ESRF	**Experiment title:** **Dislocation multiplication and dynamics in silicon**	**Experiment number**: HS 1478
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Shifts: 9	**Local contact(s)**: P. PERNOT	*Received at ESRF:*

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Report:

Single crystalline silicon is a model material to understand the plastic behaviour of crystals in terms of dislocation processes. The plastic strain rate is proportional to the averaged dislocation velocity and to the mobile dislocation density. We are concerned here by both phenomena: the velocity of dislocations as a function of stress and temperature and the multiplication mechanisms which generate fresh dislocations during the course of the deformation.

The principal aim of the present experiment was to investigate the feasability of stress reversal experiments on isolated dislocations. When the sign of the applied stress is changed, e.g. by switching from tension to compression, a given dislocation must move backwards. In case of perfectly planar slip, that is if each dislocation loop was contained in one and the same slip plane over its whole length, stress reversal should lead to the disappearance of all dislocations, by shrinkage of the previously expanding loops, before new ones are created with the opposite Burgers vector. A "real" dislocation line is however expected to contain jogs created on dislocation lines by absorption or emission of intrinsic point defects (self intertitials or vacancies) or by cutting with other dislocations.
Such jogs are expected to have detectable effects on moving dislocation segments, and impede the shrinkage of backward moving dislocation loops. More, they can introduce constriction points on dislocation segments,

which are expected nucleation sites for single or double cross slip reactions, and thus for dislocation sources formation.

The experiments were done with the straining device designed and built up by us to be inserted in the ID19 beam line, with new grips allowing tension and compression on the same specimen. Tension/compression samples with a new shape were prepared.

We used a monochromatized beam, and the images were recorded both using the FRELON camera and X-Ray films. Scanning the Bragg angle was necessary to image the whole gauge length because of unavoidable distorsions induced by the applied load. This was at the expense of the time of exposure.(about one minut).

The specimens were submitted to strain cycles under creep conditions alternatively in tension and compression between 900 and 1000 K, under stresses in the 10 to 20 Mpa range. Each half cycle lasted between 10 mn (1000 K) to about 60 mn (900 K).

The recorded images are still currently under careful analysis, but two conclusions can be drawn:

- The changes introduced in the specimen and jigs to allow stress reversal were successful. The operating mode (Bragg angle scanning, use of both films and camera) is convenient. The orientation of the specimen will however be altered, to allow a better in plane view of the moving dislocations.

- The first experiments show evidence of creation of new dislocation sources, and of formation of new slip bands during the successive tension – compression cycles, especially at higher temperatures.

The possibility of the present tests being demonstrated, they will be carried on during experiment HS 1769.

<u>Recent publications on silicon plasticity (Experiments done at the ID 19 beamline of the ESRF):</u>

Dislocation multiplication in silicon at the onset of plasticity
F. VALLINO, A. JACQUES et A. GEORGE
J. Phys: Condens. Matter. <u>12</u>, 10045-58 (2000)

Dislocation multiplication during the very first stages of plastic deformation observed by X-Ray Topography
J.P. CHATEAU, F. VALLINO, A. JACQUES et A. GEORGE
Mater. Sci. Eng. <u>A319-321</u>,152-155 (2002)