, bring your sample into the ideal orientation for the analysis as prescribed by TOCA, and acquire the perfect cECCI image to observe defects.

What are the advantages of cECCI in SEM vs. TEM?

- Observation of bulk samples now possible as users are no longer limited to investigation of thin sections.
- Simplified sample preparation eliminates the need for lamella preparation and region of interest isolation.
- Facilitated *in situ* experiments.
- Access to true sample representivity.

	ZEISS cECCI	TEM
Lateral resolution	8 to 10 nm	1 nm
Depth of observation	50 to 100 nm	100 to 200 nm
Observable area	10^8 µm²	10^4 µm²
Sample	bulk	thin foil

Reference: S. Zaefferer, N. Elhami, Acta Materialia 75 (2014) 20–50

Controlled Illumination Workflow

Ensures Best-in-Class Images on Your ZEISS FE-SEM

A ZEISS FE-SEM configured for the cECCI workflow delivers optimal ECCI conditions and enables user-friendly acquisition and analysis of electron channeling contrast images. Controlling the illumination of the crystal lattice by educated tilting of the sample lets you see and characterize defects over large areas on true bulk specimens even without lamella preparation.

Similar to the technique applied in a TEM, cECCI in SEM relies on achieving the Two-beam condition or the invisibility criterion to achieve electron channeling contrast images. This requires an extremely precise tilting of the sample with respect to the electron beam. At such a condition the defect of interest produces a backscatter signal of high contrast in comparison to its vicinity which is in channeling condition. The determination of the precise tilting parameters is made easy by the TOCA software, providing an easy to follow step-by-step workflow.

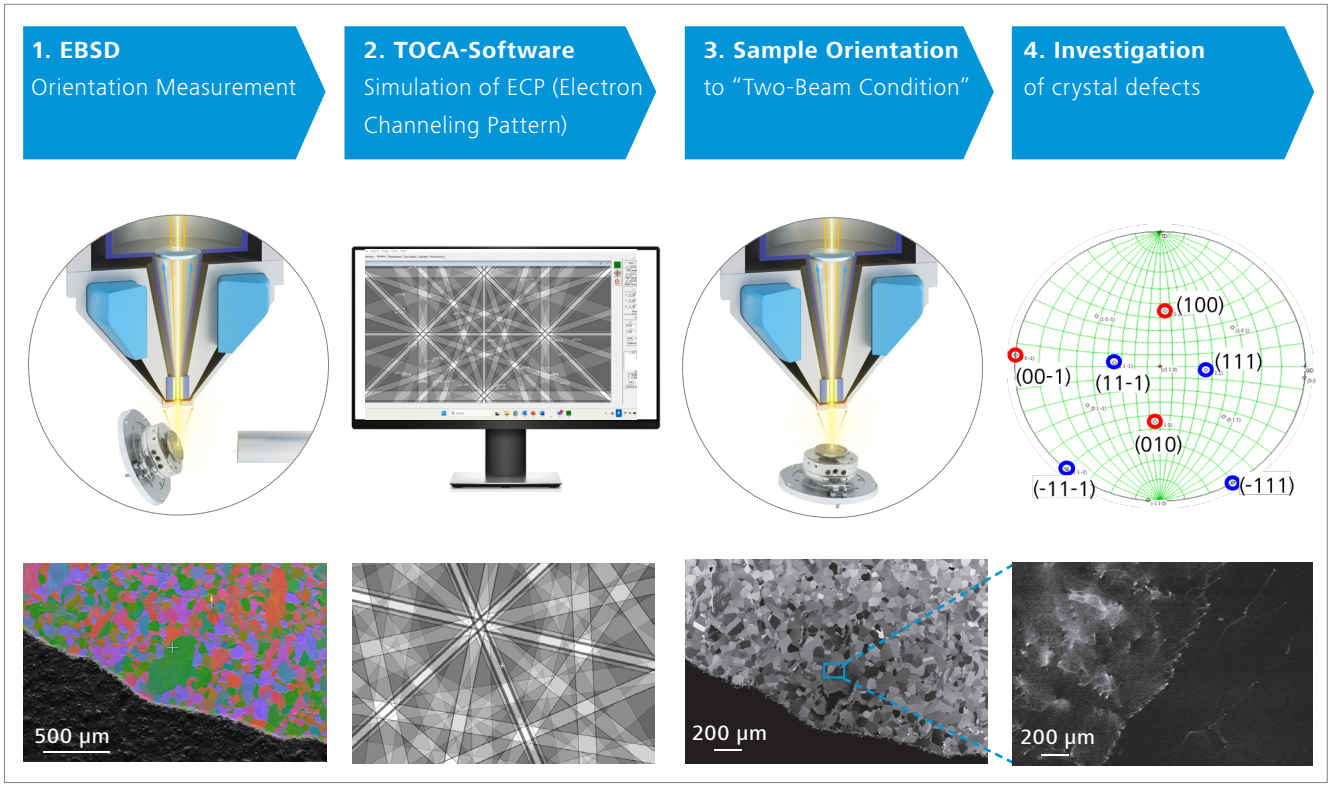
The four-step workflow to arrive at the best cECCI imaging conditions

1. Acquire an EBSD image for orientation measurement
Determine your general region of interest and acquire an EBSD map.

2. Apply TOCA for the simulation of a channeling pattern
Know how your ECP should finally look like. TOCA simulates channeling patterns for the selected grain of interest and let's you choose the specific diffraction plane of your choice for the channeling condition.

3. Bring your sample into the two-beam condition
Achieve perfect channeling condition every time for the desired diffraction plane of your choice within the grain of interest using the 6-axis stage and information from TOCA.

4. Investigate your defects
Image the defect of your interest in detail and characterize the type of your defects with analytical tools readily available in TOCA.



cECCI controlled illumination workflow.

Configure Your SEM for cECCI

Expand Your Possibilities

Achieve excellent image quality and resolution performance. Unlock a new TEM-like imaging modality. With cECCI, you will have access to defect imaging in real bulk samples with faster time-to-result and easy sample preparation

Applications

Materials researchers can get crucial insights from visualizing crystallographic defects in polycrystalline materials that arise from material deformation and processing. This requires high resolution imaging, usually on ultrathin sections as prepared for a TEM. With this novel approach of cECCI, materials researchers can utilize a more accessible FE-SEM to characterize defects in a variety of materials without the need for thin section preparation.

Materials

- Metals: Superalloys, steels (bcc & fcc), Al-alloys, Ti-alloys, Mg-alloys
- Ceramics: SiC, $SrTi0_3$
- Geological specimens or minerals: Ferropericlase, Pyrite
- Semiconductors: GaN, GaAs, CdTe, Si

Types of Defects

- Dislocations (edge and screw dislocations)
- Stacking faults, grain/phase boundaries, precipitates
- Strain fields

Requirements

- Small beam convergence
- Small beam spot size
- High beam current
- High beam stability
- Sensitive and quick BSE detector
- Precise 6-axis stage

Configurations*

ZEISS electron microscopes with Gemini Optics 2 or 3	GeminiSEM 460 GeminiSEM 560 Crossbeam 550
Analytical equipment	EBSD camera and software
Backscatter detector	6-segment BSD
Stage	6-axis stage for ZEISS Crossbeam and ZEISS GeminiSEM families
Software	TOCA

*For more details please contact your local ZEISS sales representative.

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