FOCUS ON

The High Pressure Laboratory

Diamonds and know-how available to scientists

Open to users for the last four years, the High Pressure Laboratory (HPL) provides, as its name suggests, the equipment and expertise necessary for conducting studies under extreme pressure conditions. The laboratory specialized in high pressure cells. In these cells, the studied sample is placed between two diamonds with a planar tip of 100 to 400 micron diameter. The experimental chamber positioned between these two points, is delimited by a gasket, in stainless steel or rhenium, depending on the pressure range to be explored, drilled by micro-Electrical Discharge Machining (EDM) with a diameter of 50 to 200 microns. The sample, which can also be subjected to a laser beam to raise the temperature and a ruby sphere (for pressure measurement) is then placed in the hole, together with a pressure transmitting medium. When the ruby fluorescence pressure measurement is no longer suitable for determining the pressure on the sample (values greater than 100 GPa), Raman spectroscopy of the diamond anvil can take over (equipment also provided by the HPL), or X-ray diffraction of a standard (gold, platinum or silver, for example) previously mixed with the sample, for which the volume as a function of pressure is known.

Support and training

Since its inception, many things have changed: the laboratory has moved to be closer to the beamlines that need it most, namely those carrying out X-ray diffraction or absorption, or infrared spectroscopy. The HPL now has among its regular users the ODE, CRISTAL, SMIS, GALAXIES, PSICHE and AILES beamlines. A total of 10 beamlines have already applied to HPL for their in-house research requests, as well as for their users. On average, two high pressure experiments are conducted per week at SOLEIL. Support requests vary depending on the scientists; the beamlines managers are now more autonomous. The quality of the laboratory has been recognized as it was chosen to host the 2014 training session given every two years by the CNRS high pressure network. However, although researchers have become more operational, the HPL remains at their disposal to prepare their experiments, notably the difficult step of loading the «pressure transmitting medium»: this involves introducing neon or helium into the cell at a pressure of 1300 bars. The HPL team can also offer good advice for the equipment's maintenance, and is always ready to detect early signs of a possible problem during the experiment.

Pressure, but also temperature

The HPL also proposes to link these high pressure studies to extreme temperature conditions. Two cryostats are available that can go down to 5K (-268°C) and heating jackets placed around the experimental cells can raise the temperature up to 500°C. For «large volume» samples (a few milliliters), the HPL also has a multi-anvil pressure cell, to reach pressures above 30 GPa and temperatures of 2000°C, i.e. corresponding to the extreme pressures of the Earth's mantle.

The High Pressure Laboratory is now seeking to push experimental boundaries even further through various instrumentation projects. A laser drilling system for the gaskets, to replace the EDM and decrease the size of the experimental cell to less than 50 microns, is currently being developed. This will also be used to cut ever smaller samples. The development of a more powerful vacuum heater for diamond-anvil cells is also under consideration. It should enable the 800°C barrier to be overcome, at which diamonds turn back into graphite.

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Alain Polian (on the left) and Jean-Paul Itié, in charge of the High Pressure Laboratory, checking the correct alignment between the experimental chamber and the two diamonds with a binocular microscope.