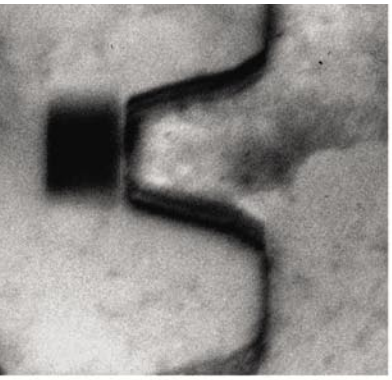
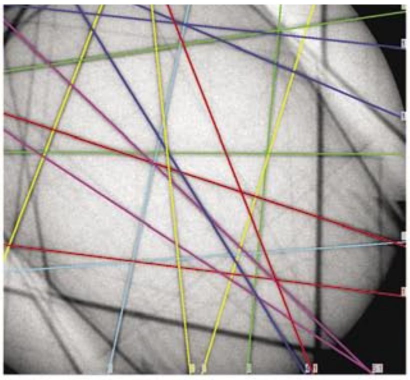
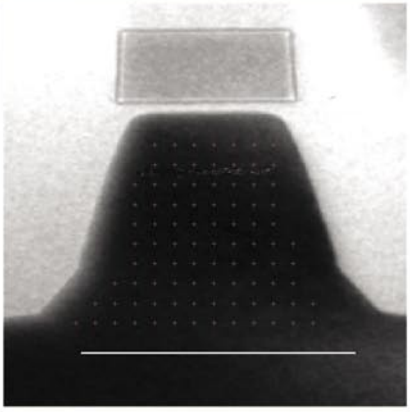
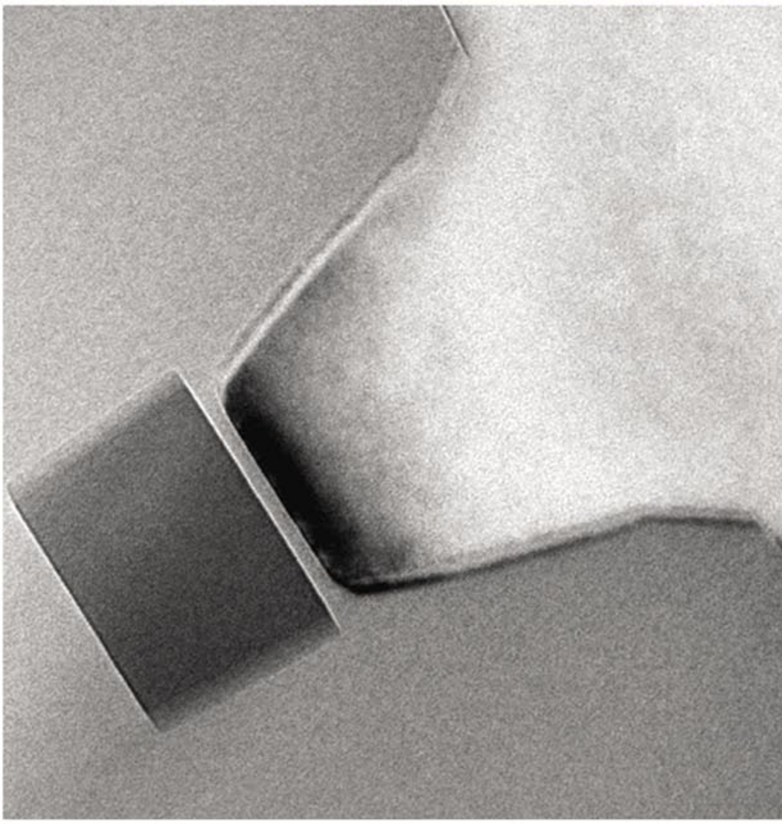
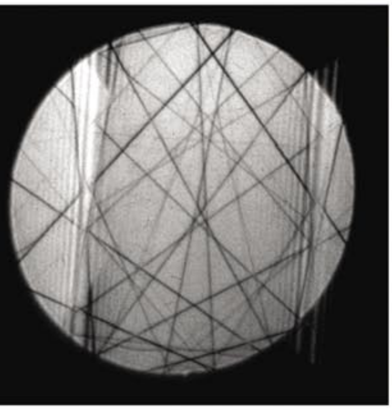
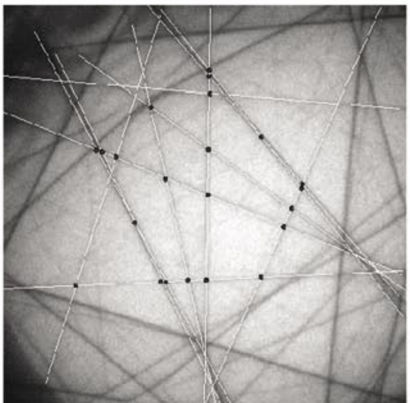
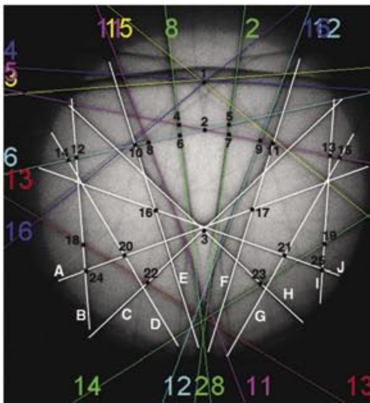
Your Vision, Our Future

Digital TEM Imaging Solutions
iTEM Solution ASAC
iTEM

Automatic Strain Analysis of TEM-CBED Images

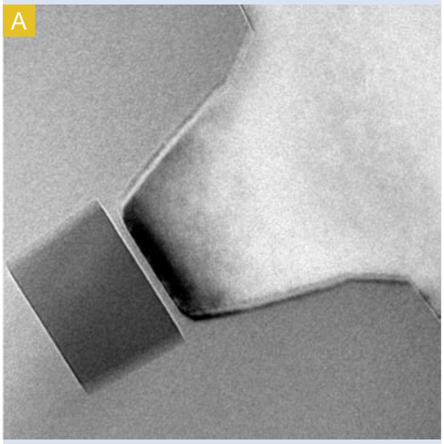








AUTOMATIC STRAIN ANALYSIS OF TEM-CBED IMAGES

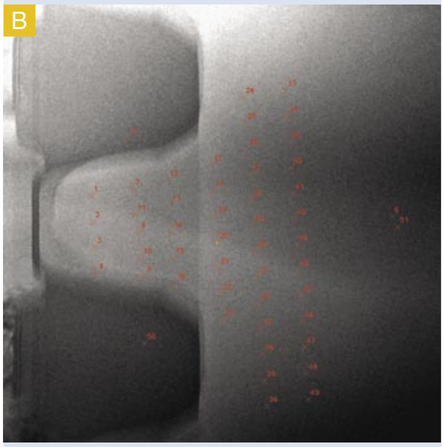
The iTEM Solution ASAC (Automatic Strain Analysis by CBED) is an advanced tool for the TEM-CBED field and for use with the TEM imaging platform iTEM. It automatically determines the strain in silicon devices using sophisticated image analysis. As with all other extensions, the iTEM Solution ASAC is fully integrated with iTEM, the Olympus Soft Imaging Solutions transmission electron microscopy image analysis platform. The base-level version offers numerous functions for processing, analysis, visualization and archiving of images and other data as well as for automation and report generation. With its solution-oriented software extensions, iTEM's range of functions can be precisely expanded according to the user's needs.

Convergent beam diffraction TEM images of Silicon (Si) <130> at 100 kV, <230> and <340> at 200 kV can be analyzed using ASAC. The algorithm detects the HOLZ (High Ordered Laue Zone) lines with a high degree of precision. Results are obtained within minutes. The iTEM Solution ASAC calculates the effective voltage, the strain tensor and its trace at the click of a button. The strain values can be visualized as colored spots within an overview image and exported as a data sheet. Using ASAC means that a series of images of a semiconductor structure can be analyzed within a very short time with high precision and reliability.

A



B



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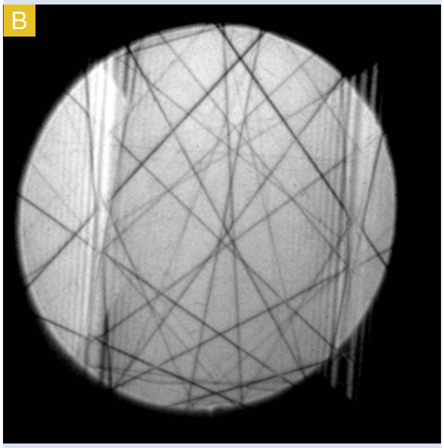


Detecting, measuring and visualizing strain

A Mechanical stress that has built up in layers and substrates influences yield, device performance and stability, as well as product reliability in deep-sub-micron integrated-circuit (IC) technologies. This is why it is important to calculate a quantitative account of these stresses. This can only be achieved by making use of: reliable and quantitative techniques for local stress determination in the substrate; of adequate and dedicated process simulation tools; and of sensitive methods for analyzing stress effects on device performance. In order to accomplish this task, ASAC provides an experimental method of the TEM convergent-beam-diffraction technique for measuring lattice strain with a precision of an order of $2x10^{-4}$.

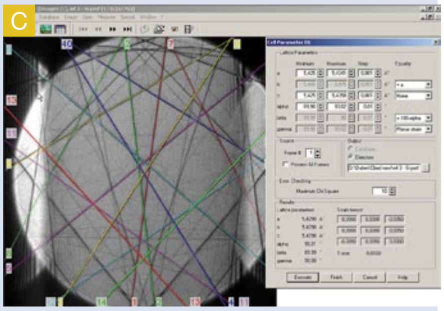
Image acquisition and image import

B The iTEM Solution ASAC supports the automated acquisition of TEM-CBED patterns for selected microscopes. A set of points (along Regions Of Interest (ROI's) in the cross-sectioned structure) can be selected and the electron probe will be located sequentially in each of them for the CBED pattern acquisition. Automatic procedures such as offset and gain correction are supported as well as TEM alignment. All standard image file formats (e.g. TIFF, MTIFF) are supported by iTEM as well as important proprietary file formats (e.g. EMISPECs file format).

Processing and analyzing

C The analysis of TEM-CBED images can be difficult due to e.g. varying and problematic contrast. The HOLZ lines are not always clearly visible and sophisticated image processing must be done in advance to be able to detect the lines automatically. The software is doing almost all preprocessing steps (e.g. noise reduction, shading correction, inverting, …) automatically and guides the user easily through the remaining processing steps. The user interface is set up in such a way that the number of parameters users have to deal with is kept to a minimum. This makes reproducibility of results highly reliable.

C



Properties and pattern simulation

Users have just three parameters to define: the atomic species, the used zone axis and the accelerating voltage initially used. Zones <130>,<230> and <340> can be selected. A simulation generates a HOLZ line pattern according to the selected material, zone axis, temperature and accelerating voltage. The simulated line pattern is displayed as a dynamic overlay of the experimental pattern. It can be easily interactively adjusted to resemble the experimental pattern exactly. Once this has been done for a single image of an experimental stack , the software will subsequently find the relevant HOLZ lines automatically through the whole stack.

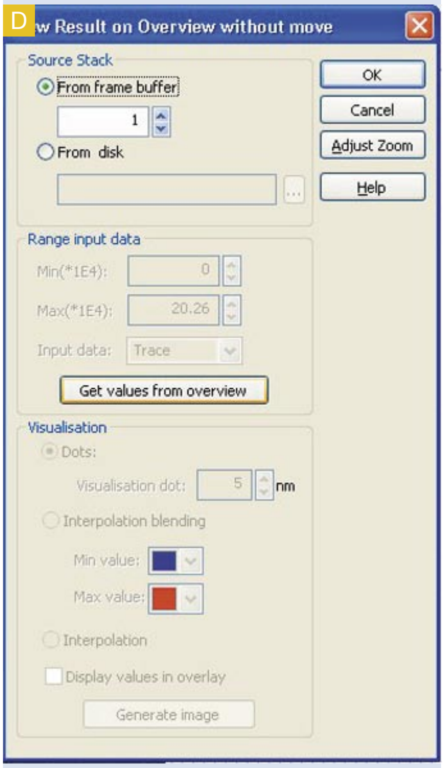
Fit algorithms

D The iTEM Solution ASAC fit procedures are divided up into two parts: Voltage Fit and Cell Parameter Fit. Calculating strain precisely is only feasible if the accelerating voltage is correct. The nominal accelerating voltage of the microscope cannot be included into the strain calculation. Rather an effective voltage value must be determined. The effective voltage is calculated based on an unstrained image at a certain experimental temperature. Once the user has determined the exact experimental accelerating voltage, the cell parameter fit is done based on this values. Using the default cell / lattice parameters or adjusting them to the experimental setup and used material is resulting in the cell parameter fit, giving as final result the strain tensor and trace with high precision. The results are both stored along with the image as well as exported to a sheet, saved along with the image in the database or automatically filled-in an user-definable report template.

Visualization of the results

E Presenting results optimally is done best using the strain visualization option. Users are able to view strain results displayed in an overview image as a 2-D strain map where colored dots correspond to the magnitude of the strain.

D



w Result on Overview without move

Source Stack

● From frame buffer

1

○ From disk

Range input data

Min(*1E4): 0

Max(*1E4): 20.26

Input data: Trace

Get values from overview

Visualisation

● Dots:

Visualisation dot: 5 nm

○ Interpolation blending

Min value: 🟦

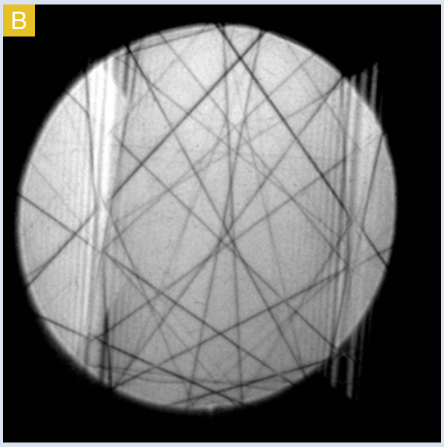
Max value: 🟥

○ Interpolation

☐ Display values in overlay

Generate image

B



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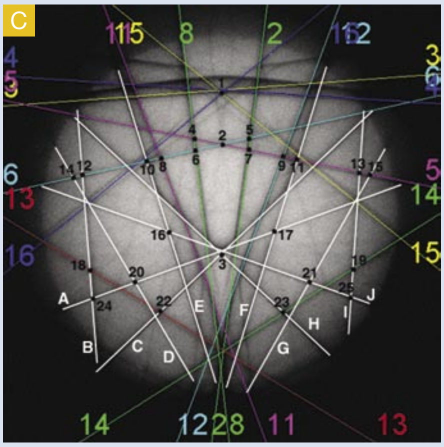
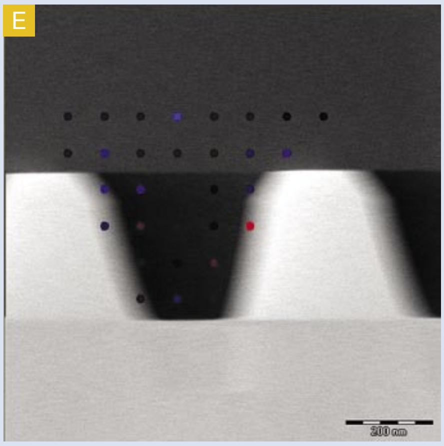


E



Specifications

- Material currently supported: (Si), more in preparation (please check our website)
- Zone axis supported: <120>, <240> @ 100 kV, <340> @ 200 kV
- Experimental temperatures supported: around RT (18 - 25 °C) and liquid N_2
- Algorithm approach: best fit , kinematical (HOLZFIT)
- Computation of strain tensor and trace with a precision of $2x10^{-4}$
- Automatic image processing, line detection and line indexing (Miller indices) on single images as well as on image stacks
- Visualization of results (tensor) with 2D maps on STI overview (STEM-) images
- All relevant image data and results saved within the image file.
- Image file formats supported: standard file formats (TIFF, MTIFF,...) , Emispec, …
- Image and data archiving

Additional iTEM Solutions

iTEM can be further expanded according to your individual needs via a wide range of specially developed solutions. Users can thus put together their own personal software solution for dealing with their particular application. All solutions work together seamlessly. The list of the available solutions is growing continually.

iTEM Solution Detection – The iTEM Solution Detection offers simple, fast and flexible particle detection and classification.

ITEM Solution Tomography – The iTEM Solution Tomography is the most convenient way to obtain 3-D data from every 2-D tomography tilt series acquired on a TEM.

iTEM Solution EMarker – The iTEM Solution EMarker provides you the decisive assistance for counting and analyzing your colloidal gold markers automatically.

iTEM Solution EFTEM – The iTEM Solution EFTEM is comprehensive software for acquisition, analysis, management and display of energy loss image series.

iTEM Solution Diffraction – The iTEM Solution Diffraction offers diffraction pattern analysis including calibration, indexing and measuring of single or polycrystalline
diffraction images.

iTEM Solution telePresence – The iTEM Solution telePresence enables the user to conveniently operate transmission electron microscopes, TEM cameras and motorized stages online unrestricted by time or place.

TEM camera solutions for iTEM – Various bottom and side-mounted scientific-grade CCD TEM cameras are fully integrated in iTEM.

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