<table>
<tr><td>ESRF</td><td>Experiment title:
MOBILITY OF DISLOCATIONS IN SILICON</td><td>Experiment number:
HS 1769</td></tr>
<tr><td>Beamline:
ID 19</td><td>Date of experiment:
from: 28 march 2002 to: 2 April 2002</td><td rowspan="2">Date of report:
24/02/03 (new report)
Received at ESRF:</td></tr>
<tr><td>Shifts:
12</td><td>Local contact(s):
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Report:

Single crystalline silicon has been for a long time a model material to understand the behaviour of individual dislocations, and compare experimental results to theoretical models. Modeling dislocation cores at the atomic scale advanced a lot in the last few years, and apparently becomes realistic. Two consequences of these models might be testable at micrometer scale. The aim of the present set of experiments is to give an experimental test to these predictions:

- **Effect of the dissociation width on dislocation velocity**: The energy necessary to create a double kink on a straight segment of a Shockley partial is expected to depend on the distance of the second partial. This can be detected only when large forces of opposite signs are exerted on the two partials (i.e. under large stresses in systems with a low Schmid factor). Under well-chosen conditions, the dislocation velocity might then have an **oscillatory dependence** on the applied load.

This is a two steps experiment: we first needed to create a controlled population of dislocations, under a high Schmid factor (to avoid creation of dislocation loops of another slip system). Two specimens were prestrained under in situ observation, and we got a suitable dislocation density for further use. These specimens will be cut under a second orientation fulfilling the requirements for the "real" experiments. Velocity measurements will be performed during the next experiment.

- **Reversibility of dislocation motion under stress reversal**: The emission/absorption of point defects by the core of moving dislocations results into jog creation. This should have consequences on the mobility of other dislocations moving on the same atomic plane, or of the same dislocation moving backwards under a reversed stress. The accumulation of such jogs also should make dislocation motion irreversible, promote cross slip, and make disappearance of backwards moving loops impossible.

A setup suitable for testing specimen alternatively in tension and compression was tested successfully during experiment HS 1478. During the present experiment, we first focussed on experimental procedure to find a reliable way to create a suitable dislocation population (isolated loops or half loops) and obtaining images of sufficent quality for further mobility measurements. In our specific conditions (specimens thick enough -2 mm- to limit bending during the compression steps) we had to use a short wavelength (0.035 nm), and to rock the specimen during exposure to image the whole jauge length. The contrast however remained very sensitive to the applied load and to the temperature.

Mobility measurements were thus done during experiment **HS 1769** by 10 mn steps in experimental conditions (600 to 650°C, 15 Mpa resolved shear stress on the slip system with the highest Schmid factor), and the images were recorded at 400°C under a residual stress. The measured velocities of dislocation segments during the first tension half cycle are coherent with these obtained by classical methods (our temperatures were however underestimated by ~10°C). However, after stress reversal, **the velocities of some (not all) 60° dislocation segments were increased by a factor from two to four (arrow in Fig b)**, while the velocity of the other segments remained, within experimental error, that of the first half cycle. This last point excludes the presence of spurious effects as specimen bending, which would have affected whole loops. A possible explanations of this velocity increase might be an additional schrinking of loops to reduce their line energy, and backwards movement of kinks stored at the edges of segments.

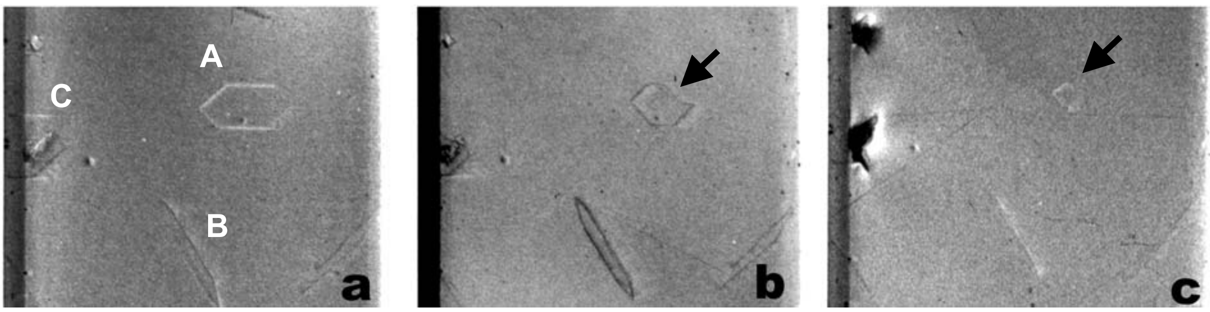

Figure: Loops A, B, C expanded under a + 15 Mpa resolved shear stress (a). several segments of loop A glided back for 30 min at 650°C under residual compressive stress (b). Loops A and B schrank for 10 min at – 15 Mpa, 650°, while dislocation sources formed in C. (c).