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1 Working space of the optical measurement system.

## CHARACTERIZATION OF STRUCTURED WIRES

### Competencies

- 3-dimensional measuring of structured wires for the multiwire sawing process
- Integrated load cell for measurement of wire tension
- Evaluation of the measured geometry data with accuracy in micrometer range
  - wire diameter
  - geometry of structure
- Calculation of the periodic structure parameters
  - bending amplitude
  - bending period
- Finite element simulation of structured wires
  - including plastic deformation during manufacturing process
  - prediction of structure parameters regarding different tensile loads

### Approach

The multiwire sawing process represents the primary technique to separate silicon blocks (Ingots) into thin wafers for photovoltaic applications. Compared to straight sawing wires the geometry of the structured wire causes a significant effect on the wafering process. In order to optimize the cutting performance it is crucial to characterize their specific geometry. For this purpose, Fraunhofer Center for Silicon Photovoltaics CSP provides measuring equipment, which enables the investigation of wire samples. Furthermore, individual simulations allow an accurate assessment of the wire structure as a result of various tensile loads.

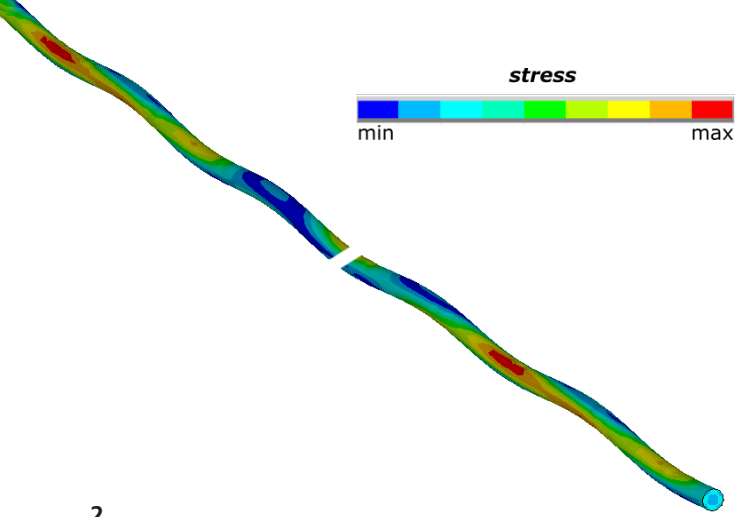
#### Fraunhofer Center for Silicon Photovoltaics CSP

Otto-Eissfeldt-Strasse 12  
06120 Halle (Saale) | Germany

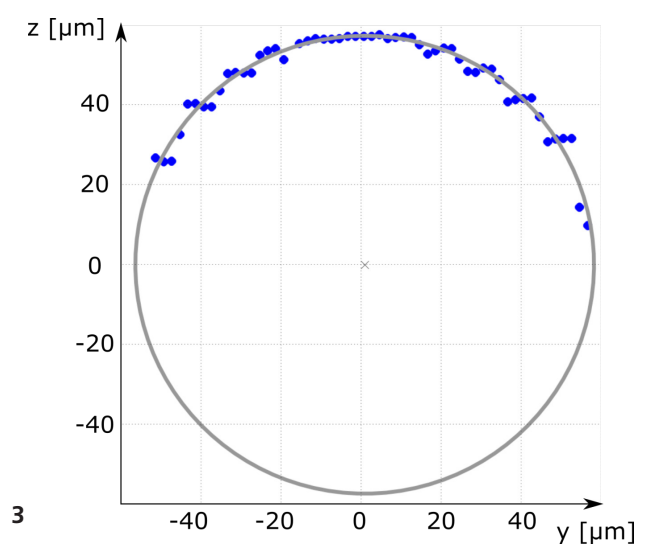
#### Contact

Felix Kaule  
Telephone +49 345 5589 5312  
felix.kaule@csp.fraunhofer.de

[www.csp.fraunhofer.de](http://www.csp.fraunhofer.de)



2



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### Measurements

The wire surface geometry is optically detected with a sensitivity of  $1\ \mu\text{m}$  and a lateral resolution of  $1\ \mu\text{m}$ . The surface scan takes the information of significant manufacture parameter in it. At the Fraunhofer Center for Silicon Photovoltaics CSP a mathematical analyses was established to detect wire parameters that are important for the wafering performance.

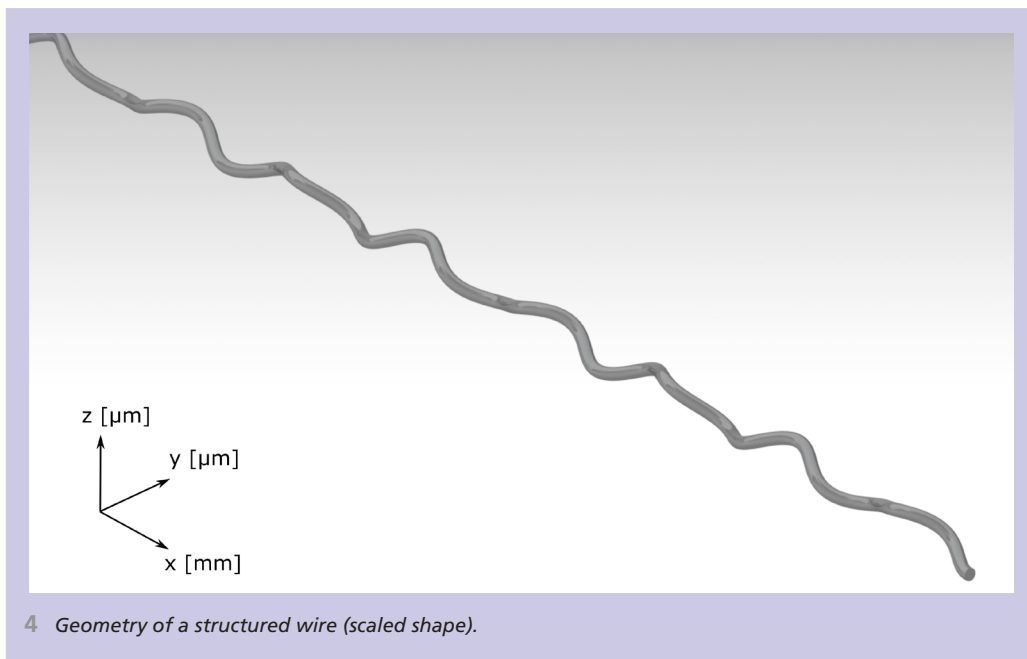
Significant wire parameters are:

- Wire core diameter
- Amplitude and wave length of all wire oscillations
- Torsion of the wire
- Angle between oscillation planes
- Position probability of the wire center point

### Simulations

Regarding the material parameters a Finite Element model is prepared to predict the non-linear mechanical behavior of the wire and the change of its structure. This analysis provides a systematically investigation of different wire structures and diameters that are used to improve the structure design and structure intensity.

In addition, it is possible to consider the manufacturing process including hardening of structured wires so that the simulation model contains realistic material properties.



4 Geometry of a structured wire (scaled shape).

2 Stress distribution caused by tensile load in the Finite Element model of a structured wire.

3 Plot of a scanned wire surface in one cross sectional plane.