# New methods for micro-mechanical testing of minerals

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## Motivation

Olivine is the dominant material in the oceanic lithosphere and its mechanical properties influence deformation and strain localization in the lithosphere. One of the current scientific debates is on strain localization and initiation of subduction. Numerical models using classical fluid dynamics fail to predict subduction as we observe on Earth. Many experiments use olivine aggregates so that the mean effect is the cumulative contributions of intrinsic crystal strength and interactions between crystals at grain boundaries. It is believed that grain boundary sliding causes self-weakening and aids strain localization in the lithosphere, but it has never been directly observed in field or experimental studies due to technical limitations. Moreover, there is no direct and quantitative evidence to support the assumption that grain boundaries are weaker than grain interiors. **Therefore, this project aims to adapt Materials science techniques in order to fundamentally test the micro-mechanical properties of olivine grain boundaries.**

## Methodology

### Step 1 - Preparation

* polish the sample with colloidal silica suspension down to 0.05 nm

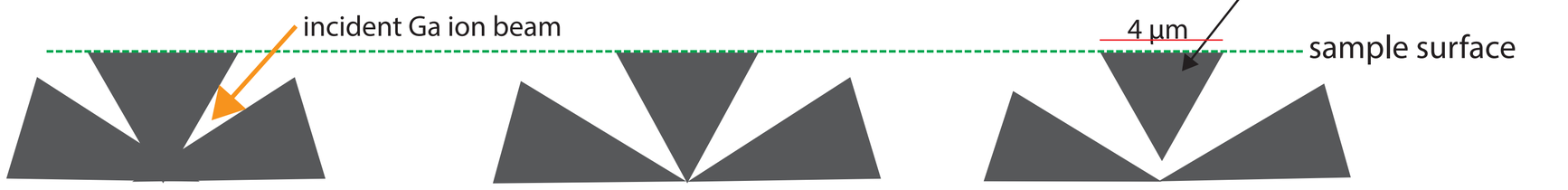
* make a grid of indentation marks

* generate an Electron Back Scatter Diffraction map (EBSD) of the sample

* carbon coat the sample

### Step 2 - FIB milling

* use the Focused Ion Beam (FIB) to fire Ga ions at the sample surface to cut a cantilever of 24x4 µm

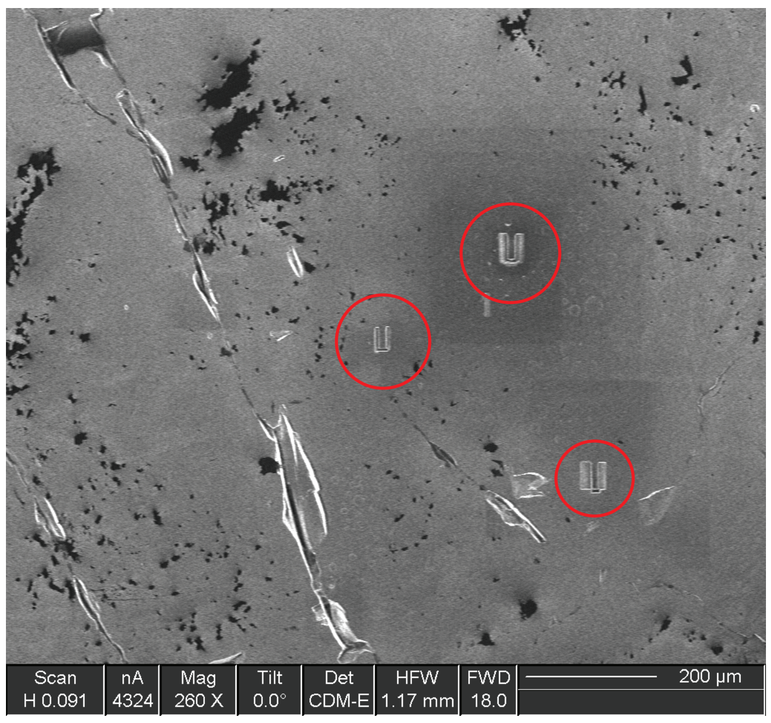



Tilt the sample at 31° and use current of 5 nA at 30kV for coarse cut. Apply carbon coat at the end.

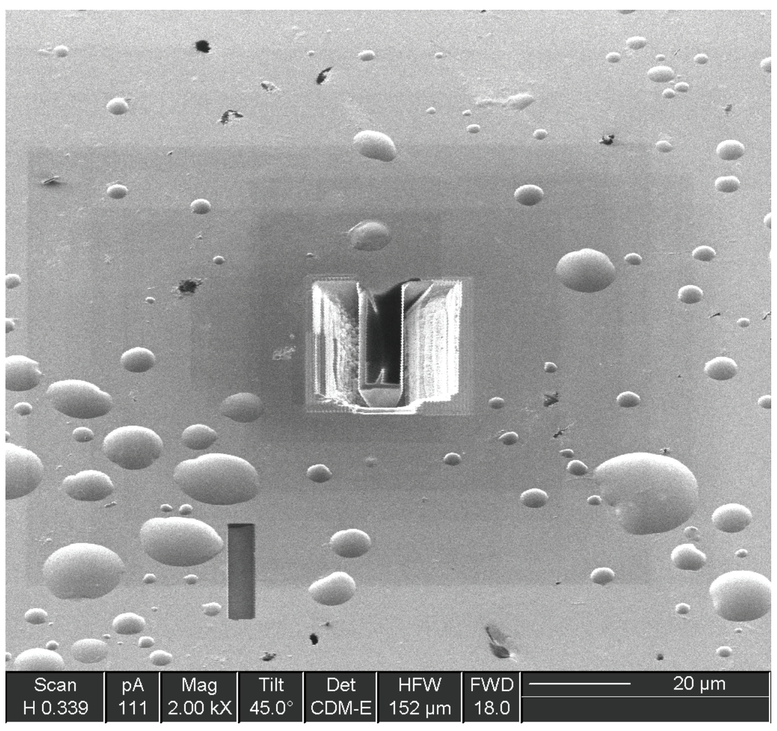
Tilt the sample at 31° and use current of 1 nA at 30kV for medium cut. Apply carbon coat at the end.

Tilt the sample at 31° and use current of 0.3 nA at 30kV for final polish.

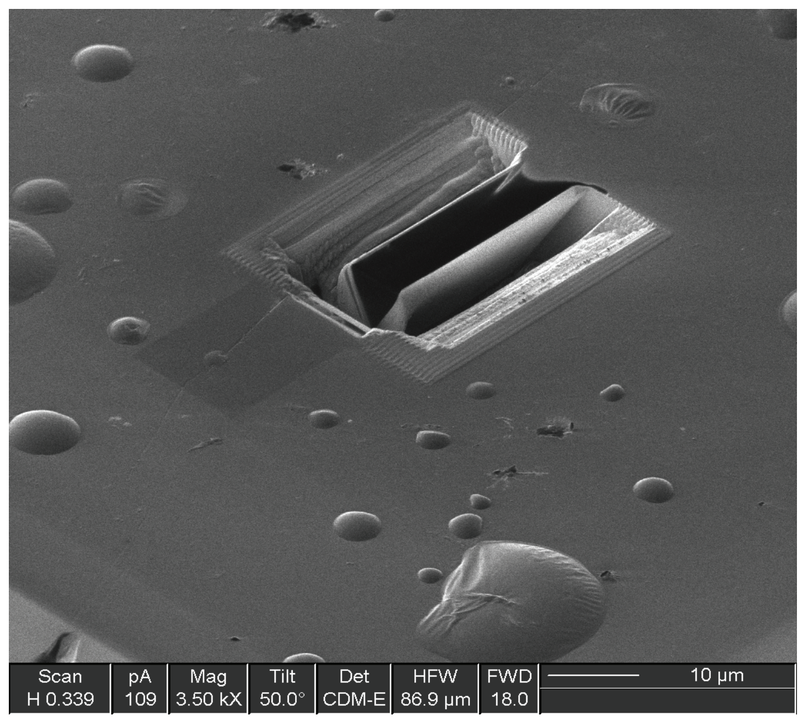
## Laboratory Results




Secondary electron image at 0° tilt of the sample surface and cut micro-cantilevers.




Secondary electron image at 45° tilt of the sample surface and one of the micro-cantilevers.




Secondary electron image at 50° tilt of the sample surface and micro-cantilever with redeposition of the Pt coat.

## Conclusions

* micro-cantilevers can successfully be cut in olivine minerals

* carbon or platinum coat is needed to reduce damage of the surface because of the interaction with secondary electrons

*FIB techniques can be adapted to Earth Materials for further type of mechanical experiments

## Further work

* testing the cantilevers with an indenter at room temperature and at elevated temperatures

* preparation of a slide through the cantilever for TEM investigation

*numerical modelling and simulation of experiments

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