X-ray topographic investigation of diamond anvils for high pressure generation - Correlation between defects and early failure

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The diamond anvil cell technique revolutionized high pressure physics some 25 years ago. This device takes advantage of the unusual mechanical properties of the diamond. A metallic gasket with a hole in it to confine the sample is compressed between two diamond anvils. This device allows the generation of pressures that reach 300 GPa (3 millions times atmospheric pressure), pressure at which the diamond exhibits large elastic strain [1].
The pressure reached in diamond anvil cells is very often limited by the failure of a diamond anvil. In order to prevent this phenomenon, anvils are selected on the basis of their chemical purity, and their internal strains. However, the chemical purity does not guarantee the resistance of diamond anvils under high pressure operation. In particular, when the diamonds are used in contact with H_2 or Helium samples, species which diffuse in diamond. Unfortunately, helium is known to be the best pressure transmitting medium, and is often loaded for that use in diamonds anvil cells [2]. A better understanding of early breakdown of diamond anvils and an *a priori* diagnostic of their resistance would thus constitute a major improvement for high pressure techniques.
X-ray topography helps to establish this anvils quality diagnostic, because this method evidences intrinsic crystallographic defects of the anvils. These defects are likely to influence the mechanical properties of the anvil [3]. However, the liability of x-ray topography diagnostic had to be proven.
For this purpose, numerous diamond anvils used by our laboratory have been characterized by x-ray topography before/after high pressure operation. We have correlated their resistance to high pressures with the observed defects. It appears that pre-existing defects do influence this resistance, probably because they enhance the diffusion of Helium in the stone. Other factors, such as polishing, may also influence the behaviour of diamonds under high pressure.

The first part of this talk will be dedicated to a general presentation of the diamond-anvil cell technique, and the second part to the diagnostic of anvil quality by x-ray topography that we have established.

References

[1] - Hemley et al., Science, **276**, 1242 (1997); Loubeyre et al., Nature, **41**, 613, 2002

[2] - Loubeyre et al., Nature, **383**, 702, 1996

[3] - J.E. Field, The properties of natural and synthetic diamond, Academic Press, 1992