| ESRF | **Experiment title:** Compression of Neon to above 500 GPa in a toroidal DAC. | **Experiment number**: HC-3088 |
|---|---|---|
| **Beamline**: ID27 | **Date of experiment**: from: 03 to 05/05/2017 | **Date of report**: 09/07/2017 |
| **Shifts:** 9 | **Local contact(s)**: M. Mezouar | *Received at ESRF:* |


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## Report:

The aim of this proposal was to qualify Ne as the pressure medium for the TPa range. Essentially to show that: a 5 µm diameter sample of Ne could be loaded in a toroidal diamond anvil cell; Ne can be compressed up to 500 GPa; Ne can be quantified as a good hydrostatic pressure transmitting medium by measuring the deviatoric stress from the analysis of the diffraction line width.

The concept of double stage anvil is now recognized very promising to overcome the compression limit faced when using the diamond anvil cell equipped with beveled anvils. Indeed, pressures up to the 1 TPa range have been obtained by using half spheres of nano-diamond placed as secondary anvils in a diamond anvil cell [1]. In the same vein, we have developped the toroidal anvil design. By FIB machining, a double stage type anvil is sculpted in a single crystal diamond anvil. Pressure up to 600 GPa had so been achieved on gold ( Report ME-1380). The advantage of this approach of just changing the shape of the anvil is that the standard procedure for loading a DAC can be applied and loading of gases such as He, Ne or H2 is feasible.

Two DACs equiped with Toroidal anvils were loaded for the beamtine. In both, the gasket was made of rhenium. A 1 µm ball of gold, to estimate the pressure from the measured volume of gold, was placed in the gasket hole made with FIB in the pre-indented gasket. The DACs were then gas loaded with Ne under 1400 bars.

- The first DAC was equipped with a Tore having a 25 µm central and a Tore shape extending to 85 µm. A 7 µm diameter Ne sample could be obtained under pressure ( see photo). As seen in figure 1, good diffraction pattern ( from which the volume of Ne, Au & Re could be obtained) was obtained up to 145 GPa. Unfortunately above this pressure the Tore broke at the edge of the 25 µm flat.It is interesting to note that the topology of the sample should not change much by going to higher pressures and so we can expect a similar diffraction pattern up to the 500 GPa presures.
- The second DAC was equipped with a tore with a 20 µm flat and extending to 65 µm. A 6 µm Ne sample was obtained. Unfortunately, the sample moved on the side of the central 20 µm culet because of a slight misalignement of the two 20 µm tips. The experiment was thus stopped.

The encouraging results of this beamtime are that a good Ne sample can be loaded in a toroidal DAC and that a good diffraction pattern can be obtained on such a sample in the Mbar pressure range. That proves the feasibility of the aim of this proposal. However, the design of the toroidal shape that operates to compress Au up to 600 GPa is not properly working here. Because of the large volume reduction of the Ne sample between its loading pressure (1400 bars) and the 100 GPa range, the gasket thickness strongly decreased and that caused the failure in compression by a punching at the edge of the 25 µm central flat part. The failure of the second DACs showed that perfect stability under pressure of the alignment of the two toroidal anvils is mandatory.

These two feedbacks will be taken into account for preparing a future x-ray campaign.

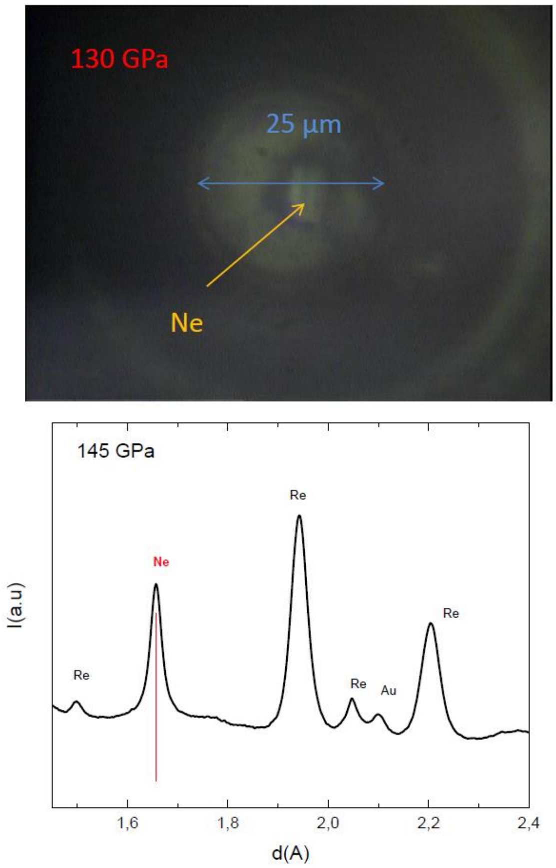


**Figure 1:** Ne sample in a Toroidal DAC at 145 GPa. a) Photo of the sample at 145 GPa. The central flat tip of the Tore is 25 µm. On the right part, a failure of the diamond due to punching of the gasket is observed. b) Integrated diffraction pattern at 145 GPa. The peaks of the 7 µm Ne sample, 1 µm Au ball and edge of Re gasket are of comparable intensities.

**References:**
[1] Dubrovinsky *et al*., Implementation of micro-ball nanodiamond anvils for high-pressure studies above 6 Mbar, Nat. Comm. 3, 1163, 2012
[2] Report ME-1380.