Laser drill for diamond anvil high pressure cell gaskets

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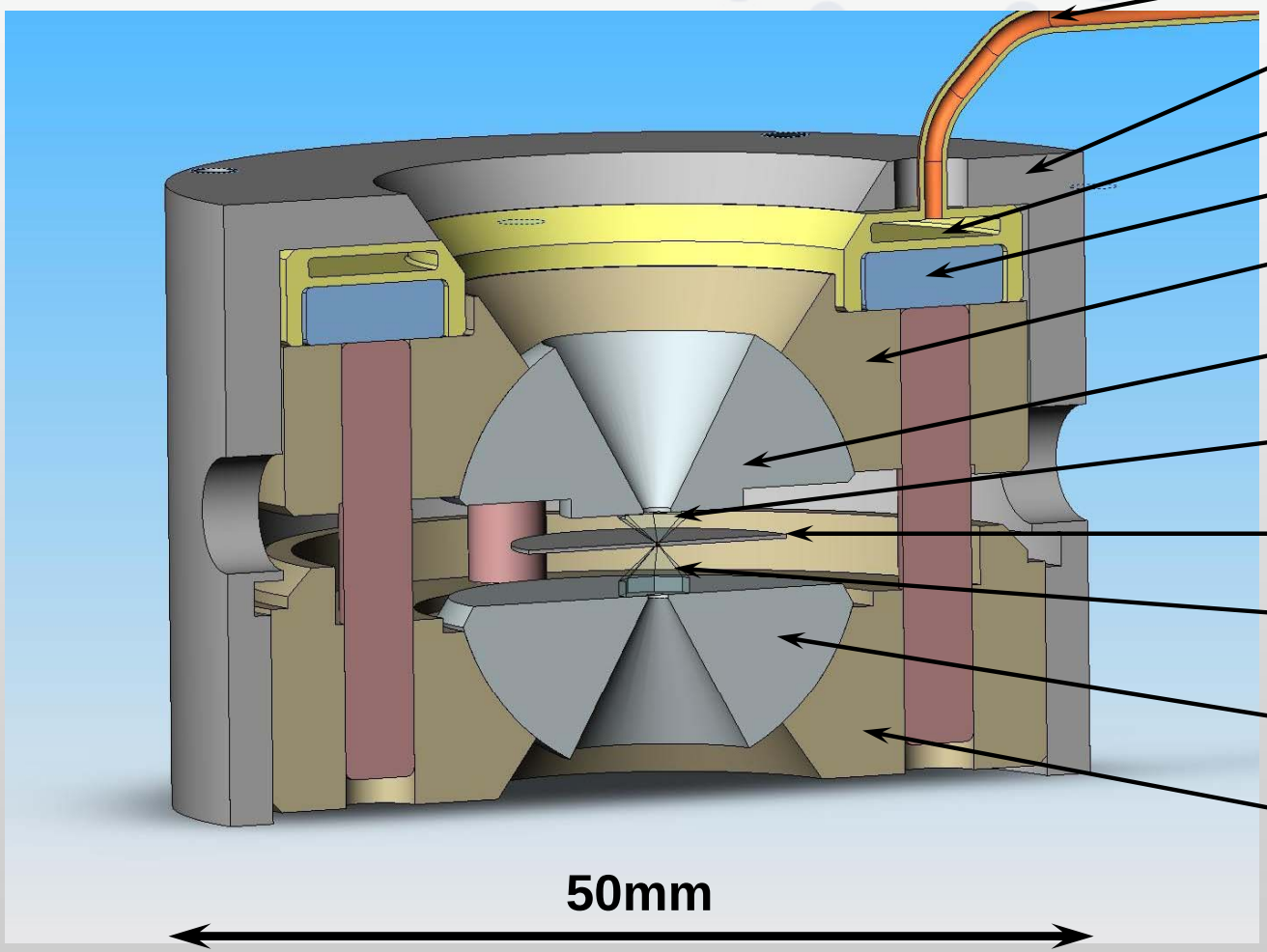
Outline

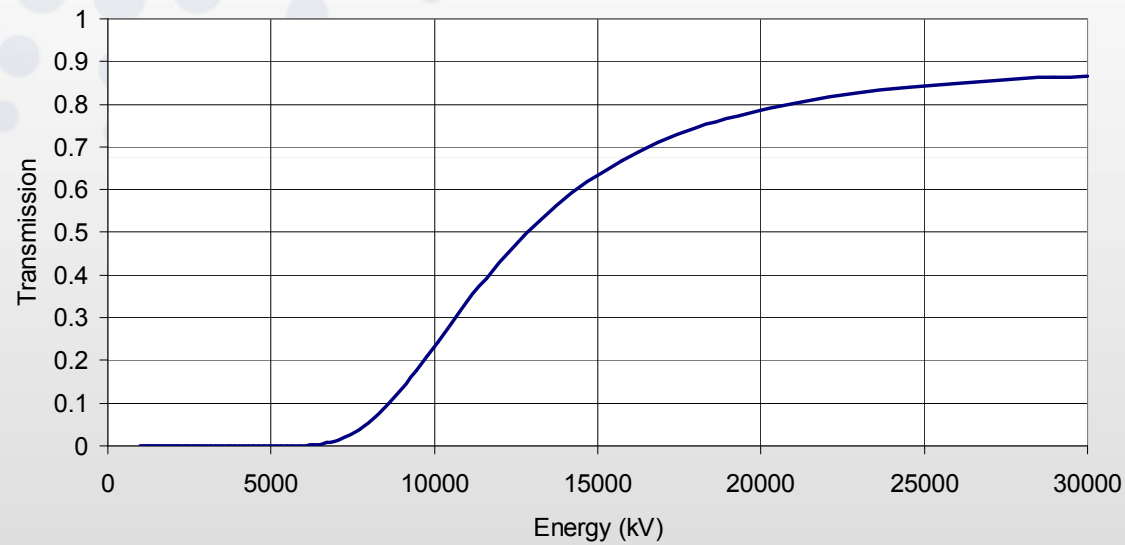
- What a diamond anvil cell looks like
- Current procedure: electro erosion drilling
- Principle of the laser drill
- Some components of the laser drill
- Examples of work done

What a diamond anvil cell looks like:



Helium
Cover
Membrane
Spacer
Top cell half
Top seat
Top diamond
Gasket to be drilled
Bottom diamond
Bottom seat
Bottom half cell

Why the DAC is popular:



Transmission of 3mm of diamond
0.05 at 8 keV
0.2 at 10 keV
0.5 at 13 keV

Small size

Pressure range: few kBar up to >2MBar

Temperature: <1K to >3000K

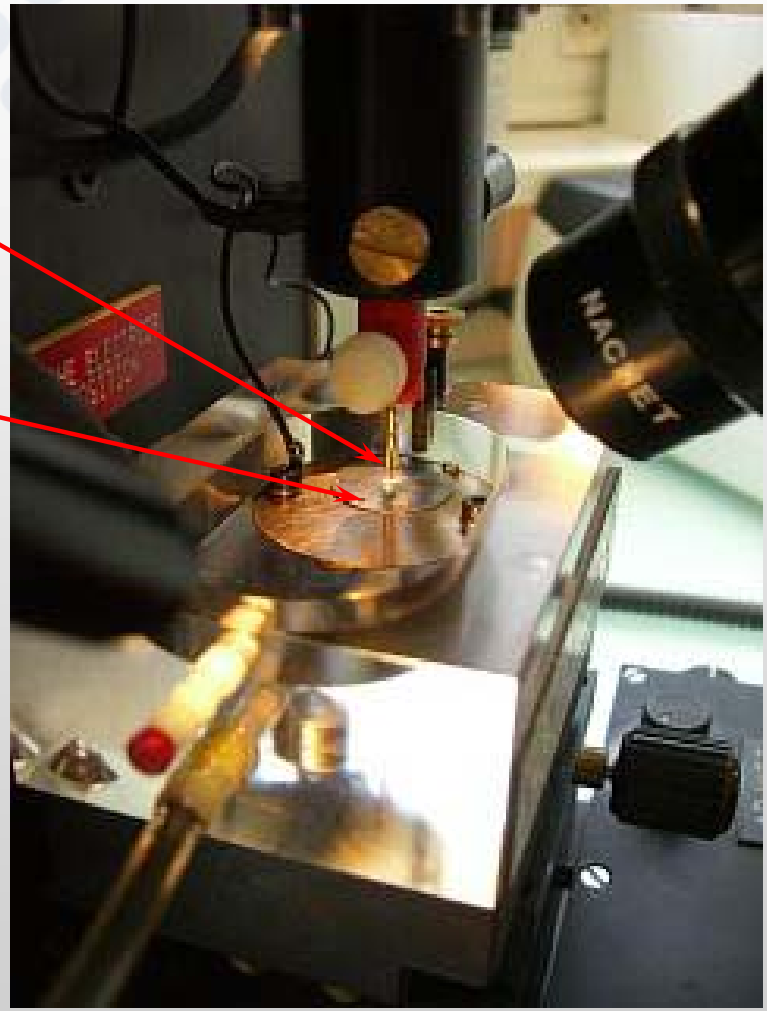
Techniques: diffraction/scattering/spectroscopy

Scientific: physics, earth sciences, chemistry, materials

Sample volume:, Ø=20-300µm , h=10 – 50µm

Sample size corresponds well to beam size

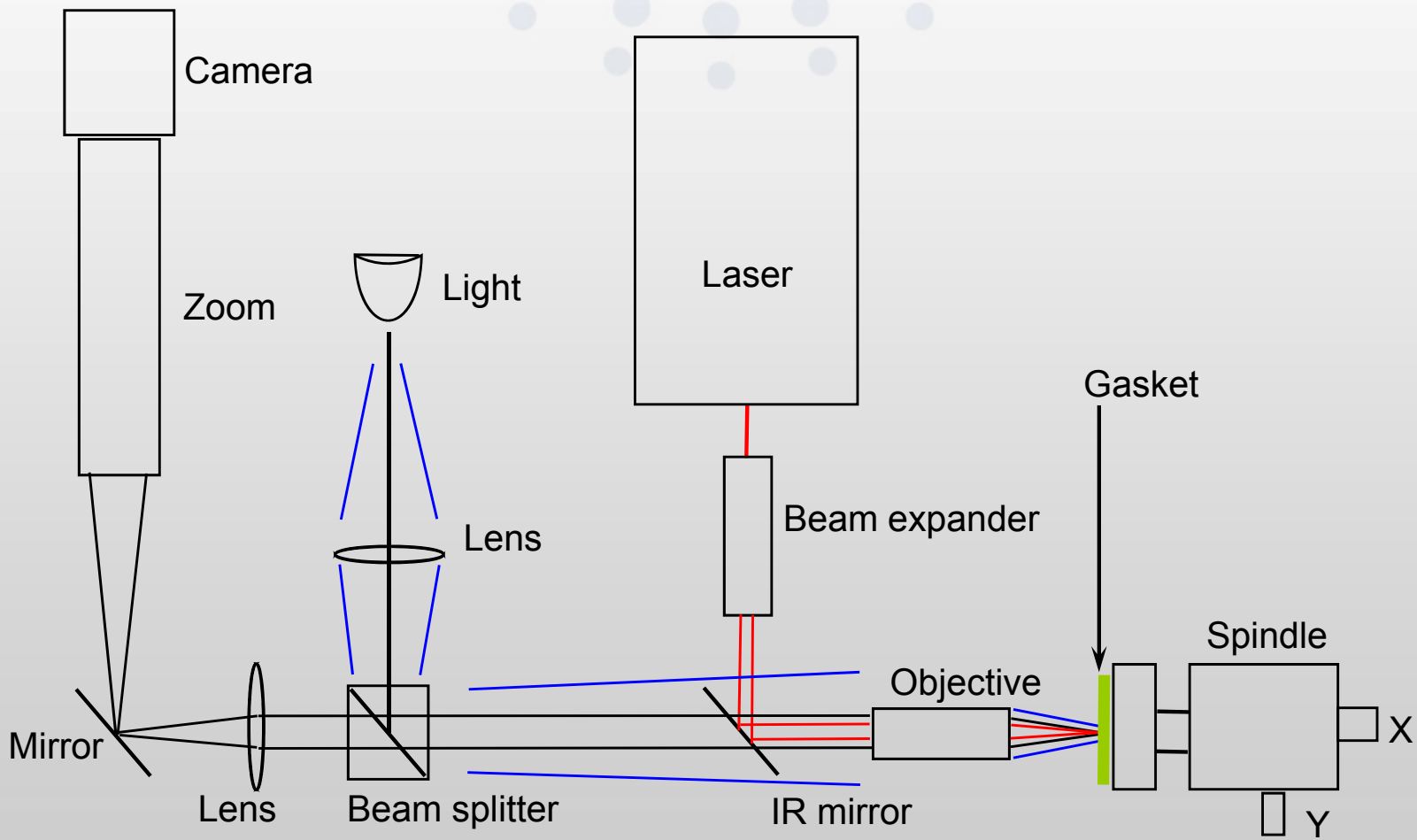
Current procedure - electro erosion



- Difficulties below 100 micron.
- 1 hr to drill.
- Positioning not guaranteed.
- Therefore several attempts are normally required to drill holes to within 3µm of the culet center.
- Smaller hole = bigger problem

At the same time the trend is for smaller culets, increased pressure!

Principle of the setup

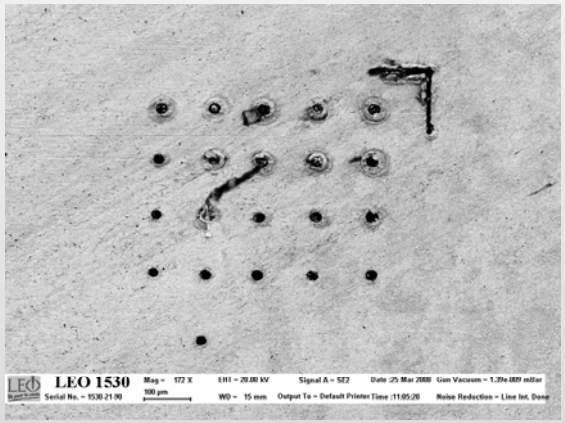


High precision spindle

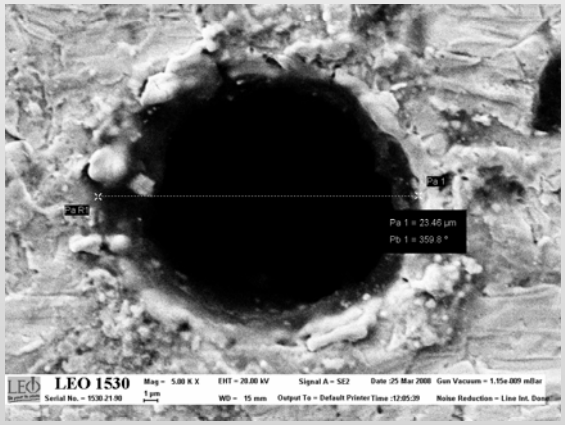
- Includes piezo 100x100 micron
- Oblique angled bearings stabilise axis
- Slip ring contacts
- DC motor + reduction + belt drive
- Belt drive centered to bearings to reduce mechanical noise
- Thermal compensation of axis length change
- Precision of alignment 1 micron

Examples – 1: pinholes

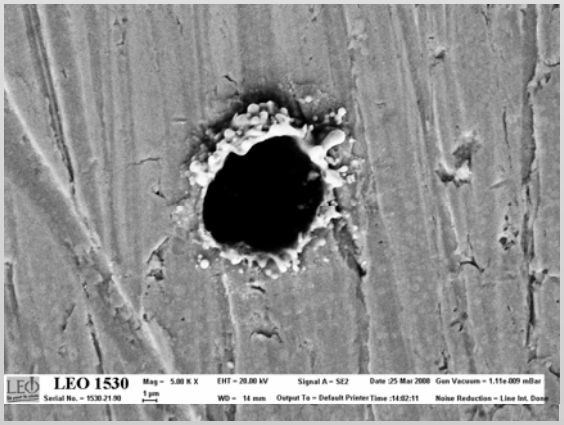
Drilling pinholes: tests in 200 µm Tungsten sheet
General interest: price of 1 pinhole 500€



Laser parameter search



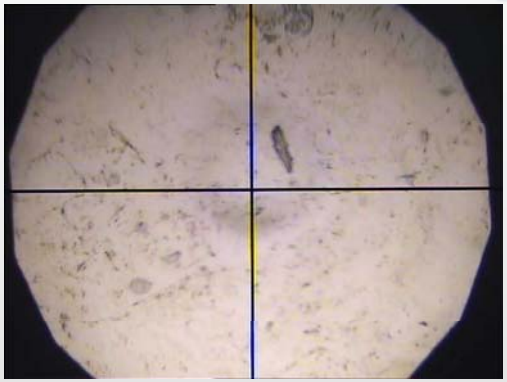
Entrance hole 25 µm



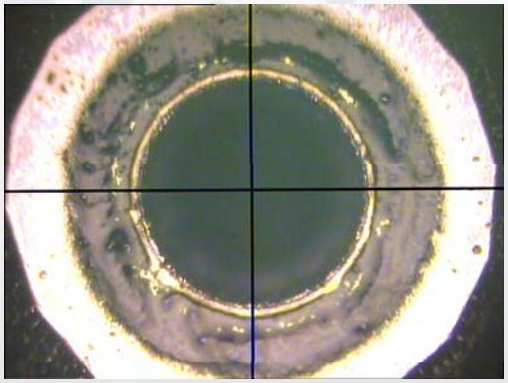
Exit hole <10 µm

To be tested in the beam
Looks promising, will take time

Examples – 2: built up gasket



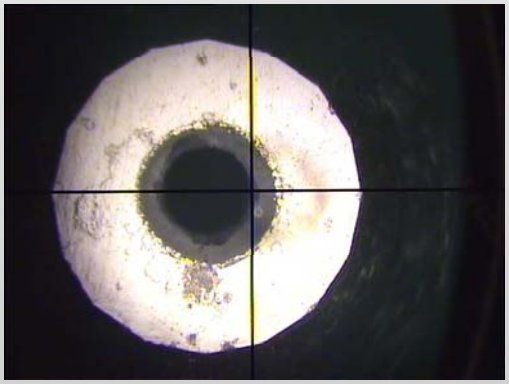
1: Re gasket, 600µm culet



2: Drill hole 340µm

Reactive sample of Tellurium would attack the Rhenium of the gasket. Ruby is also protected in salt.

3: Fill with NaCl, compress hole reduces to 300µm



4: Drill hole 250µm

Examples – 3: increase of pressure

Fe K-edge XANES analysis of Al-bearing(Mg,Fe)SiO3 Perovskite and post Perovskite phases

Two step experiment:

Beamline ID27 – laser anneal and diffraction to synthesize sample

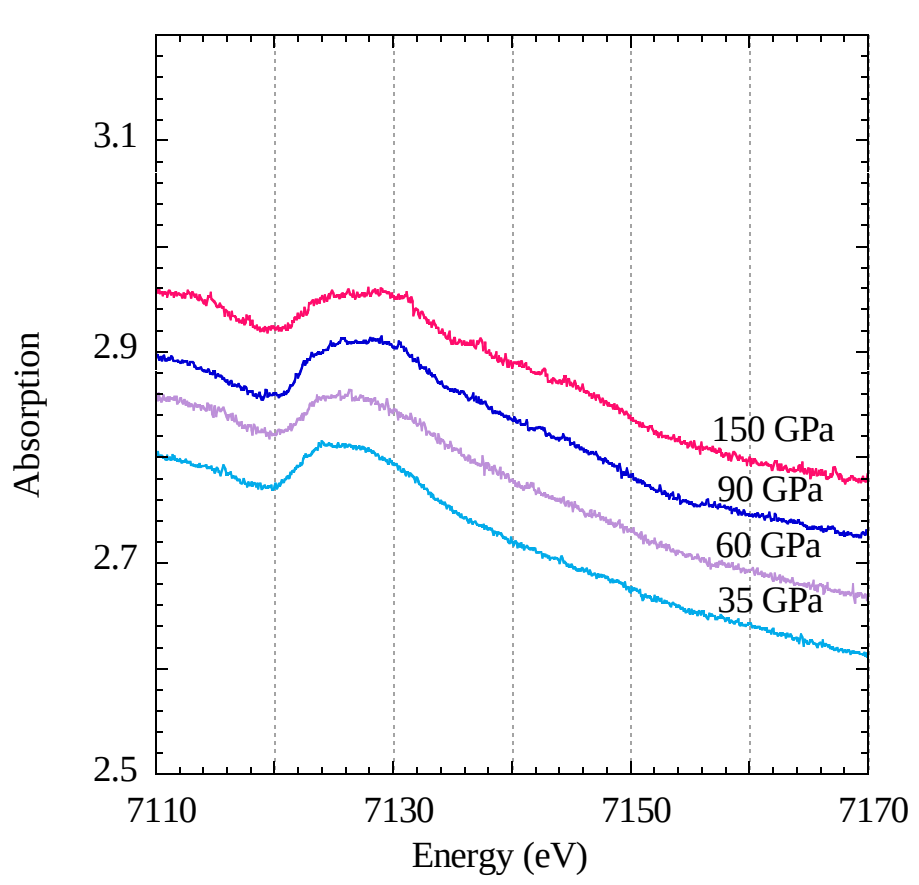
Beamline ID24 – XANES to determine the Fe oxidation state

Gasket material: Re

Diamond size: 75µm

Hole size: 35µm

Pressure reached 1.5 Mbar (!)



Conclusion

- Drill time: 15 minutes independent of hole size
- Precise centering of the drilled hole
- Hole size 25µm to 1mm, independent of hole size
- Also sample cutting
- Non metals: NaCl, diamond, …
- Multiple holes in one gasket: multiple samples or separate ruby

The laser drill was built to drill smaller holes, but finally does a lot more!

Future: motorised YZ for arbitrary shape cutting

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ESRF