Standard Project

Experimental Report template

Proposal title: Stress analysis with Laue microdiffraction: accuracy of a new data treatment method based on image		**Proposal number:** 20120602
Beamline: IF-GMT (BM32)	**Date(s) of experiment:** from: feb 20th, 2013, 16:00 to: feb 26th, 8:00	**Date of report:** Sept 2013
Shifts: 15 15	**Local contact(s):** Odile Robach	*Date of submission:* Feb. 2012

Objective & expected results (less than 10 lines):

The long term aim of our research is to understand the way polycrystalline materials deform with emphasis on the link between microstructure (dislocation structure, crystallographic texture), activated deformation mechanisms at the grain scale (dislocation glide, twinning, …), and overall behavior. The Laue microdiffraction setup at beamline BM32 allows 2D mapping of local intragranular stresses in polycrystalline specimens. The technique makes use of a highly focused white X-ray beam and allows reaching (sub)micron spatial resolution. The setup has greatly benefit from a significant upgrade (new KB optics, new motorized detector holder, ...) that is operational since may 2012.
This experiment aimed at generating a complete and adapted data set for determining the accuracy of a new method for the mechanical interpretation of Laue images, based on a Digital Image Correlation technique (hence Laue-DIC method), and extending it plastically deformed materials.

Results and the conclusions of the study (main part):

For this experiment, several specimens were deformed in-situ under four-point bending. The long and narrow specimen surface was scan transversally in order to evidence strain gradients, from compressive strain on the inner part to tensile strain on the outer part. We used a beam size of ~500×340 nm^2 (H×V), and the Photonic Science (VHR) detector was positioned at different distances from the specimen (ranging from ~50mm to ~150mm) to check the accuracy that can be reached for those different setup.
We could scan various specimens for typically four different loading steps each :

- Si single crystals with 3 different crystal orientations to investigate the effect of the elastic anisotropy on the measured strain
- One Ge single crystal, which presents, compared to Si, much finer Laue spots
- One Cu single crystal which contains a much larger density of lattice defects that Si and Ge
- A Fe multicrystal (large grains)
- And a Fe single crystal.

Fe and Cu specimens were loading into the plastic regime in order to investigate the accuracy of Laue-DIC when Laue spot shape changes.
Single crystal data are now being compared to the reference solution provided by a Finite Element calculation of the strain prescribed in-situ.
High-Resolution EBSD has also been carried out on some specimens (ex. Fe single crystal) in order to evaluate the respective merit of HR-EBSD compared to laue-DIC.
This experiment ran as expected. It provides a complete data basis necessary to assess precisely the accuracy of the new Laue-DIC method, for different specimen qualities (from “perfect” Si or Ge crystals to industrial materials). This work is the central part of the PhD of Fengguo Zhang working within the MICROSTRESS project funded by ANR. The new Laue-DIC method will then be implemented in the free software LaueTools developed at ESRF, to make it available to the community.

Justification and comments about the use of beam time (5 lines max.):

We have needed the first day for the alignment and calibration of the setup, and installation of the in-situ tensile rig. Data have been acquired continuously after that. Some beamtime was lost due to an issue with the synchronization of the used detector, but otherwise the experiment ran nicely.

Publication(s):

We are still working on the data obtained during this experiment. They are central for the PhD of Fengguo Zhang. Publication will be submitted when final conclusions can be reached.