DIFFRACTOMETERS FOR MATERIAL SCIENCE STUDIES

Beam tube	6T (thermal source)
Monochromator	Cu 111
Incident wavelength	1.159 Å
Maximal beam size	2 x 2 cm^2
Neutron flux at specimen	10^7 n cm^{-2} s^{-1}
Collimation	α_1 = 10', 15', 54'
	α_3 = 10', 60'
Range of monochromator angle	$2\theta_m$ = 32°
Ranges of spectrometer angles	-20° < θ < 80°
	-10° < ω < 40°
	0° < χ < 180°
	0° < φ < 360°
Detector	^{3}He
equipement	Furnace for in situ measurements T < 950°C

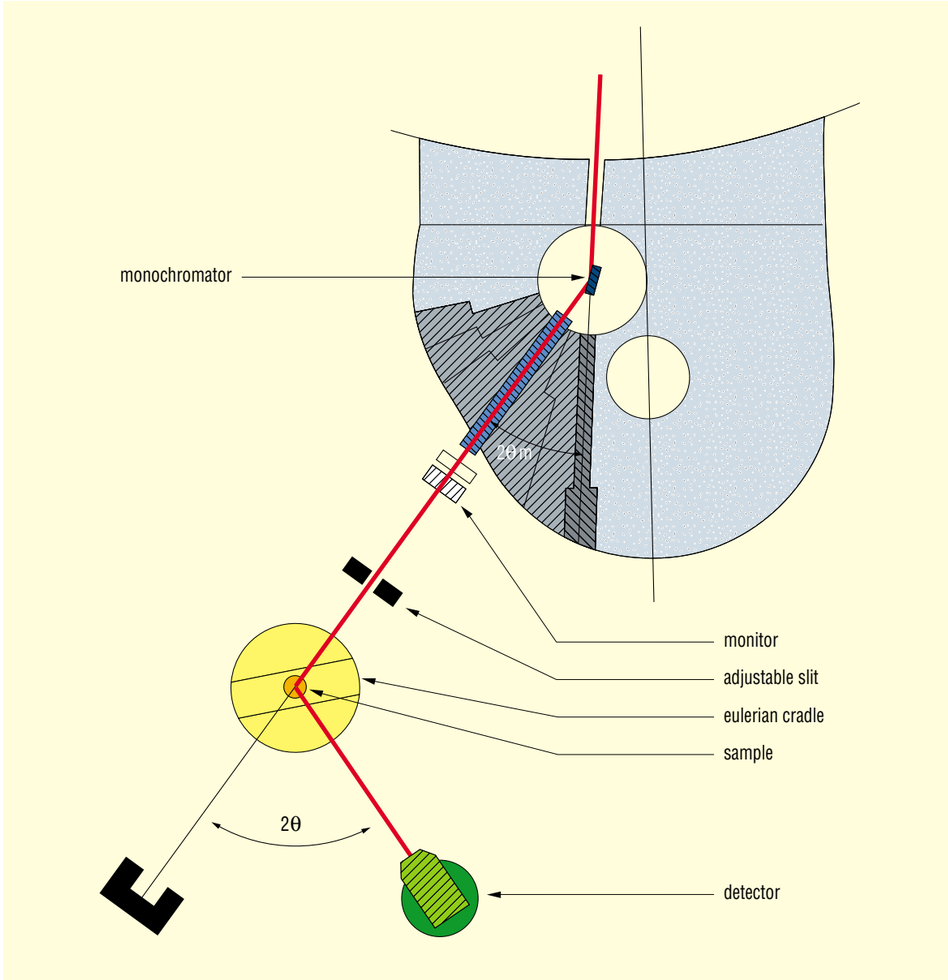
The 6 T1 diffractometer is dedicated to pole figure determination, for crystallographic texture analysis.
Neutron diffraction technique allows to measure complete pole figures in transmission mode and to analyse large volumes up to 1 cm^3. This technique is useful for large grain materials, or heterogeneous materials. It allows characterising the texture of minority phases. Moreover, no surface preparation is required for the sample.

The neutron wavelength is 1.159 Å, selected by a Cu (111) monochromator. The maximal beam size is 2 x 2 cm^2 but a window device can reduce it. The diffractometer is equipped with a deported Eulerian cradle (Frank Heydrich Ø 400 mm) with 0.01° precision. The sample-counter distance can change between 80 and 150 cm.

Depending on the aim of experiment, various collimations of the incident and diffracted beam can be used. The 6 T1 resolution allows determining the energy stored in the grains during the deformation as a function of crystallographic orientation through Bragg peak broadening analysis.

A Windows NT PC computer pilots the diffractometer. The pole figure measurement time is at least 2 or 3 hours (grid 5° x 5°).

Moreover, at the LLB, several programs are available to calculate the Orientation Distribution Function using harmonic or vectorial methods.



General layout of the diffractometer 6 T1.

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Beam tube	Cold Neutron Guide G 5
Monochromator	Pyrolytic graphite (002) or (004)
Incident wavelength	2.3 Å ≤ λ ≤ 6 Å continuously variable
Type of instrument	Two-axis
Detector	100 x 100 mm^2 EMBL (Grenoble outstation) ^{3}He PSD
Neutron flux at specimen	ca. 3.8 x 10^6 n cm^{-2} s^{-1} at 3 Å
Angular ranges	20° < 2θ < 120° 0° < ω < 360°
Resolution	Δd/d = 1.9 x 10^{-3} at d = 2 Å (λ = 2.8 Å, using the (004) monochromator reflection)
Positioning table	with x, y and z movements : +/-75 mm x, y axes travel and 300 mm z-axis travel
Position repeatable	to 1 micron (x, y, z). Samples up to 500 kg in weight can be supported
Gauge dimensions	from 0.3 mm to 25 mm incident and outgoing beams Variable in both dimensions.
Data collection and instrument Control system	Personal computer (PC)

Ancillary equipment

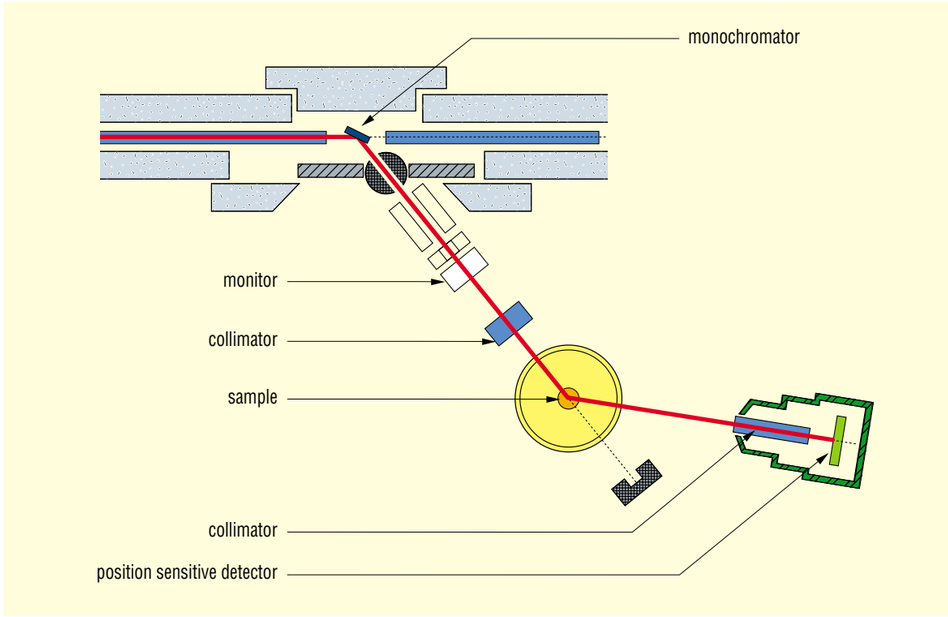
★ Uni-axial loading rig : ± 20 kN dynamic loading for tension, compression and tension-compression. It can be mounted on positioning table
★ Eulerian cradle (inner diameter = 400 mm) 0 < χ < 160° and 0 < ϕ < 360° for complete stress tensor determination
★ Four point bending device
★ Furnace (T < 800°) for high temperature measurements

Internal and residual stresses in materials have a considerable effect on material properties, including fatigue resistance, fracture toughness and strength. Neutron diffraction provides a powerful non-destructive tool for stress analysis deep within a crystalline material. In this way, it does not need specimen preparation and samples with cumbersome geometries can be studied. The principle of the technique, called Neutron Strain Scanning, is to use crystal lattice as an atomic strain gauge to measure strain distributions with a sub-millimeter spatial resolution with an accuracy of better than 50 microstrain (50 x 10^{-6}). The stresses are thus calculated from the measured strains by using elasticity laws.
In the last years, a new diffractometer “DIANE” entirely dedicated to stress analysis was built at the Laboratoire Léon Brillouin in Saclay in collaboration with the Italian INFM (Istituto Nazionale Fisica della Materia). The instrument is a two axis diffractometer, consisting of a monochromator, a sample table and a multidetector. It is situated on the G5 cold guide of the Orphée reactor.

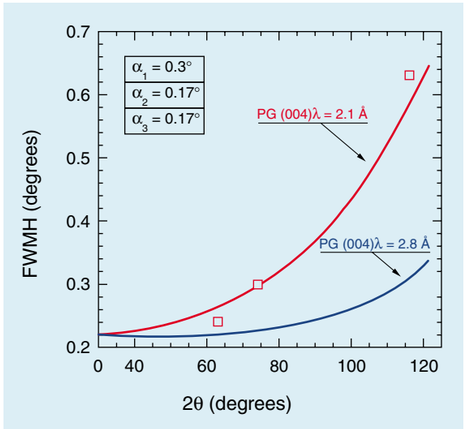
The monochromator is a pyrolytic graphite single crystal, using the (002) or the (004) reflection, providing a continuously variable wavelength spectrum between 2.3 Å and 5 Å. When it is possible, the preferred reflection is the (004), providing a good instrumental resolution.

The sample table has been constructed in order to support very big samples, up to 500 kg in weight. It is equipped with x-y-z translation tables and a ω rotation about the vertical axis. In this way, the residual stress field in real industrial components can be evaluated. For smaller samples (up to 5 kg weight), an Eulerian cradle, equipped with a x-y-z stage, for the determination of complete stress tensor in a point, is also available. Different sized Cd masks, ranging from 0.3 mm to 25 mm in width, just before and after the sample, are available to define the size and the shape of the gauge volume, according to the different experimental requirements. As an example, with a gauge volume of about 1 mm^3, a steel sample of about 30 mm thick can be investigated, whereas aluminum samples may be four times as thick.

Two-Axis Strain Diffractometer “DIANE” G 5-2



General layout of the diffractometer G 5-2.



Instrumental resolution of G 5-2, measured with a standard germanium powder with a neutron incident wavelength of 2.8 Å and of 2.1 Å using the graphite monochromator (004) reflection.

The PSD is actually operating as a linear one dimensional detector system. The advantage of this solution with respect to the classical linear one-dimensional detector is that it has a larger effective detection area. The PSD is positioned at a distance ranging from 900 to 1200 mm from the sample, with an angular aperture of 4°- 6° in 2θ and an electronic resolution of about 0.03°- 0.02°. In this way complete Bragg peaks are recorded in single exposure type measurements, reducing the measuring time with respect to a single detector.

A new device for in situ mechanical loading of test samples during neutron diffraction strain measurements has been installed. It can be mounted on the neutron diffractometer and can be aligned with the loading direction parallel or perpendicular to the scattering direction for measurements of longitudinal and transverse strains. The capacity of the applied load cell is 20 kN and it is controlled by a pneumatic system. Different jaws of grips are available in order to study different specimen geometry.

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