ESRF	**Experiment title: X-Ray topographic investigation of the distribution of stress in a diamond anvil under high pressure operation. Correlation with the intrinsic defects of the stone**	**Experiment number**: HS-1036
Beamline: ID19	**Date of experiment**: from:12/13/2000 to: 12/15/2000	**Date of report**: 02/01/2001
Shifts: 6	**Local contact(s)**:J. Haertwig	*Received at ESRF:*

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Report:

Synchrotron radiation white beam X-Ray topography has been used to characterize the crystallographic defects of (1) commercial diamond anvils dedicated to high pressure cells; (2) diamond anvils fractured under high pressure (10 to 50 GPa); (3) pure argon single crystal loaded in a diamond-anvil cell at P=1.6 GPa. The aim of experiments (1) and (2) was to establish a statistical correlation between intrinsic defects of the stones and the maximum pressure reached in the diamond anvil cell when using these anvils, as well as the failure mode of the anvils due to diffusion of helium and hydrogen. The aim of experiment (3) was the determination of the generation of defects in a Van der Waals solid deformed under high pressure.

Experiments (1) and (2):

Topographies of 22 ULF and ULB (Ultra Low Fluorescence and Ultra Low Birefringence) diamond anvils provided by the Drucker company were recorded. In all anvils, the flat tips (that are in contact with the sample in a high pressure experiment) were parallel to a (100) plane. Defects that could influence the mechanical properties, especially fracture toughness of the stones have been identified:

- dislocation arrays emerging from an inclusion (figure 1) in 3 stones
- dislocation and/or stacking faults emerging from the tip of the diamond (figure 1). These defects could facilitate impurity diffusion from the sample and weaken the diamond.

The correlation between these defects and the high pressure behaviour of the diamond anvils will be established in the future.

Most of the 10 broken anvils (all with tips following a (100) plane) exhibit the same crack characteristics. These anvils have been broken when pressurized in contact with either He or H_2 samples. A penny-shaped crack, parallel to a (110) plane of the crystal ((110) is an easy cleavage plane, [1]), lies between 100 and 2000 μm beneath the tip surface (figure 2). The field of displacements observed on topographs is compatible with a mode I crack opening (uniform normal traction) [2]. The direction of crack and crack opening mode are compatible with models of the stresses in the diamond anvils cell: vertical compressive stresses (i.e. perpendicular to the tip) are expected to be higher than radial compressive stresses [3]. But the position of the cracks does not always correspond to the region were the deviatoric stresses are the highest (100 to 300 μm beneath the tip surface). This could be explained by a pre-existing defect. A more quantitative interpretation of the topographs (stress intensity factor determination) could be performed by synthetic topograph generation. This would clarify the failure mechanisms of diamonds under high pressure.

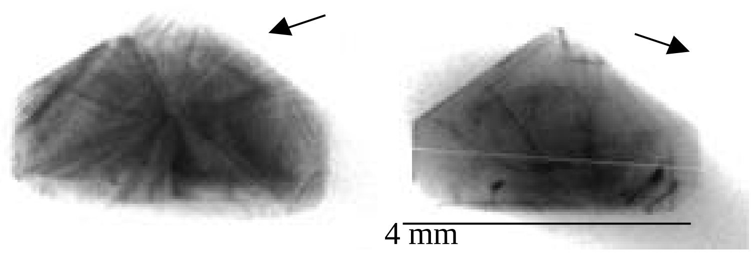

Figure 1: topographs of 2 diamond anvils; arrows indicate the projection of the diffraction vectors (111 for the left image, 110 for the right image). On the left image one can see a dislocation array, probably centered on an inclusion; on the right image, a dislocation is present near the diamond tip and a dislocation array is centered on the diamond table.

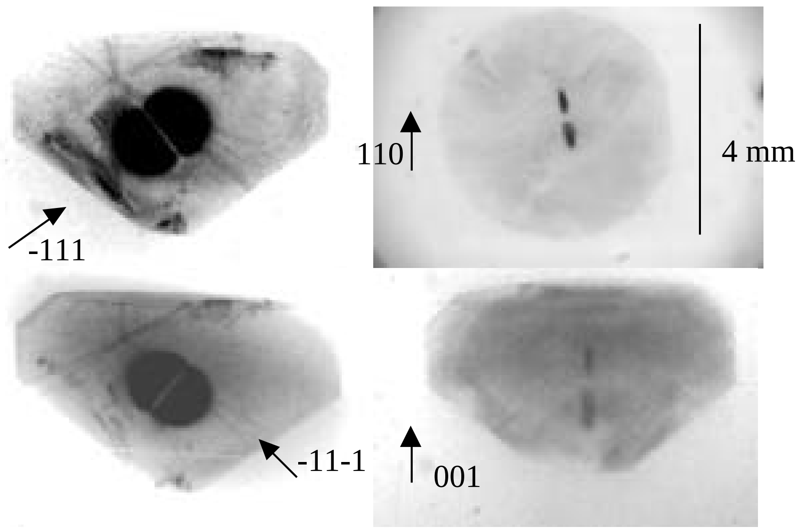

Figure 2: 3 topographs of the same broken diamond. The crack plane is parallel to the plane of the left images and parallel to the 110 and 001 diffraction vectors on the right image.

Experiment (3):

The argon single crystal exhibited a too strong mosaicity at 1.6 GPa to study its crystallographic defects.

References:

[1] R.H. Telling et al., Phys. Rev. Lett., **84**, 5160 (2000).
[2] V. I. Fabrikant, Adv. Appl. Mech., **27**, 153 (1990).
[3] S. Merkel et al., proceedings AIRAPT (1999).