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Low temperature remote pressure measurement in sapphire-anvil and other cells.

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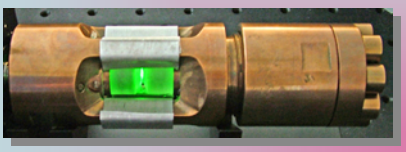
With the advent of large volume high pressure cells which allow optical access to the sample chamber it is possible to measure the generated pressure by ruby fluorescence, without the use of polycrystalline pressure markers or electrical measurements. In this poster we describe our current and future development work to obtain remote pressure change and measurement in cells.

Sapphire anvil cell:

- Pressures >6 GPa possible.
- Sample size: <2 mm^2.
- Low neutron background.
- Quick cell cooldown time (<20 K in 2 hours on a CCR).
- Anvil size: 18 mm diameter.



Sapphire-anvil cell illuminated with laser light during ruby fluorescence measurement.

Ruby Fluorescence:

- Ruby excitation by green laser light.
- Excitation results in emission of light the wavelength of which is related to the pressure experienced by the ruby:

$$P = \frac{A}{B}\left[\left(\frac{\lambda}{\lambda_0}\right)^B - 1\right]$$

where P is pressure (GPa), A = 1904 GPa, B = 7.665 and λ is wavelength (Mao et al. 1986). The wavelength also shifts with temperature.

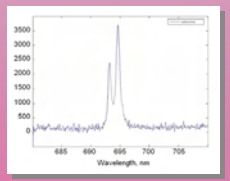
- No polycrystalline calibration salts needed allowing hydrostatic pressure media to be used (Meth:Eth, N_2, Ar), giving larger sample volumes and higher pressure ranges in an hydrostatic environment.
- Only small fragment of ruby required (50 μm).

Wavelength of ruby fluorescence related to pressure

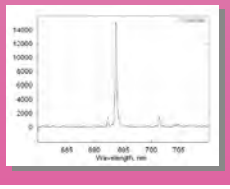
Low-temperature remote measurement system:

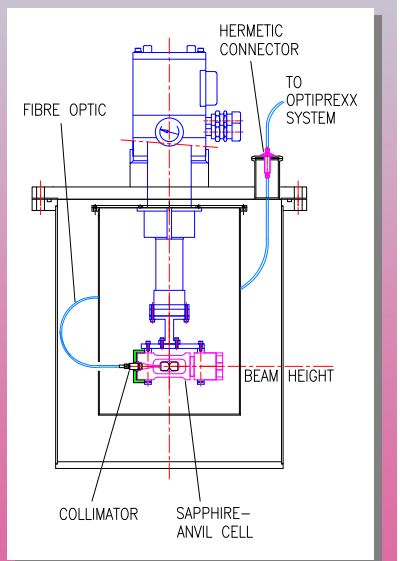
- EasyLab Technologies Optiprexx system: 20 mW 532 nm laser, XYZ positioning stage and an Ocean Optics spectrometer.
- Additional interlock fitted to Class III laser system for safety.
- CCD Camera and LCD screen added for easy alignment of fibre end.
- 1mm bore fibre optics used.
- Hermetic connector custom made with matched 1mm fibre bore.
- Collimation package added to minimise divergence from fibre.
- Tests made with loaded sapphire-anvil cell at room temperature and after cooldown to 20 K in a CCR system.

Optiprexx ruby fluorescence system.



Ruby spectra at 273 K (above) and at 20 K (below).





Drawing of sapphire-anvil cell and fibre optic assembly in test CCR system.

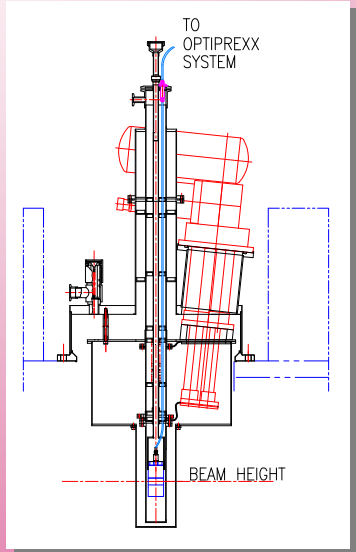
Tests on Paris Edinburgh cell diamond anvils:

- Optically transparent anvils in VX variant PE cell tested.
- Ruby fluorescence allows in–situ pressure measurement during experiments.
- Fibre allows access to sample chamber without need for long focal length lenses.
- Allows testing of anvil designs remotely.

Paris Edinburgh cell. Fibre optic system used for in-situ ruby pressure measurements in safety bunker.

Future cell development:

- Joint project between ISIS and University of Edinburgh to produce new high pressure cells
- Cells will have optical access for in-situ ruby fluorescence measurement.
- Cells will be suitable for low temperature use, down to mK range.
- Planned pressure range of cell: 10 GPa and above.
- Cells hydraulically driven, with remote pressure change capability.



Sketch of new cell and fibre optic assembly on pulse tube toploader. Cell will have the capacity for both remote pressure change and measurement.