Karlsruhe Institute of Technology

Institute of Microstructure Technology

Improving correlative characterization: Structure Development for Micro and Nano sized Material based on Measurement Results

Increasing Information Quality and Precision of Micro-/Nanostructures enable Predictions to create new Materials and Structures using GUI based Correlative Characterization

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Introduction:

The project deals with metrological characterisation of micro- and nano structures with different and not collocated technologies.

Correlation of different characterisation methods may gain more information and improved precision of manufactured structures and materials.

To get most meaningful correlation results the single measurements must be improved first. That means the uncertainties of each single measurement should be kept as minimal as possible.

Workflow

Scientific question → Searching for a ROI → Characterizing ROI → Interpreting Correlation

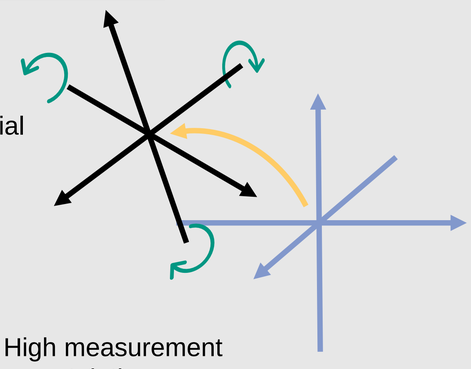
Repetition of ROI characterization with different Method

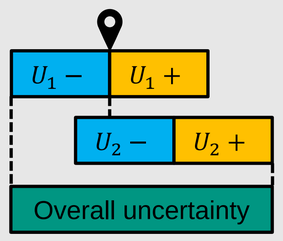
Challenge 1:
Finding ROI again
See previous poster

Two challenges

Challenge 2: Deviations

Samples interchanging between different measurement devices causes changes in spatial orientation what may cause measurement uncertainties.

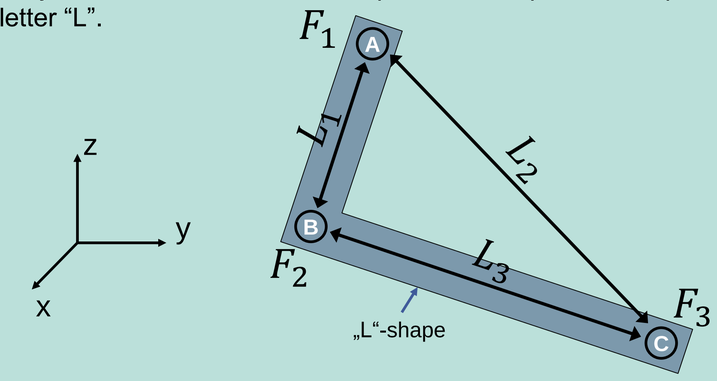




High measurement uncertainties can cause even higher uncertainties while correlating measurement results later.

Automated Fiducial position sorting

Using the tool is easier with automated Fiducial position sorting. Only demand: Fiducials must be placed in shape of the capital letter “L”.



Vectors between the Fiducials will appear in a shape of a triangle. Two of the three triangle legs (L_1 and L_3) are used for calculation the ROI position and for calculating the alignment angles.
To figure out the Fiducial’s order the distances between them must be calculated.

$L_1 = \overline{F_1F_2} = -(\overline{F_2F_1})$
$L_2 = \overline{F_1F_3} = -(\overline{F_3F_1})$
$L_3 = \overline{F_2F_3} = -(\overline{F_3F_2})$

Six possible vectors between the Fiducials.
Three of them are the same as the other ones with opposite sings.

Using vectors for calculating the distances results in six possible distance combinations.
Sorting by length in three steps through the code.

No.	Combinations
1	$L_1 > L_2 > L_3$
2	$L_1 > L_3 > L_2$
3	$L_2 > L_1 > L_3$
4	$L_2 > L_3 > L_1$
5	$L_3 > L_1 > L_2$
6	$L_3 > L_2 > L_1$

Step 1	Step 2	Step 3	No.
$L_1 > L_2$	$L_1 > L_3$	$L_2 > L_3$	→ 1
		$L_3 > L_2$	→ 2
	$L_3 > L_1$		→ 5
$L_2 > L_1$	$L_2 > L_3$	$L_1 > L_3$	→ 3
		$L_3 > L_1$	→ 4
	$L_3 > L_2$		→ 6

Using length sorted vectors, the Fiducial order is determined.

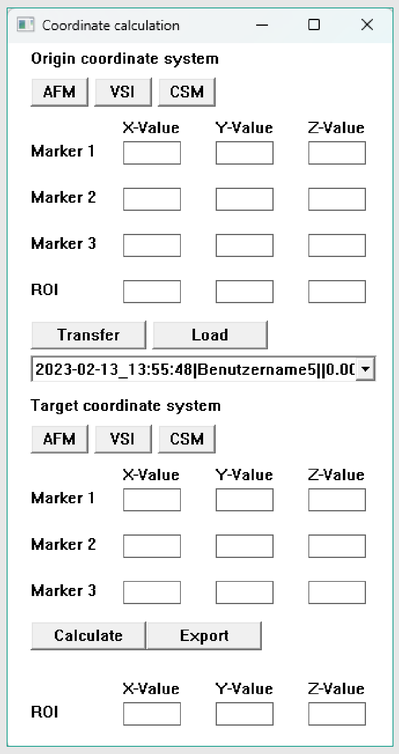
Combination	Corner point	Endpoint long leg	Endpoint short leg
$L_1 > L_2 > L_3$	C	A	B
$L_1 > L_3 > L_2$	C	B	A
$L_2 > L_1 > L_3$	B	A	C
$L_2 > L_3 > L_1$	B	C	A
$L_3 > L_1 > L_2$	A	B	C
$L_3 > L_2 > L_1$	A	C	B

A helping tool: A small application

The ROI-Calculation program was expanded to make measurement improvement easier. Sample alignment is recommended if necessary.

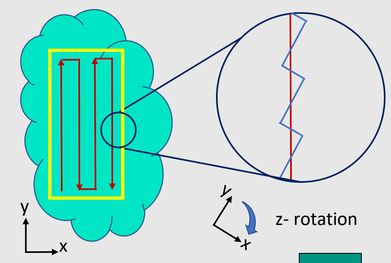
Overall features included:

- ROI Position Calculation
- Sample Alignment
- Cache function
- Export function
- Automated sorting function of typed in Fiducial coordinates

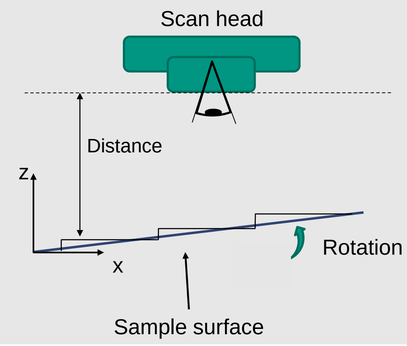


Gradation: Rotation around z-axle

Can be effective in scanning probe microscopy methods in which the probe tip is moved relative to the sample surface on a path parallel to the coordinate axes of the measuring device.
If x- and y-axle in the second measurement device are rotated around z-axle the previous measurement path can only be approximated.



Gradation: Rotation around x-/y- axle

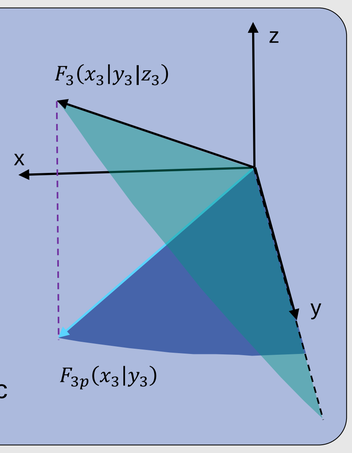


Can be effective at optical measurement techniques. Rotations around x- or y-axle cause sharp and blurred areas in the measuring field. Unequal distances requires refocusing the surface or can lead to areas that are no longer addressable.

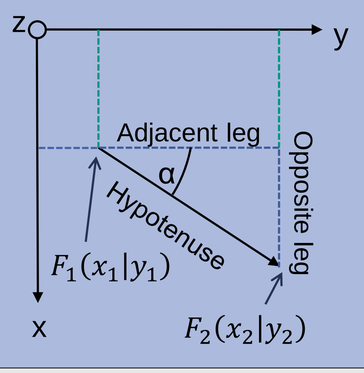
Alignment:

Three steps for aligning the samples orientation:

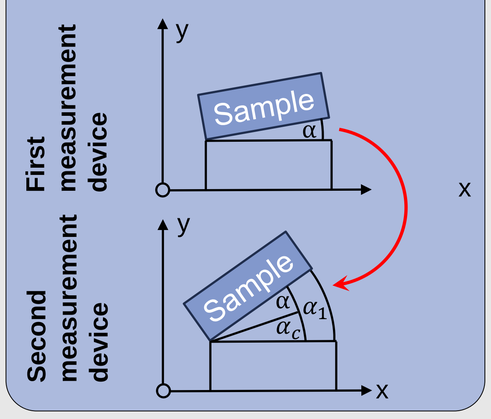
Step 1:
For manually alignment, rotation angles must be calculated around each coordinate axle. Each angle must be calculated separately in its turning plane. Therefor a vector projection in specific plane is necessary.



Step 2:
Calculating the angle in corresponding plane is done with arc sin or arc cos function.
Required edge length are calculated from vector components.



Step 3:
Correction angle α_c must be a difference of specific orientation angle in first and second measurement device.



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