



ANALYTICAL INSTRUMENTS GROUP

EXPLORER



MULTI-PURPOSE AND HIGH RESOLUTION X-RAY DIFFRACTOMETER

www.gnr.it

About us

GNR, thanks to its 35 years of experience, is a worldwide market manufacturer of advanced analytical instruments, developing procedures of analysis for various applications, supplying the corresponding laboratory equipment and providing consulting and Customer support worldwide, through its well established sales and post-sale network.

GNR projects and manufactures Optical Emission Spectrometers (OES) and Rotating Disc Electrode Optical Emission Spectrometers (RDE-OES) for the measurement of elemental composition of metal alloys and the analysis of contaminants, additives and wear metals in oils and lubricants, coolants and hydraulic fluids.

GNR designs and produces X-Ray Diffractometers (XRD) and X-Ray Fluorescence Spectrometers (XRF) for the study of material structure and elemental composition for both academic and industrial applications.



GNR Head Office and Production Site is located in Agrate Conturbia (Novara), near Lago Maggiore; 20 minutes from MALPENSA Airport.

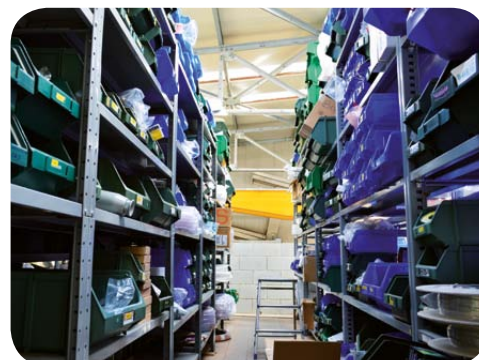
Certified Company

Highest quality in our products and services is a core value for **GNR**.

Full commitment is dedicated to support our quality system in the overall process and continuous improvement is fundamental to guarantee GNR compliance to the internationally accepted quality management standard ISO 9001.



GNR periodically organizes at its facility courses and training for technicians and agents as well as seminars and demonstrations.



Thanks to an extensive network of agents GNR provides technical support and delivers spare parts worldwide.

In relation to the process of continuous development, GNR reserves the right to change specifications of the instruments without previous notice at any time; the real ones will always be those shown in the final order confirmation.



GNR Analytical Instruments Group is a worldwide market leader in supplying advanced X-Ray (XRD, XRF) and Optical Emission Spectrometer (OES) systems for complete solutions in structural and elemental analysis.

These analytical methods provide elemental composition of solids and liquids as well as structural parameters of powders, thin films and bulk materials.

GNR new generation of instruments has been designed with many improved features and functionalities. GNR has completely reviewed several parts of its diffractometer system with the aim to provide the most advanced and efficient tool for customer analytical tasks.

The modularity and flexibility of **GNR Explorer** allows starting with an entry level set up system that can be upgraded in any time to meet additional requirements.

With no limits to its applications, **GNR Explorer** modular system offers high performances in all analytical areas, ranging from phase quantification of mixtures to the determination of microstructural properties as residual stress and preferred orientation of crystallites on bulk materials as well as on thin films.

Thanks to the **modularity and the Plug&Scan concept** all the components can be quickly exchanged with extremely precise reproducible positioning. The optics permit switching from para-focusing Bragg-Brentano to parallel beam geometry without any extra alignment. All optics have been designed to return to perfect alignment every time.

From the X-ray tube, through the optics, to the sample stages and to the detectors, any user is capable of changing from one beam geometry to another very easily.

GNR Explorer offers solutions for a wide range of analytical requirements, from routine crystalline phase identification and quantification, to crystallite size/lattice strain and crystallinity calculations, retained austenite quantification and polymorph screening (XRPD). From crystal structures to residual-stress analysis, thin films (XRR, GID), non-ambient analyses, phase transition monitoring, textures and preferred orientation.

Safety Assurance

Explorer complies with the complex statutory requirements regarding x-ray, machine and electrical safety.

Maximum x-ray safety with radiation level significantly below the annual dose limit for general public (1 mSv/year).

The radiation enclosure door cannot be opened when x-rays are on and the system immediately switch off if shutter is forced to open.

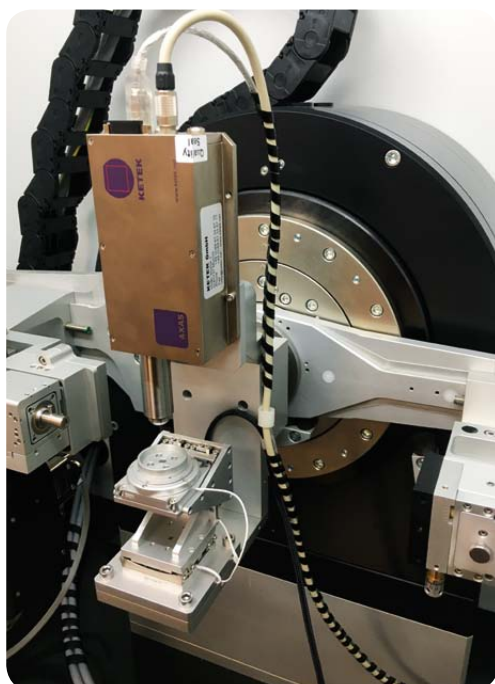
This function completely protects users from radiation exposure.

Main Features

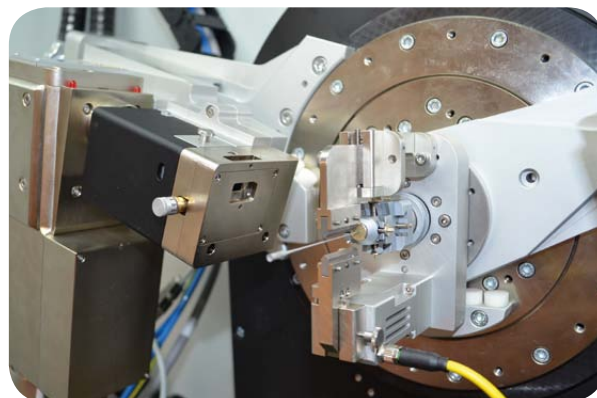
- Goniometer control with torque motor and optical encoders
- Radiation enclosure with high accessibility to the goniometer
- Double safety circuits
- Measuring circle diameters: from 400 to 600 mm
- All components can be exchanged quickly and without extra alignment
- High brilliant X-ray sources, glass and ceramic tubes plus parabolic mirror
- Rotatable line/point focus tube shield without disconnecting cables
- Interchangeable Soller slits
- Adjustable mechanical slits
- Reflection/transmission and capillary spinner sample holders
- Spinning multisample holders
- Secondary graphite monochromators
- Non-ambient experiments in reflection and transmission geometry
- High, low temperature and humidity chambers, fully software integrated
- Parallel beam optics using parabolic monochromators
- Z – Rx/Ry – Phi multipurpose sample holder
- Silicon Drift Detectors (SDDs), DECTRIS multi strip linear detectors in 0-mode and tilted by 90°
- XRR and GID with incident and diffracted parallel beam
- Silicon Drift detectors (SDDs) for EDXRF and TXRF analysis
- Monocapillary and polycapillary collimators for high speed and high intensity texture analysis
- Open Eulerian cradle with XYZ stage
- Versatile compact XYZ stage piezo motors



Z – Rx/Ry – Phi multipurpose sample holder



Silicon Drift Detector (SDD)



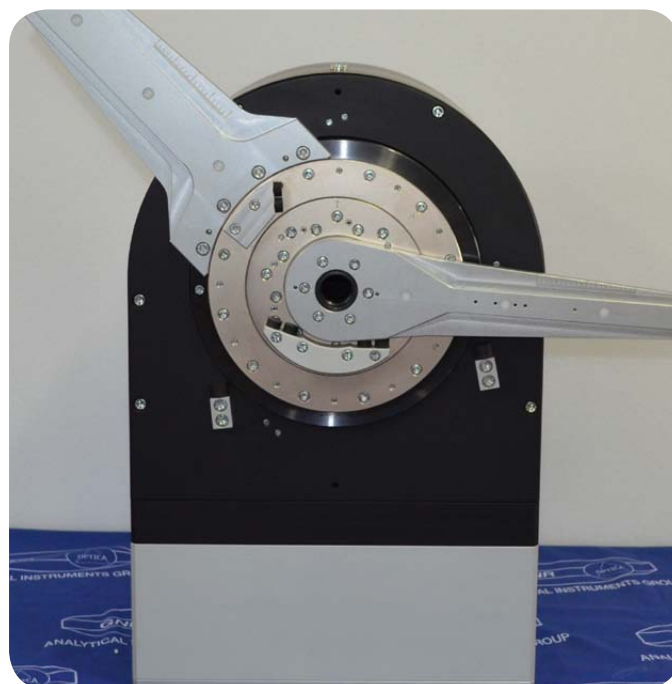
Capillary spinner sample holder



Open Eulerian cradle

The Theta/Theta configuration allows easy sample preparation, as the measured surface remains in a horizontal plane while the tube and the detector arms are rotating. This configuration is equally suitable for the analysis of loose powders, liquids, thin films and heavy samples that cannot be easily fixed in position.

The **GNR Explorer** Theta/Theta high resolution diffractometer incorporates the high efficiency of the direct drive torque motors controlled by optical encoders, allowing to reach an angular accuracy of **0.00001°**.



Ultra-high-precision goniometer

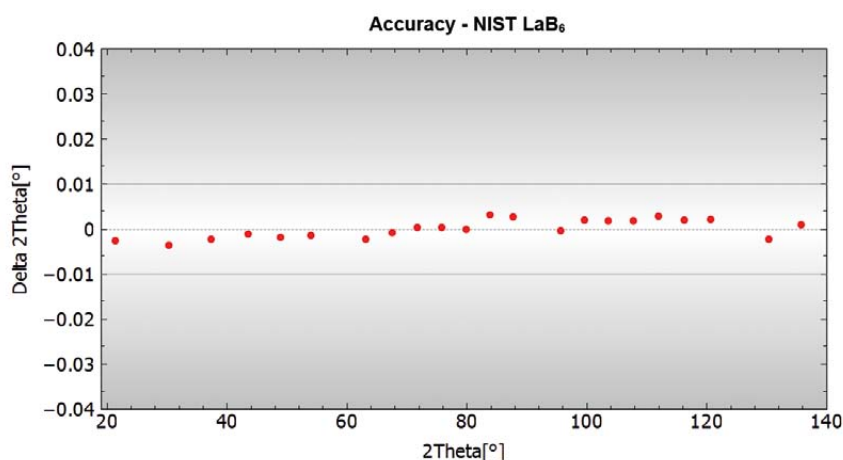


The direct drive technology offers many benefits compared with other well known technologies like worm gear, gear train, reducer or timing belt. The load is directly coupled to the motor rotating parts, resulting in an efficient and effective gearless construction.

GNR solid and maintenance-free goniometer is one of the key parameters to maintain this superior performance throughout the instrument lifetime.

You will be very impressed by our new **GNR Explorer** goniometer. **Torque motors with optical encoders** ensure extremely precise angular values.

Goniometer Accuracy



GNR developed a high performance goniometer featuring high precision and outstanding results.

An angular accuracy better than $\pm 0.01^\circ$ over the whole 2-Theta range guarantees optimal instrument alignment to support accurate and reliable analysis.

Every single instrument must pass internal test procedures based on the internationally accepted NIST Standard Reference Materials (SRM) Alumina 1976, Lanthanum Hexaboride 660 and Silicon Powder 640.

Dectris 1D Hybrid Photon Counting (HPC) microstrip detectors

Dectris multi strip detectors take full advantage of both Hybrid Photon Counting (HPC) and Single Photon Counting technologies, providing:

- X-Ray direct detection;
- noise-free performances;
- high intensity measurements;
- extremely fast data collection, without any sacrifice in data quality and peak resolution.

Our Dectris 1D detectors allow to perform data collection in an extremely short time: they can capture simultaneously a large angular range and thus reducing measurement time from hours into minutes.

Dectris 1D detectors can be used in 0D-mode and turned by 90° to cover an extremely large dynamic range.



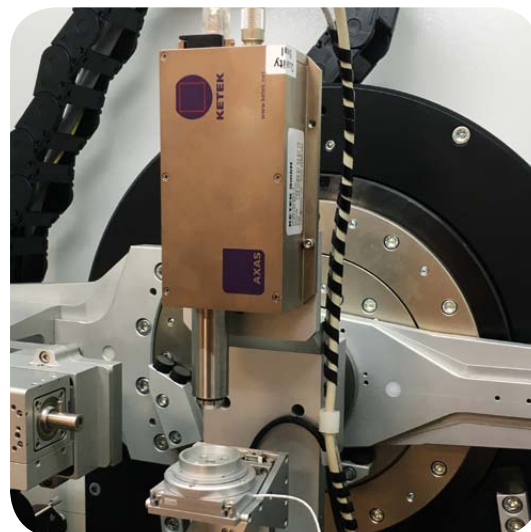
Dectris 1D mod. Advanced

Main Specifications	Dectris 1D mod. Advanced	Dectris 1D mod. Plus
Number of counting pixels	640	1280
Pixel width [μm]	50	50
Active area	256 mm ²	512 mm ²
Dynamic count rate range [counts/s]	Up to 1×10^{10}	Up to 1×10^{10}
Energy range [keV]	5-40	5-40
Cooling	Air	Air

Silicon Drift Detectors (SDDs)

Silicon Drift Detectors (SDDs) combine a large sensitive area with a small value of the output capacitance and are therefore well suited for high resolution, high count rate X-ray spectroscopy like EDXRF and TXRF.

Main Specifications	Silicon Drift Detector - SDD
Active area	10 – 170 mm ²
Energy resolution	Shaping time 1 μs : ≤ 129 eV FWHM@Mn K α
Cooling	Air



Silicon Drift Detector

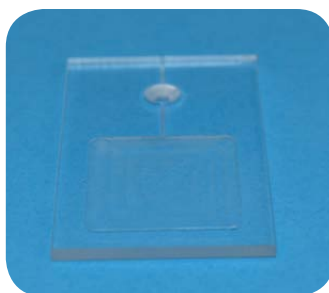
Specimen holders

GNR provides several dedicated solutions for different kinds of specimen. These fit to the analytical requirements and guarantee the best achievable data quality. Here below an overview of some specimen holders available. Upon request tailored solutions can be realized to further optimize the analytical results.

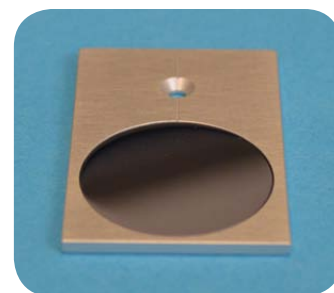
Flat specimen holders (length 44 mm)



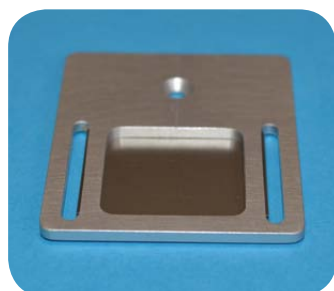
Front loading sample holder
Material: Al
Cavity:
HxL: 20 mm x 20 mm
Depth: 1 mm



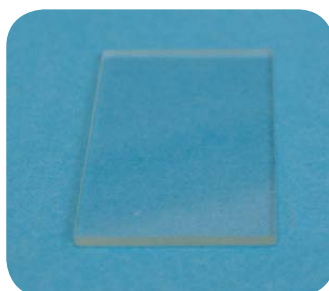
Front loading sample holder
Material: PMMA
Cavity:
HxL: 20 mm x 20 mm
Depth: 0.2/0.5 mm



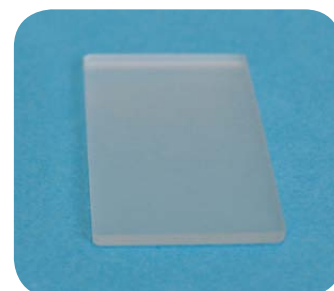
Si zero background sample holder
Material: Al
Cavity:
Diameter: 24.7 mm
Depth: 0.5/0.1 mm



Back loading sample holder
Material: Al
Cavity:
HxL: 20 mm x 20 mm
Depth: 1.9 mm



Glass slide for clay oriented mount

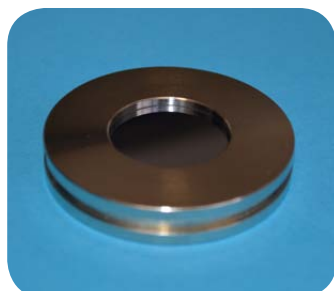


Glass slide for side loading sample holder filling

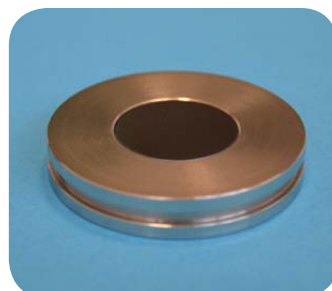
Circular sample holders (external diam: 51.5 mm - Herzog press)



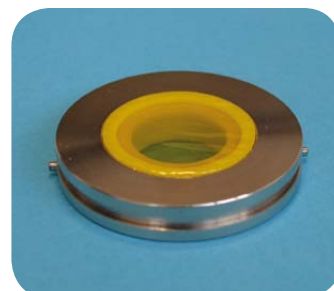
Back loading sample holder
Material: steel
Cavity:
Diameter: 24.7 mm
Depth: 2.5 mm



Side loading sample holder
Material: steel
Cavity:
Diameter: 24.7 mm
Depth: 2 mm



Si zero background sample holder
Material: steel
Cavity:
Diameter: 24.7 mm
Depth: 0.2 mm

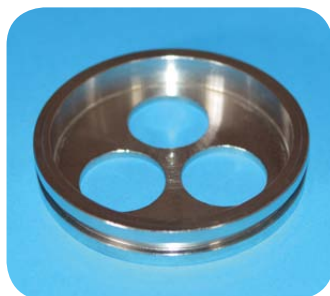


Reflection/transmission sample holder with X-Ray transparent film for air sensitive samples
Material: steel
Sample volume:
Diameter: 20 mm
Thickness: 0.5/1 mm

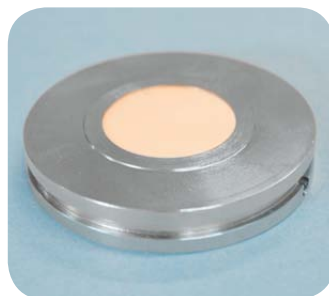
Circular sample holders (external diam: 51.5 mm - Herzog press)



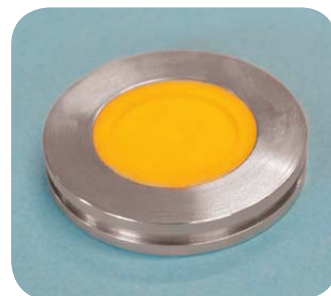
Clay oriented aggregate mount
sample holder
Material: steel and glass
Cavity:
Area: 37 x 37 mm²
Depth: 2.5 mm
Glass: 25x25 mm²



Massive sample holder
Material: steel
Cavity:
Diameter: 45 mm
Depth: 7 mm



Air monitoring filter sample holder
Material: steel
Cavity:
Diameter: 25.7 mm



Air sensitive sample holder
Material: steel and teflon
Cavity:
Diameter: 25 mm
Depth: 1.5 mm
Foil: Kapton, 8 µm

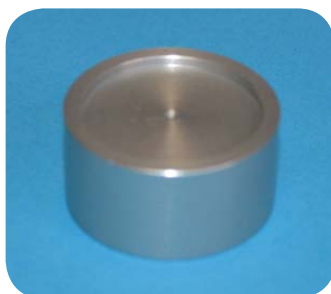


Massive sample holder



Air sensitive sample holder

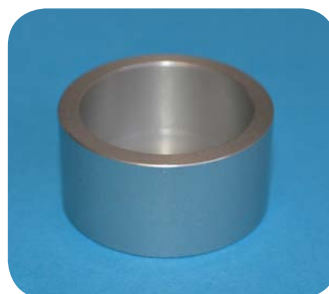
Circular sample holder for Z, Rx/Ry, Phi stage (diameter: 30 mm)



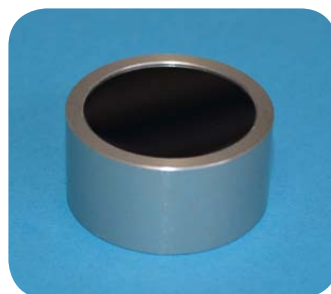
Powder sample holder
Material: Al
Cavity:
Diameter: 22/24.7 mm
Depth: 1/1.5/2 mm



Powder/Thin film sample holder
Material: PMMA
Cavity:
Diameter: 22 mm
Depth: 0.2/0.5/1 mm



Massive sample holder
Material: Al/PMMA
Cavity:
Diameter: 24 mm
Depth: 12 mm



Si zero background sample holder
Material: Al
Cavity:
Diameter: 24.7 mm
Depth: 0.5 mm

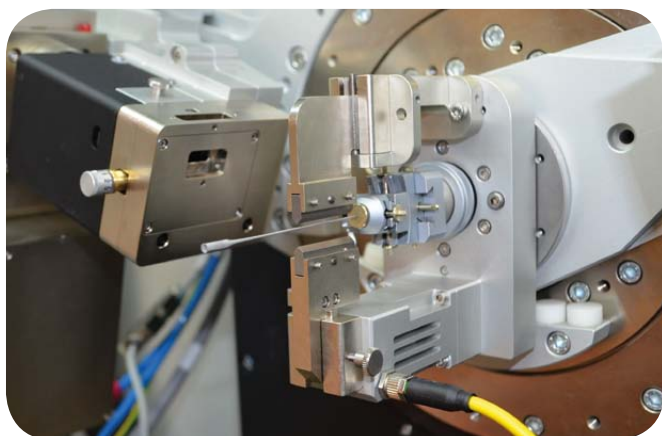
Capillary and reflection / transmission spinner sample holders

Both sample holders can be used with almost all types of samples: powder, suspensions, small sample quantities, air sensitive samples.

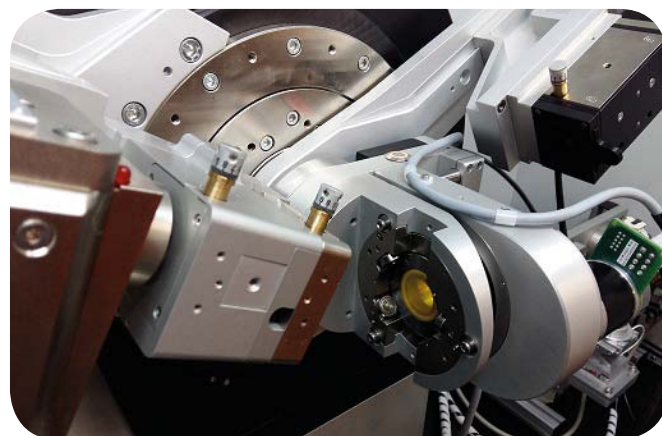
The transmission setup is the most appropriate choice for preferred orientation, organic materials with low absorption coefficients and sensitive sample measurements.

Very small sample amount or air-sensitive materials can be prepared in glass capillaries and measured by a high intensity beam with the advantage that all the crystallites of the rotating sample contribute to the diffraction signal.

Thanks to the primary parabolic mirror and the Dectris multi strip detectors **GNR Explorer** produces high-quality data in an extremely short time, even with small samples quantities.



Capillary spinner sample holders



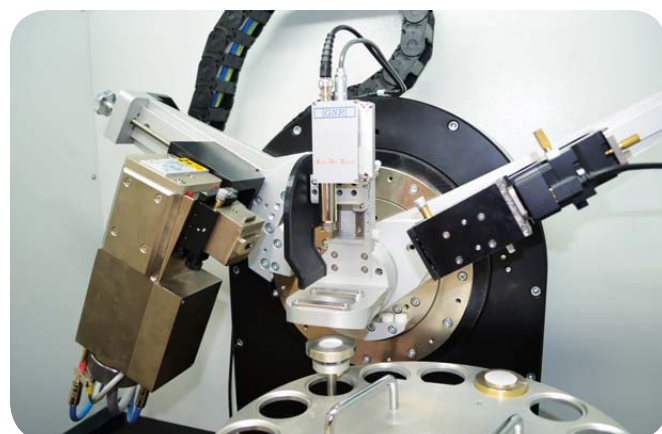
Reflection / transmission spinner sample holder

Multi sample holders

GNR multi sample stages can be used in reflection mode in order to meet customer requirements and to analyse almost every kind of samples.



Spinning multisample holder



Spinning 15-position auto-changer (ext. diam: 51.5 mm)

Non-ambient X-ray diffraction has become an indispensable technique to understand the influence of temperature, atmosphere or pressure on materials of any kind. Besides its relevance for conducting research, this knowledge is essential for optimizing technical processes and performing quality control in industrial applications.

Our samples stages ensure a precisely controlled sample environment in terms of temperature, atmosphere and pressure.

Automatic sample height compensation also guarantees the correct geometrical position of the sample in the X-ray beam throughout the experiment. Use of high-quality materials avoids unwanted chemical reactions between sample and stage components and ensures a long lifetime for the equipment.



Non-ambient X-ray diffraction

HTK 16N / HTK 2000N - Filament heating up to 2300 °C

Technical data	
Temperature range	25 °C to 1600 °C (HTK 16N)
	25 °C to 2300 °C (HTK 2000N)
Atmospheres	Air/inert gas, up to 1600 °C
	Vacuum (10^{-4} mbar), up to 2300 °C
X-ray geometry	Reflection



HTK 16N / HTK 2000N

Environmental heating for homogeneous sample temperature - HTK 1200 / HTK 1200 Capillary

Technical data	
Temperature range	25 °C to 1200 °C
Atmospheres	Air, inert gas, vacuum (10^{-4} mbar)
X-ray geometry	Reflection and transmission



HTK 1200 / HTK 1200 capillary

Low-temperature XRD studies between -190 °C and 600 °C - TTK 600

Technical data	
Temperature range	-190 °C to 600 °C (liquid-nitrogen cooling)
	-10 °C to 600 °C (compressed-air cooling)
Atmospheres	Air, inert gas, vacuum (10^{-2} mbar)
X-ray geometry	Reflection and transmission



TTK 600

Phase analysis is the study of the different polycrystalline materials within a sample. One phase is identified among the others due to its unique powder diffraction pattern which arises from its unique combination of composition and crystal structure.

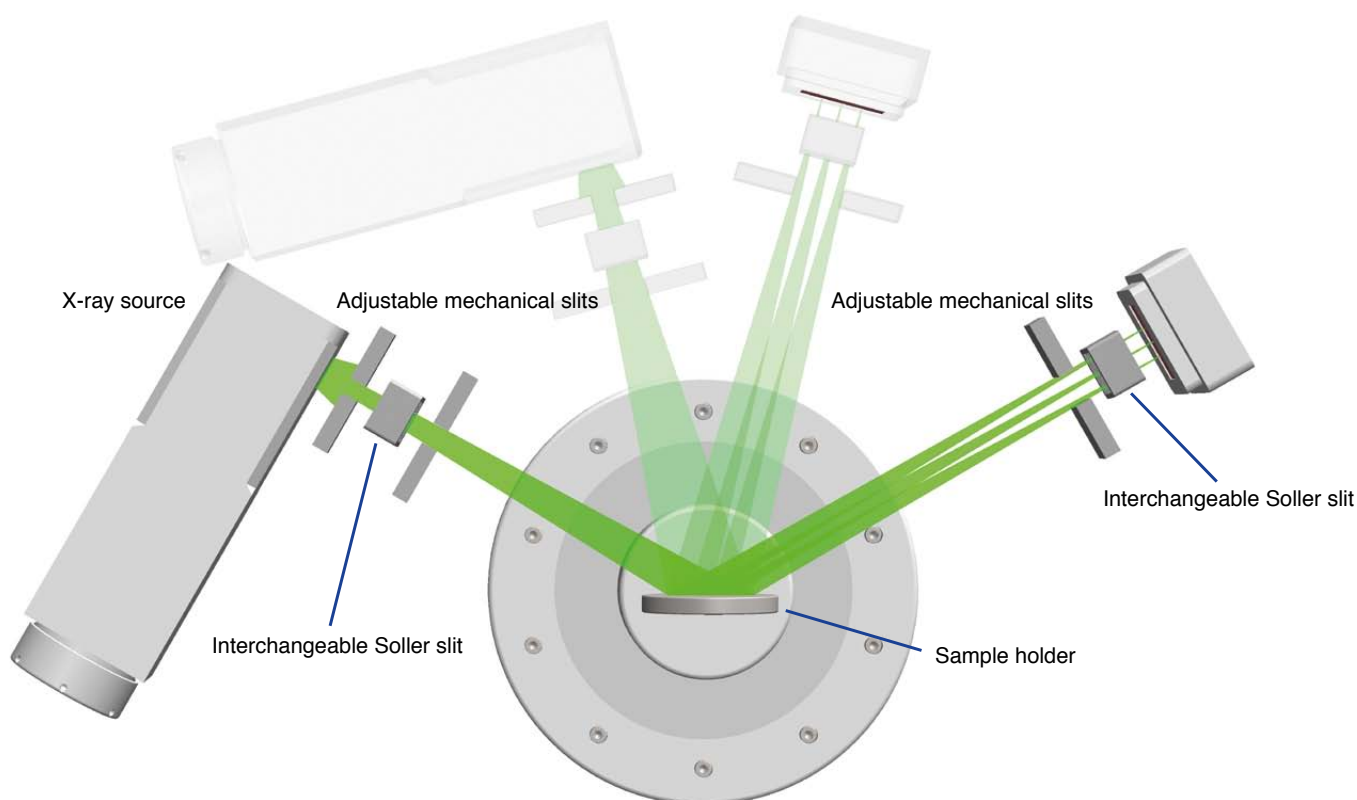
The analysis is applicable to all types of crystalline materials and can be restricted to identification only or extended to full quantitative analysis.

Mounting a capillary spinner and a multi strip linear detector, **GNR Explorer** is ready to accept powder samples prepared in glass capillaries. This option is useful for material that may be sensitive to oxidation or humidity.

With a polycapillary accessory on the incident beam plus the suitable sample stage, a spot of 0.1 mm makes it possible to carry out microdiffraction measurements on small samples such as forensic specimens. The development in manufacturing polycapillary optics is directed to a further decrease of spot size and an increase of brilliance.



Bragg-Brentano geometry

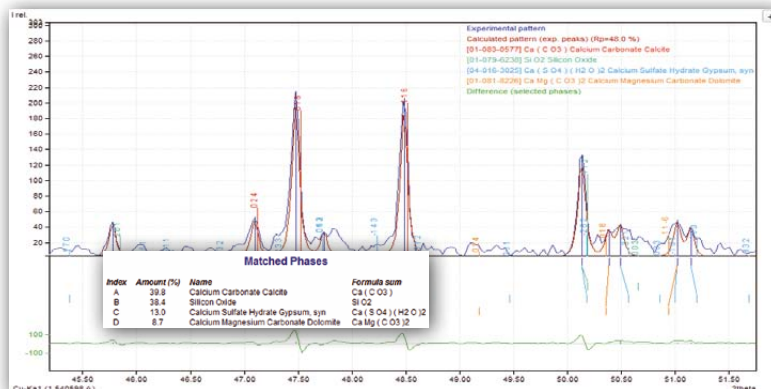


EXPLORE POWDERS

- Crystalline phases ratio (E. Calibration, RIR, Rietveld)
- Amorphous content in samples
- Crystal structure
- Phase transitions
- Crystallinity index and percentage

Phase Identification and Quantitative - Mineralogy

GNR Explorer can be used in phase identification and quantitative analysis in mineralogy domain. Match! can identify the phases present in the sample and report the weight percent composition. In this case the sample is a mixture of Quartz, Calcite, Gypsum and Dolomite.

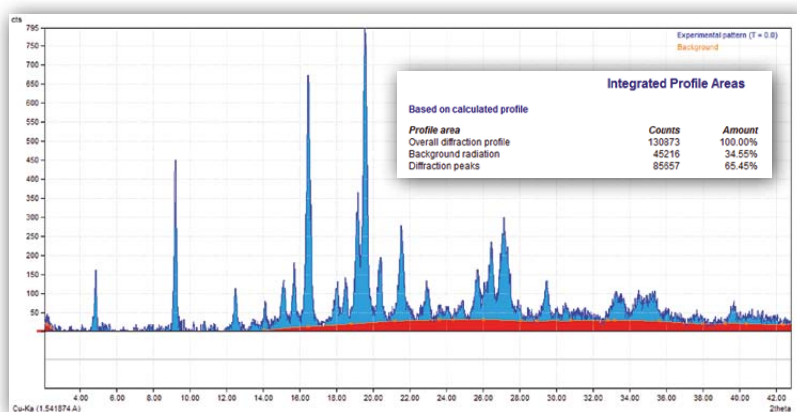


Quantitative Phase Analysis using Match!

Crystallinity Degree Calculation - Pharmaceutical

In pharma industry product development and quality assurance it is common to measure the amorphous phase amount in order to determine the degree of crystallinity.

It is important to monitor the amount of the amorphous phase within a drug because of its thermodynamic instability, relative to the crystalline state. Match! allows to determine it easily through the Degree of Crystallinity calculation.

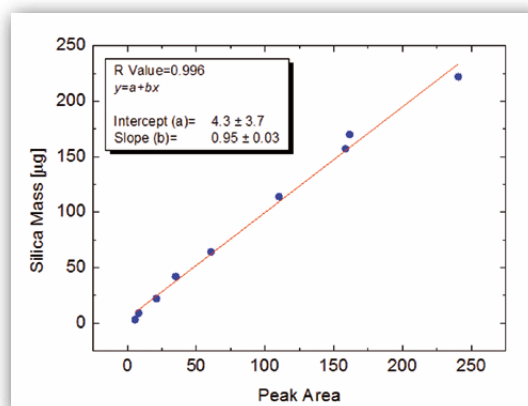
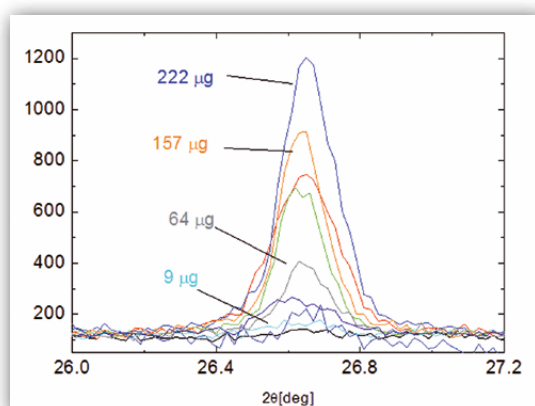


Crystallinity Degree Calculation using Match!

Silica Dust Monitoring - Environmental

Crystalline silica is a basic component of soil, sand, granite, and many other minerals. Quartz is the most common form of crystalline silica. The seriousness of the health hazards associated with silica exposure is demonstrated by the fatalities and disabling illnesses that continue to occur in sandblasters and rock drillers. Crystalline silica has been classified as a human lung carcinogen. Measuring and quantifying silica dust collected on air filter is important to protect health of workers involved in activity exposed to silica dust.

Quartz (101) diffraction peak area is proportional to the mass of silica dust deposited on a filter. Using NIST – SRM 1878 quartz standard is possible to calculate a calibration curve for silica dust mass quantification and monitoring.



Calibration curve for silica dust mass quantification

Software

GNR Explorer adopts a specific modular design software package able to support the user in all activities.

GNR software supports several type of analysis, from Data Acquisition, having the full control of all the process and hardware settings (motors, x-ray generator and tube, detector, measurement set up), to Data Analysis.

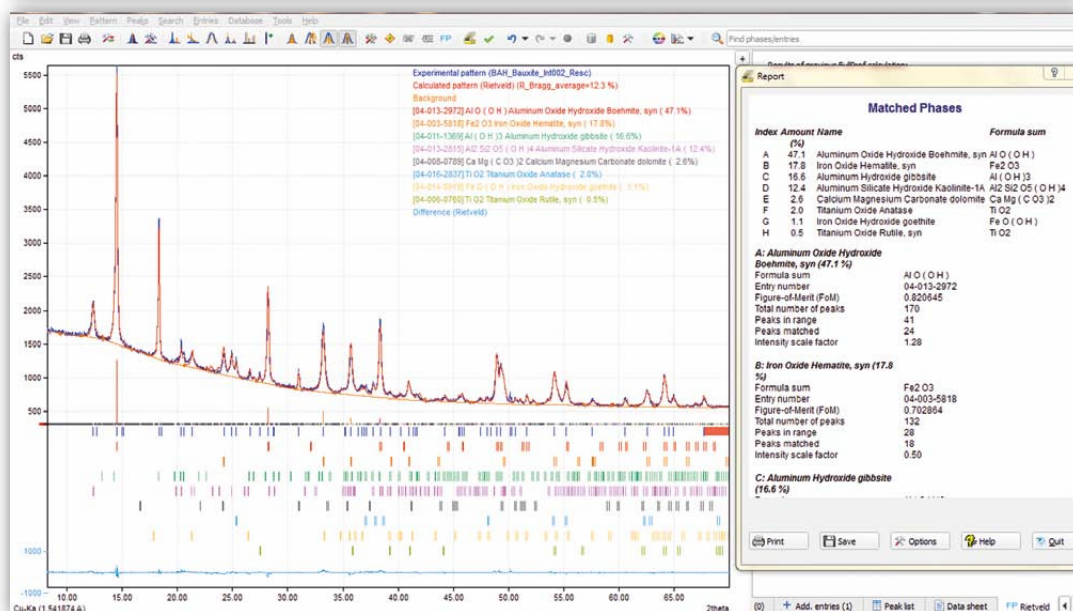
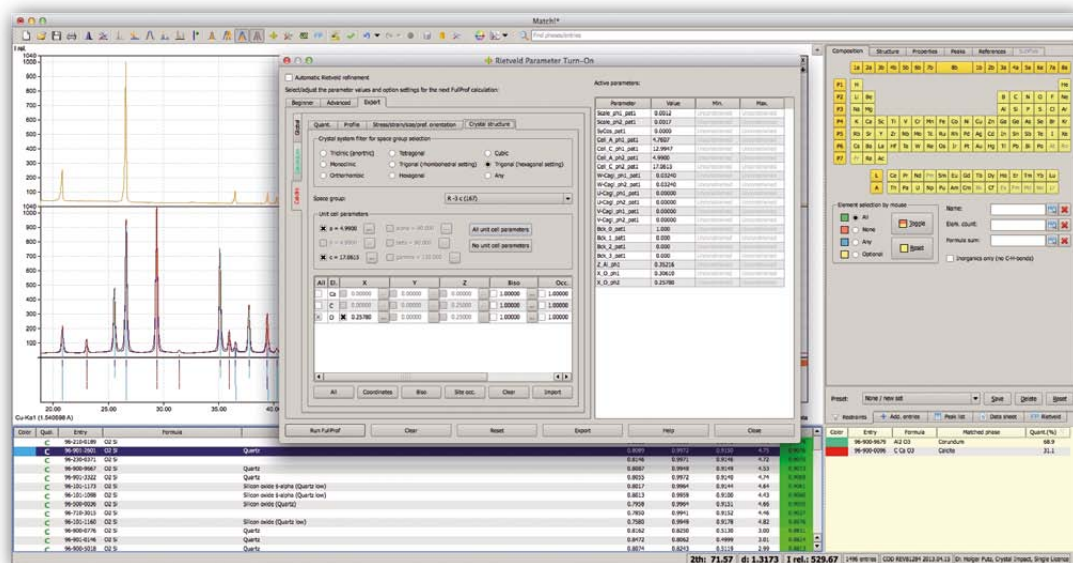
Match! is an easy-to-use software for phase identification from powder diffraction data.

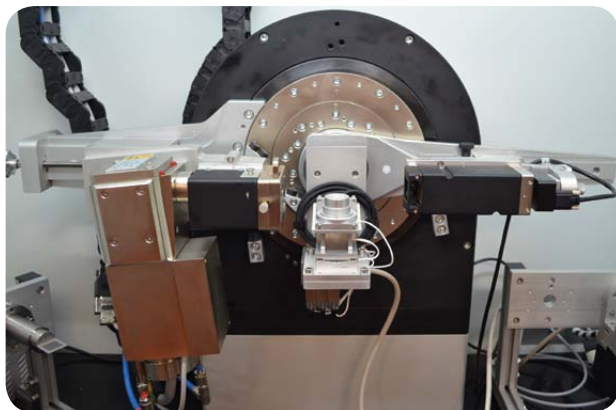
It compares the diffraction pattern of your sample to a database containing reference patterns in order to identify the phases present in the sample. Additional knowledge about the sample like known phases, chemical elements or density can be applied.

In addition to this qualitative analysis, a quantitative analysis (using either RIR method or Rietveld refinement) can be performed as well.

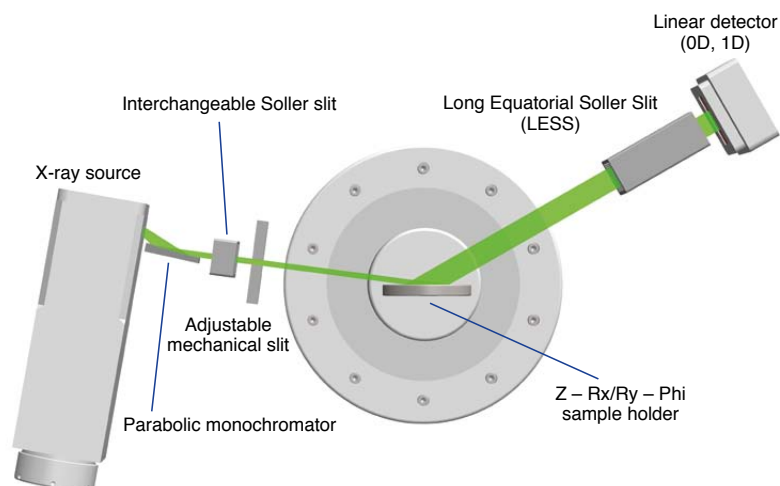
End user can easily setup and run Rietveld refinements within Match!, with the actual calculations being performed automatically, using the well-known program FullProf in the background. Match! provides a gentle introduction into Rietveld refinement, from fully automatic operation to the "Expert" mode.

As reference database, you can apply the included free-of-charge COD database and/or ICSD/Retrieve (if you have a valid license), use any ICDD PDF product, and/or create a user database based on your own diffraction patterns.





Parallel beam geometry



EXPLORE THIN FILMS

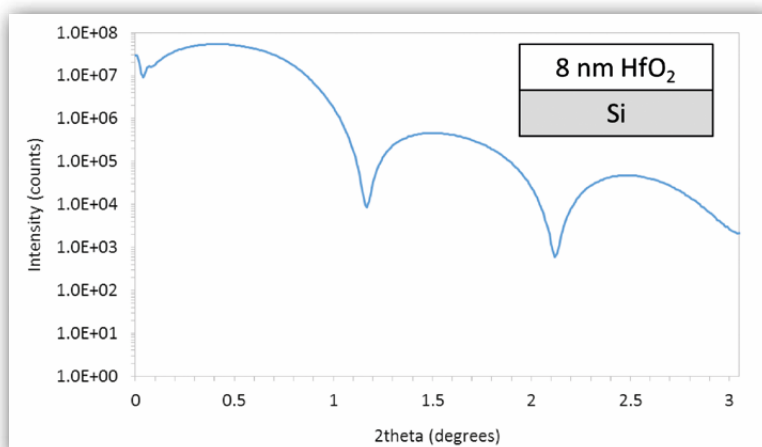
- Layer(s) phases
- Layer roughness
- Residual stress
- Layer thickness
- Layer density
- Micro-strains

Reflectometry (XRR)

The **GNR Explorer** can accomplish in a single measurement the characterisation of thin film layer thickness, density, surface and interface roughness. If the films are single or multilayer, only a few atoms or up to about 0.2 μm thick, the procedure is fast, easy and completely non destructive.

The specificity of our reflectometry configuration is based on the optimal combination of parabolic mirror, multipurpose piezoelectric sample stage, knife edge collimator and Dectris 1D detector.

The high resolution reflectometry studies can be performed with **GNR Explorer** to characterise layer thickness from 1 to 200 nm with an accuracy better than 1%, density with an accuracy better than $\pm 0.03 \text{ g/cm}^3$, surface and interface roughness from 0 to 5 nm with an accuracy better than $\pm 0.1 \text{ nm}$.

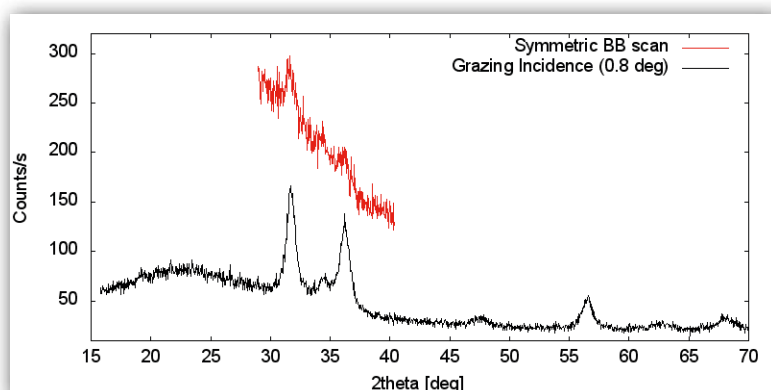


XRR - 8 nm of HfO_2 deposited on Si

Grazing Incidence Diffraction (GID)

Coatings and other thin polycrystalline layers can be measured at a fixed angle of incidence using parallel beam geometry.

Measurements can be done at low glancing angles of the X-ray beam to increase the intensity of the signal from the layers while reducing the substrate contribution. During the measurement the incidence angle remains fixed while the detector is scanned through the 2-theta range.



GID - comparison between traditional symmetric (Bragg Brentano) and grazing incidence geometry for ZnO thin film on glass substrate: the thin film signal is almost completely hidden by the glass substrate one in traditional Bragg Brentano geometry (red profile)

Parabolic mirror monochromator

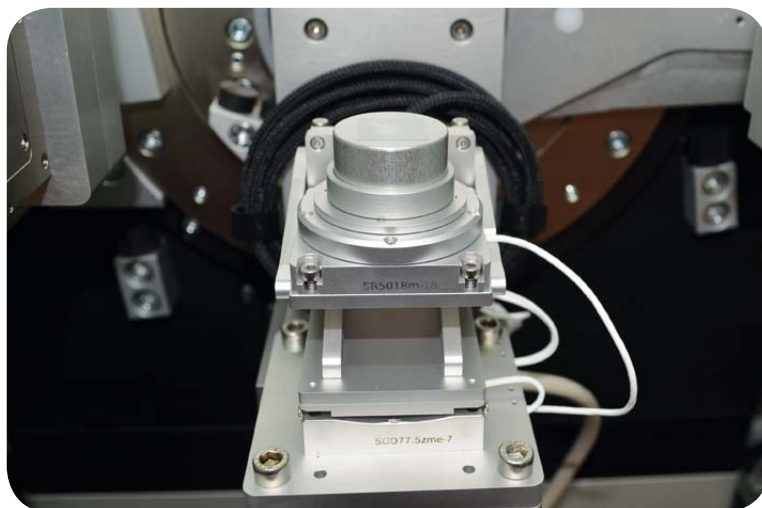
The parabolic mirror is a parabolic graded multilayer, whose purpose is to convert the divergent beam from the X-Ray tube anode into a parallel monochromatic beam in the equatorial plane. The parabolic monochromator provides additional performances for reflectivity measurements (XRR) and grazing incident diffraction (GID) with its high intensity beam.



Parabolic mirror monochromator

Z – Rx/Ry – Phi multipurpose sample holder

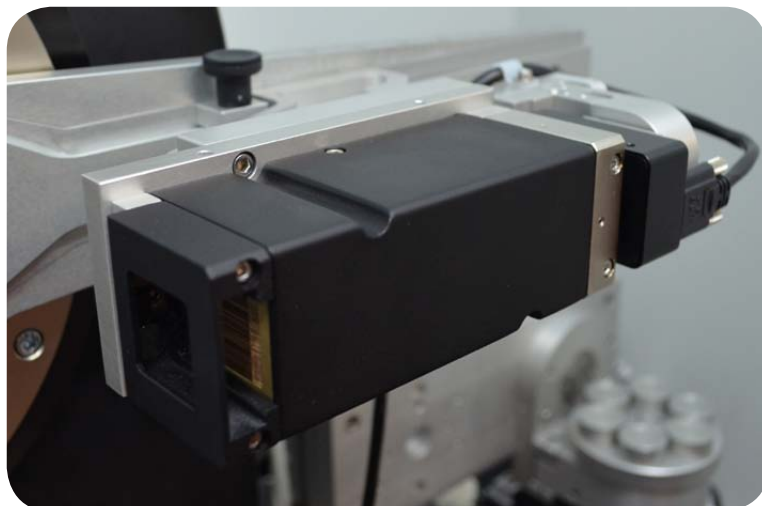
Motorized Z - Rx/Ry - Phi sample stage allows an easy and accurate sample alignment: this is very important when measuring coatings, thin films and small samples in general. Fast, accurate and software-controlled micro sample positioning, is achieved using piezoelectric motors.



Z – Rx/Ry – Phi multipurpose sample holder

Long Equatorial Soller Slit (LESS)

The Long Equatorial Soller Slit (LESS) consists of a set of parallel plates separated by equal spacers, which results in a set of narrow parallel collimators defining the equatorial acceptance angle seen by the detector. The LESS attachment is used in the Explorer diffractometer when polycrystalline samples in the form of thin film or multilayers have to be analysed with the grazing incidence geometry.



Long Equatorial Soller Slit (LESS)

RESIDUAL STRESS AND TEXTURE CONFIGURATION

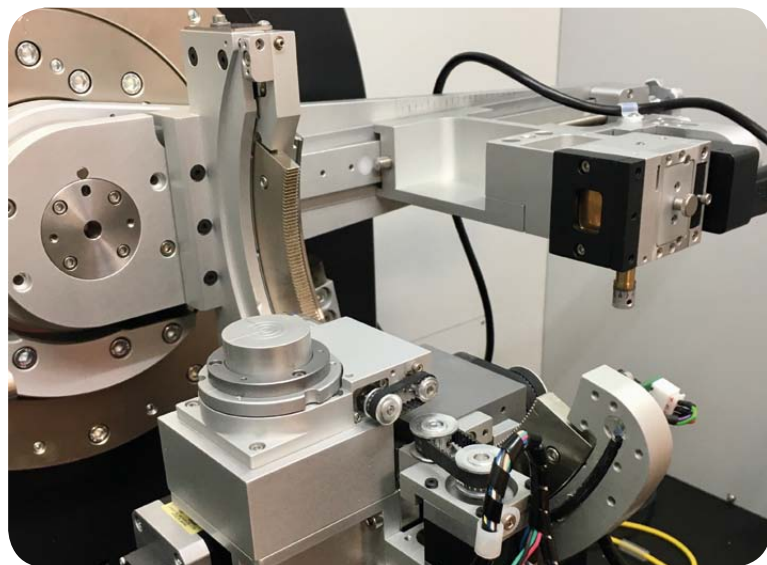
Polycrystalline materials are often characterized by a different degree of departure from the ideal random orientation of its constituent crystallites, i.e. texture. Beyond its role for correct quantitative phase analysis, texture also affects the functional properties of materials: thus, its estimation is of paramount importance in several technological fields.

Explorer diffractometer, thanks to the new Eulerian cradle and Dectris Hybrid Photon Counting linear detector, allows to perform texture analysis in an accurate and straightforward way.

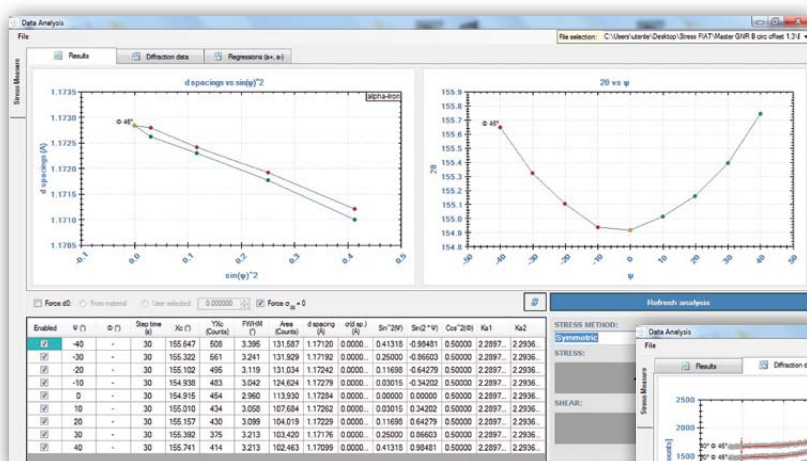
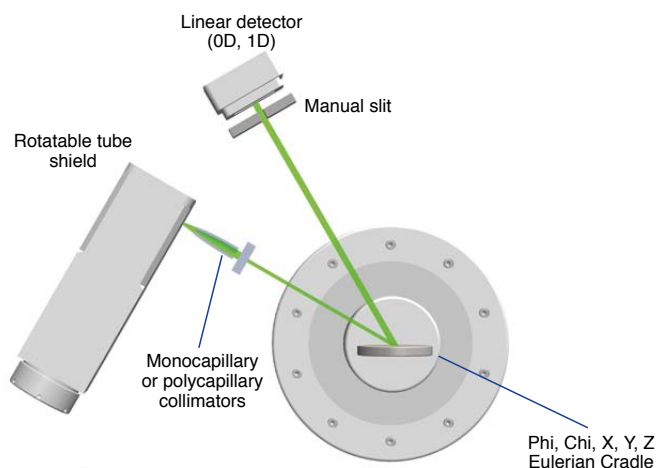
With our high precision open Eulerian cradle we can rotate, incline and adjust our sample (Φ , χ , X , Y , Z) under software control with several data collections and evaluation strategies.

Recent development in high brilliance optics and fast detectors offer result in enhanced quality and reduced time consumption.

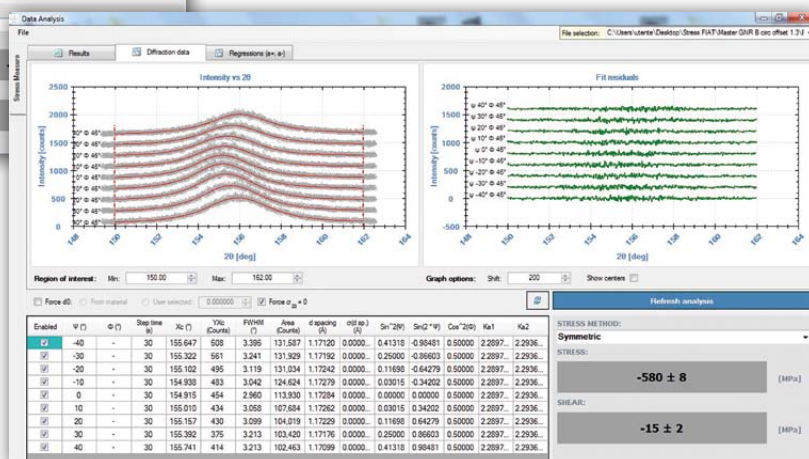
If need higher intensity at only one specific point and a high resolution with maximum speed, our polycapillary lenses together with the Dectris 1D detectors are the best choice.



Residual stress and texture geometry

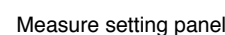


Stress analysis panel: results tab



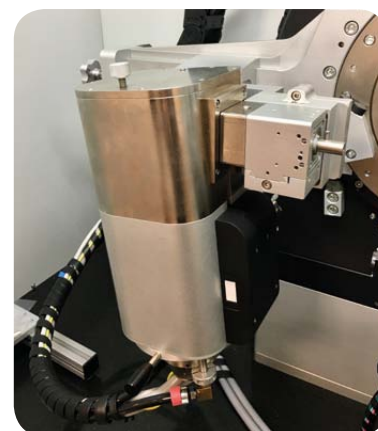
Stress analysis panel: diffraction data tab

The most important feature is the determination of the orientation distribution from 1 to 100 complete or incomplete pole figures using the discrete WIMV algorithm.



The majority of powder diffraction measurements on polycrystalline materials are done with line focus.

Hence, an easy switching from line to point focus is an important feature of a true multi-purpose diffractometer.



- Micro-strain
- Crystallographic textures (ODF, PFs, IPFs)
- Stress tensor
- Compressibility
- Deformation
- Qualitative and quantitative texture analysis

■ ■ ■ GNR Explorer in shielded glove box



GNR Explorer in shielded glove box

Radioactive materials can be characterized for chemical form and certain physical properties with **GNR Explorer** customized for containment in a shielded glove box. The glove box has several special engineered features for nuclear and X-ray safety. The facility is designed to handle alpha and beta emitting samples with moderate neutron and gamma radiation.

Samples containing plutonium and other transuranic elements can be analysed to support nuclear site, waste handling and waste stabilization operations.

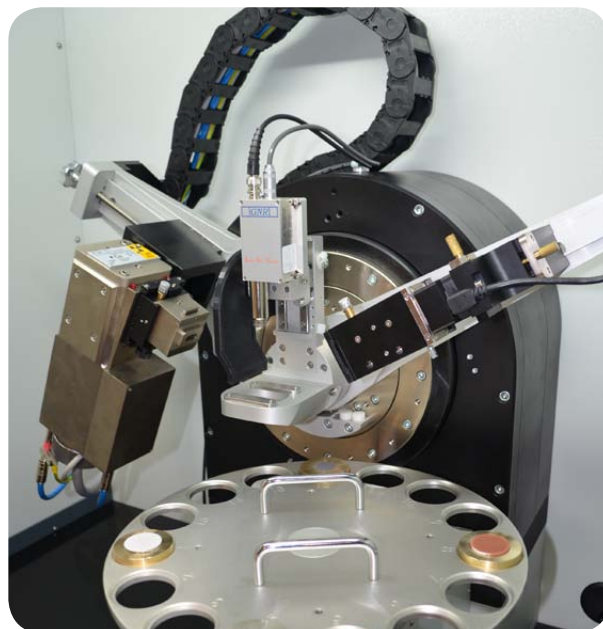
■ ■ ■ Aluminum electrolytic bath monitoring by GNR Explorer

The optimization of aluminum production process by electrolytic reduction requires constant monitoring of the bath parameters: X-ray diffraction has been an effective technique to determine Bath Ratio and Excess AlF_3 for several years.

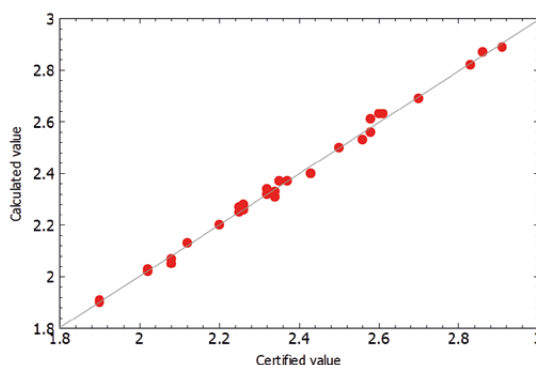
The **GNR Explorer** with Dectris 1D detector, SDD detector and 15-position auto-changer allows to cope with short available time for measurement and analysis in an easy-to-use way.

Besides, the use of a Silicon Drift Detector for XRF allows to monitor the content of both Ca and other elements of interest (e.g. K) at the same time, which can be very useful for an unconventional bath chemistry.

GNR Explorer in aluminum electrolytic bath configuration allows to determine electrolytic bath parameters (BR, CR, ExAlF_3) in a fast and easy way. Reference samples have been used to set-up calibration curves that are adopted in the analysis. User loads real production samples and analysis the results. Successful testing was performed with both Alcan Electrolytic Bath standards and custom-reference standards.

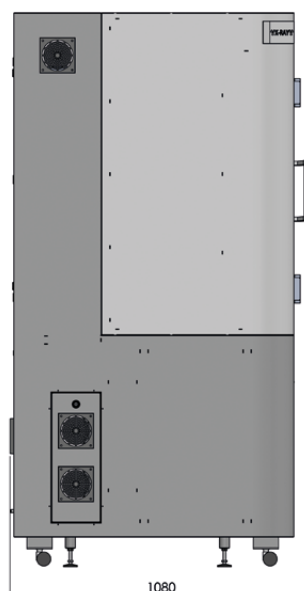
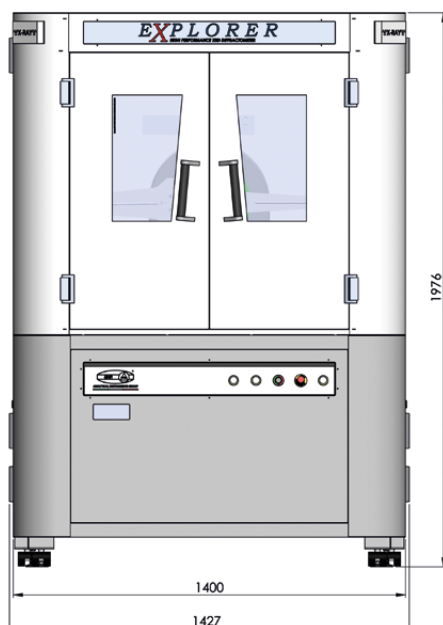


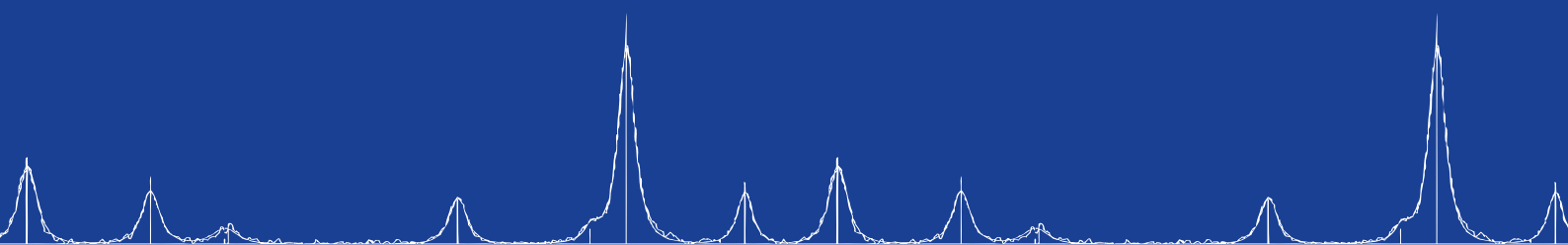
GNR Explorer in aluminum electrolytic bath configuration



CR calibration curve with customer standards
RSD=0.02

Configurations	Vertical Theta/Theta geometry
Measuring circle diameters	from 400 to 600 mm
Angular range	- 110° < 2 theta < + 168° (depends on accessories)
Angle positioning	Direct drive torque motors with optical encoders
Smallest selectable stepsize	0.0001°
Angular accuracy	Better than ± 0.01° over the whole 2-Theta range
X-ray generator	3 kW (option 4 kW)
Max. output voltage	60 kV
Max. output current	60 mA (option 80 mA)
Voltage step width	0.1 kV
Current step width	0.1 mA
X-ray tube	Glass (option ceramic), Cu anode (option: Co, Fe, Cr, Mo, W, Ag)
Focus	0.4x12 mm LFF (Long Fine Focus) (options: 0.4x8 mm FF; 1x10 mm NF)
Detectors	Scintillation counter Dectris 1D multi strip detectors Silicon Drift Detectors (SDDs)
External dimensions	Width 1427 mm, height 1976 mm, depth 1080 mm
Weight	605 Kg
Water cooling supply (without optional water chiller)	Min. flow rate: 4l/min – Pressure 4 bar to 6 bar
Maximum power consumption (including water chiller)	10 kVA





Local Agent



G.N.R. S.r.l.
 Via Torino, 7
 28010 Agrate Conturbia (NO) - Italy
 Tel. +39 0322 882911
 Fax +39 0322 882930
 E-mail: gnrcomm@gnr.it - gnrtch@gnr.it
www.gnr.it