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Custom Development in 2008:

Total High-Precision X-Ray Orientation Mapping of Polycrystalline Silicon

Polycrystalline silicon is the cornerstone material used in the production of highly efficient solar cells. It is a material consisting of multiple small silicon crystals, also called grains. In contrast to single crystal production, the process control for thin multicrystalline silicon production is not yet fully established and a variety of analytical methods is therefore of interest.

On special customer request, EFG has developed an orientation measurement device based on the well-established high-precision Ω -scan method. As a world-premiere this machine does not only allow the orientation analysis of each single grain on foils and wafers up to 280 mm diameter but it can also detect orientation variations within selected grains. Therefore we coined the phrase **Total High-Precision X-Ray Orientation of Polycrystalline Silicon (TOPSI)**.

Polycrystalline silicon – a challenge for the Ω -scan

EFG has worldwide reputation for measurements based on the Ω -scan method [1]. A sample is placed on a turntable spinning at about 3 secs per revolution. X-ray source and detector as well as the laser system have fixed geometry. During rotations certain crystal netplanes fulfill the reflection condition and a pair of intensity signals can be detected. For orientation analysis at least two netplane reflection pairs are required. For cubic silicon crystals the usual method was extended to include arbitrary orientations. The typical orientation measurement accuracy is in the range of 10-30 arc secs.



[1] H. Berger: "X-ray Orientation Determination of Single Crystals by Means of the Ω -Scan Method", J. Phys. IV France 118, 37-42 (2004).

Basic machine design

The X-ray unit consists of a high-voltage generator, X-ray tube and two detectors. Height adjustment of the X-ray system is performed automatically.

A laser system is employed for surface normal determination.

An optical camera is used for taking reference images of the sample.

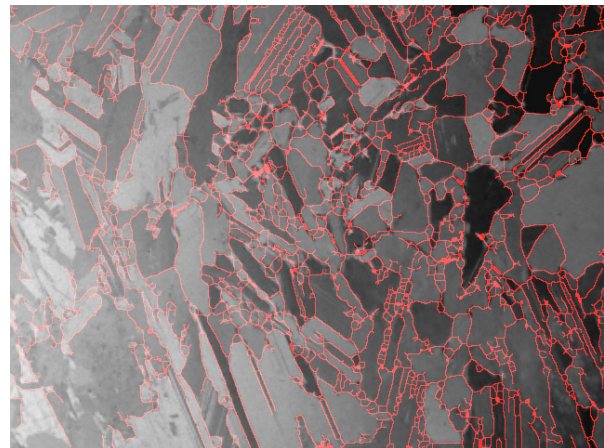
The sample positioning is achieved with a special turntable with integrated polar coordinates translation stage. While the positioning accuracy is 0.1 mm the X-ray spot size on the sample can be set to 0.5-1.0 mm. Thus, the best overall spatial mapping resolution is about 0.5 mm.



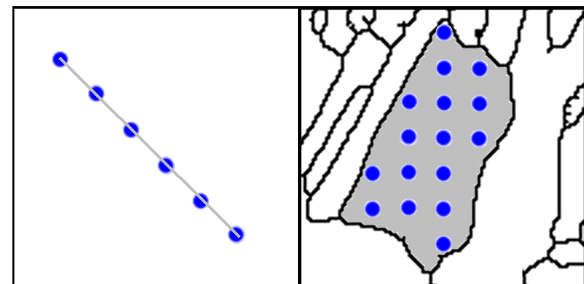
Measurements and results

In addition to the orientation measurement system, an optical camera is provided for automatic detection of grain boundaries.

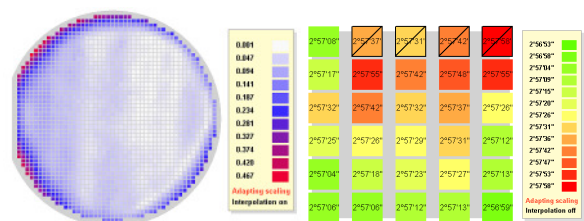
Images are processed and various parameters such as e.g. the grain centroid position are determined. The optical images may serve as reference system for 2D-surface points.

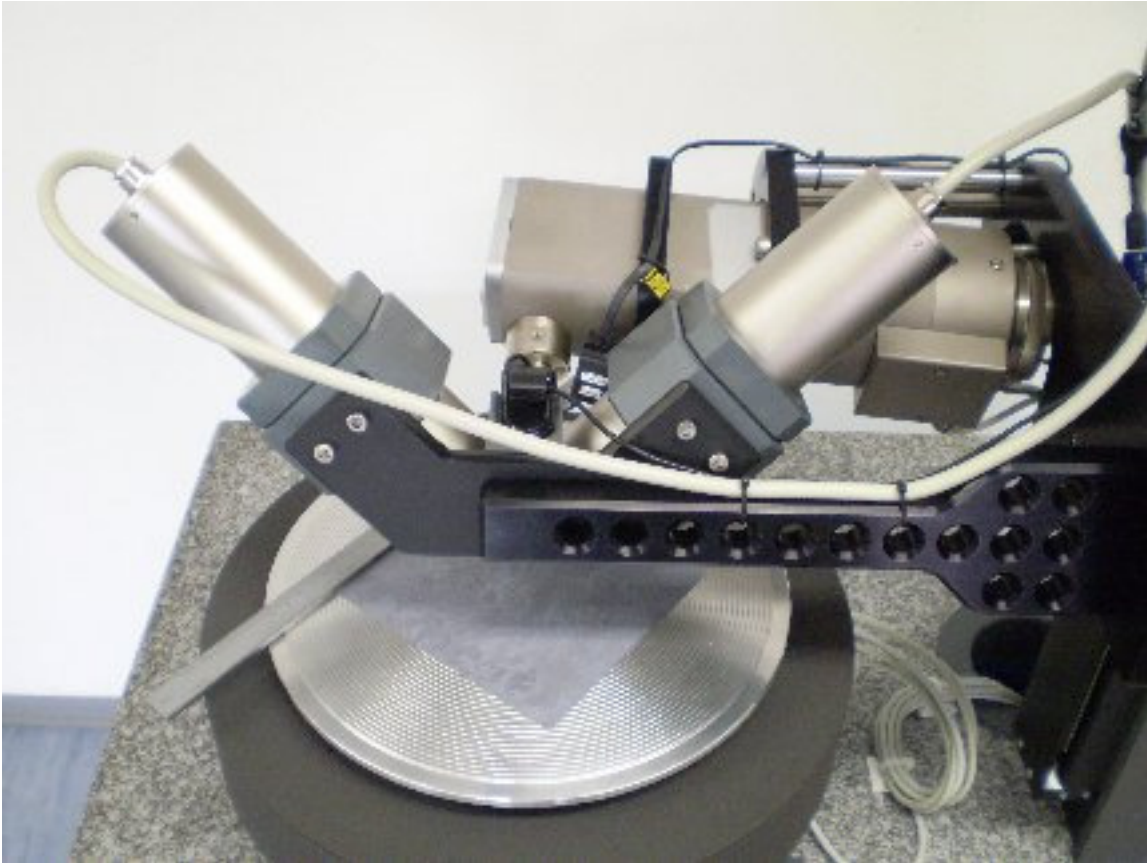


Several options for the selection of mapping points are available, e.g. points along a line, points in rectangular regions and of course all points within user-selected grains.



Measurement results can be displayed in the form of coloured maps, maps with text and are also available for export in standard spreadsheet tabular format.





Side view at the measurement system showing the fixed 2-detector geometry.

Features

The complete system consists of the following components:

- Stable granite ground plate
- Mechanical system including 300 mm polar coordinates positioning turntable
- X-ray orientation measurement system with generator
- Laser surface normal measurement system
- Optical camera system for grain structure and referencing
- Electronic control unit
- Modern control PC with graphical user interface for control software
- Radiation full-protection plexiglass housing

Technical data

Weight:	about 185 kg
Dimensions:	2.00 m x 1.07 m x 0.83 m
X-ray system:	High-voltage generator max 30kV/30mA X-Ray tube max 3kW, CU-anode 2 Szintillation detectors
Power supply:	230 V, 16 A, 50 Hz single phase
Cooling water conditions:	4 l/min, 0.3 MPa pressure difference, maximum pressure 0.8 MPa, about 20 °C, clean water without any additives
Radiation Safety:	Full protection plexiglass housing



Front view of the complete system (without full-protection housing).

EFG INTERNATIONAL

<http://www.efg-berlin.de>

- More than 40 years X-ray experience –
 - World-wide service and technical support –
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