Metallurgy

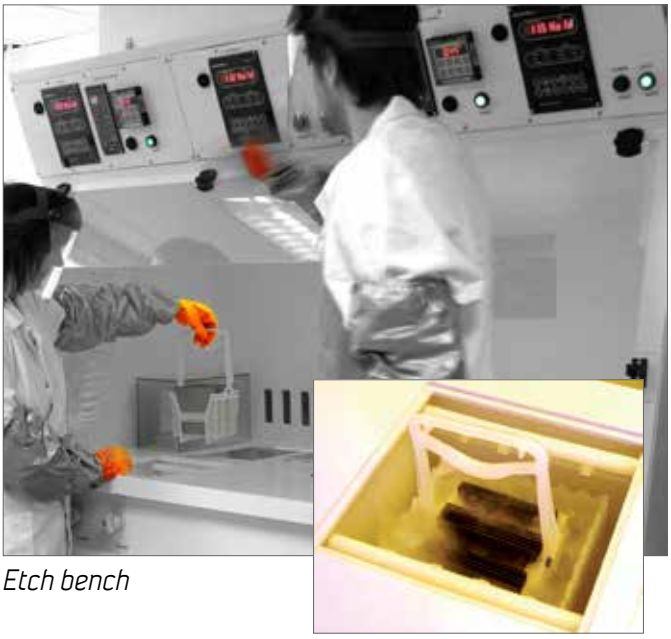
September 2012

Characterisation of silicon for solar cells

SINTEF, in collaboration with NTNU, operates extensive characterisation laboratories dedicated to material characterisation in general and solar cell silicon in particular. In our extensive laboratories we are able to follow one defect or type of defects from macroscopical scale down to atomic scale. SINTEF/NTNU environment possesses an impressive expertise in several completive fields, which gives us a strong scientific base for our research on silicon for solar cells.

Sample preparation

We have in-house laboratories dedicated for sample preparation, such as cutting, grinding, mechanical- and chemical polishing of wafers and other samples. Our state of the art etching facilities includes two etch benches dedicated for silicon etching with automatic filling and careful temperature control for chemical polishing, defect etching and texturisation as well as dissolution of silicon matrix to study inclusions.



Etch bench

PVScan

Structural properties of mc-Si

Microstructure characterisation is crucial for solar cell research and our laboratories include an extensive electron microscopy laboratory with both SEMs and TEMs and other specialised instruments, for studying microstructures in mc-Si ingots, blocks, wafers and other samples. The use of large scale mapping techniques (such as PVScan for mapping of dislocation densities, high resolution EBSD for grain orientations maps of areas up till 5x5 cm^2 and IR camera) combined with several high resolution techniques and accurate sample preparation (including FIB) makes it possible to map microstructures of interest throughout a whole ingot as well as study selected features in detail.

Structural properties of mono-Si

Characterisation of defects in monocrystalline silicon (mono-Si) requires a different set of dedicated techniques as compared to multicrystalline silicon. To detect voids, interstitials and oxygen precipitates, the following techniques are available in our laboratories:

- Flow pattern defects (FPD)
- FCu decoration
- FOxygen induced stacking fault (OiSF)

Chemical analyses

In our laboratories we can measure dopants and metallic impurity elements in silicon matrix of solid- or dissolved samples on a 0.1 ppbw level (GDMS and high resolution ICP-MS, respectively) . Oxygen and Carbon concentrations are measured by FTIR and LECO.

Impurities may form inclusions and precipitates, and these are detected and measured with respect to the types, forms and density of inclusions, by:

- Near IR screening of Si blocks
- PVScan on polished wafers
- SEM with Energy Dispersive Spectroscopy (EDS) detector

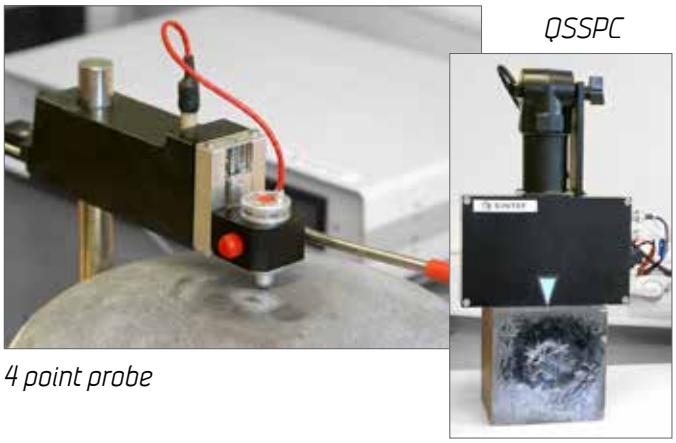
GDMS

Electrical properties

Electrical properties, such as resisitivity (4pp) and minority carrier lifetime (QSSPC and CDI), are measured on a macroscopical scale where whole wafers or other large samples are mapped with respect to the property of interest.

On a microscopical scale (probe electrical structure), electrical properties can be measured by:

- Electron Beam-Induced Current (EBIC)
- Photoluminescence Spectroscopy (PLS)
- X-ray photoelectron spectroscopy (XPS)
- Auger spectroscopy (AES)



QSSPC

4 point probe

Characterisation equipment relevant for mechanical properties of wafers

At our laboratories, standard techniques, such as 4 point bending test, have been adapted for silicon wafers. Bending tests of wafers have also been developed for use with nearIR ellipsometry for in situ inspection. Further, a high speed (visual light) camera, that is able to take up to 500 000 frames/second can be used e.g. for inspection of fracture initiation point and fracture propagation in 4-point bending test. Acoustic emission is also used for sensing of micocracking during e.g. handling operations on wafers.

Surface metrology

The features of a wafer surface are important characteristics for a solar cell producer. An infinite focus microscope makes us able to create 3D images of surfaces, allowing for detailed measurement of roughness, TTV etc. The lateral resolution is 400 nm and the depth resolution is 10 nm.

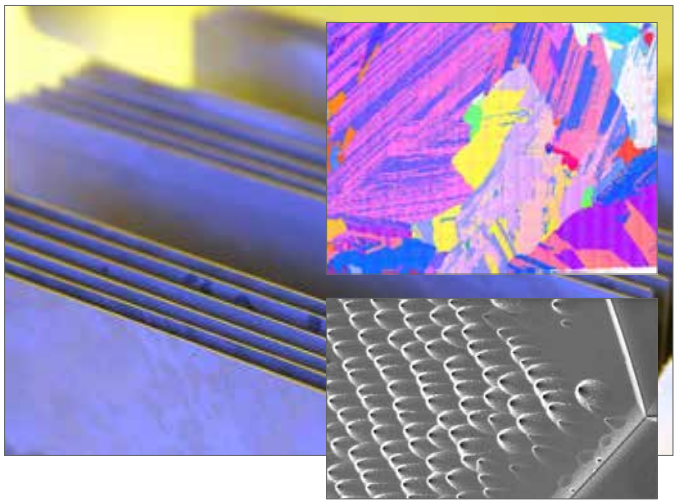


Photo: Melinda Gaal, M. Karlsen, B. Ryningen

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