A multi-technical approach to the study of the physical properties of materials. Examples from the PSICHE beamline, Synchrotron SOLEIL

Nicolas GUIGNOT (Synchrotron SOLEIL, France),
Daniele ANTONANGELI (IMPMC, France),
Lola PERRUCHON-MONGE (IMPMC, Synchrotron SOLEIL, France),
Guillaume MORARD (IMPMC, France),
Silvia BOCCATO (IMPMC, France),
Agnès DEWAELE (CEA, France),
Laura HENRY (Synchrotron SOLEIL, France),
Paul CHAUVIGNE (Synchrotron SOLEIL, France),
Andrew KING (Synchrotron SOLEIL, France),
Yann LE GODEC (IMPMC, France),
Adrien NERI (UMET, France),
Julien CHANTEL (UMET, France),
Jen-Pierre DESLANDES (Synchrotron SOLEIL, France)

Abstract

The PSICHE beamline of the Synchrotron SOLEIL proposes a range of techniques for science at extreme conditions for a wide range of communities. The beamline specializes in combining diffraction, imaging and complementary techniques and can work in both polychromatic and monochromatic modes [1]. This presentation will showcase several recent developments, illustrated with examples from user experiments.

We will first present our large volume presses programs. The most innovative setup is the UToPEC system, a Paris-Edinburgh Cell designed for ultrafast tomography (> 1 tomo/s) at extreme conditions. The press can be continuously rotated by a high precision tomograph while heating, cooling the anvils and now controlling the pressure using an onboard compressor. A wide set of techniques are available, including CAESAR XRD, high-speed imaging, Beer-Lambert absorption measurements [2] and ultrasonic measurements. All are available almost simultaneously, creating new opportunities. For example, it is possible to perform Beer-Lambert absorption and ultrasonic measurements and control the sample geometry with tomography, giving access to the elastic properties of materials. While having access to XRD for structure analysis and pressure measurement.

Next, we will present our laser heated diamond anvil cell (LHDAC) setup, based on a technique that is widely used to generate temperatures of more than several thousands of K for pressures reaching tens and even hundreds of GPa. This technique is however known to generate high radial temperature gradients, that are detrimental for several reasons: 1/ they generate chemical diffusion (Soret effect) that are very problematic in the case of chemically complex samples; 2/ a very small X-ray beam is usually needed, which can be an issue when a good grain statistics is required; 3/ kinetic properties are very difficult to study; 4/ the sample microstructure may be difficult to interpret correctly.

For all these reasons, we have developed and implemented a new combination of techniques:

- Real-time sample surface temperature and emissivity mapping using an adapted 4 color pyrometry setup [3].
- Laser beamshaping to modify the power distribution of the laser focused spot. 4 color pyrometry can then be used to measure how this influences the temperature distribution at the sample surface, depending on the sample and environing materials thermal properties.

We will present a few examples of the opportunities that this innovative setup can bring to our users.

References

[1] A. King et al, Rev. Sci. Instrum., 87, 093704 (2016)

[2] Henry, L. et al., J. Synchrotron Radiat., 29, p. 853-861 (2022)

[3] Campbell, A.J., Rev. Sci. Instrum. 79, 015108 (2008)