MiniFlex

Materials analysis by X-ray diffraction

Advanced benchtop X-ray diffractometer

Rigaku

Leading With Innovation

6th generation benchtop X-ray diffractometer

More power
More flexibility
More results

6th generation MiniFlex retains the characteristics that have made it popular for so many years:

- Compact size allows it to be installed on a lab bench
- ½ the cost of a traditional floor-standing diffractometer
- Distinguished scientific literature record
- Easy to use, operate, and maintain
- Able to use pre-existing utilities
- 600 W of X-ray tube power

The latest version has advanced features and options that deliver powerful capability, including:

- HyPix-400 MF – 2D hybrid pixel array detector
  - Acquire data in 2D, 1D or 0D modes
- D/teX Ultra – 1D advanced silicon strip detector
  - Uniquely available with receiving monochromator
- ASC-8 – unique 8-position autosampler

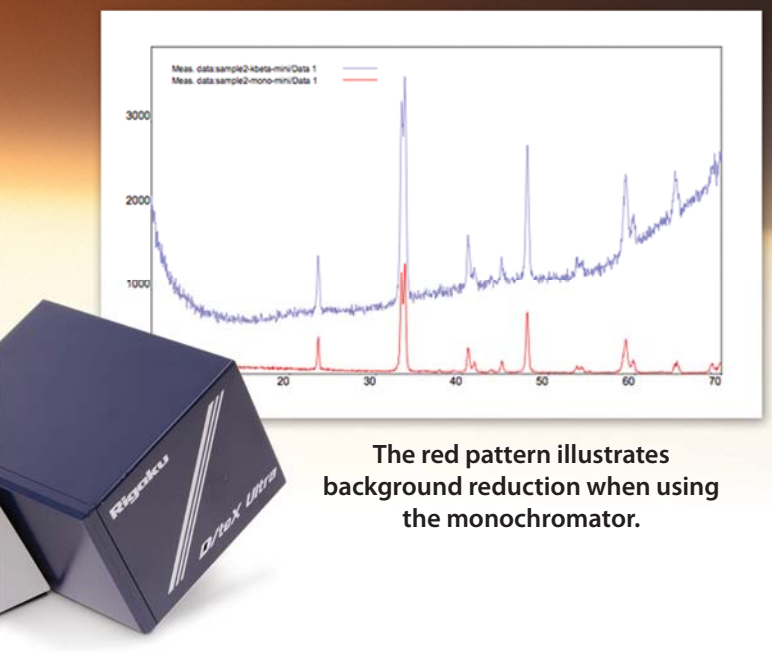
MiniFlex

Rigaku's MiniFlex benchtop XRD redefines X-ray diffraction

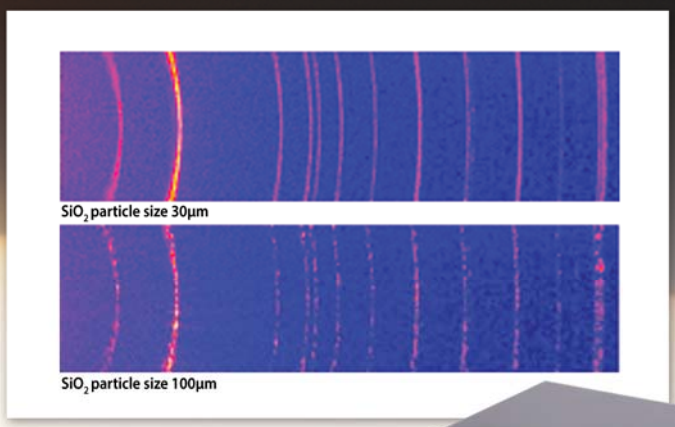
X-ray diffraction (XRD) is a powerful and well-established technique for analyzing materials. Industries as diverse as cement, catalysis, petroleum, energy and pharmaceuticals rely on XRD to characterize materials from basic research all the way to quality control. It is also an important scientific technique taught to students who study geology, material science, chemistry and crystallography.

Rigaku MiniFlex is a fully featured, general purpose X-ray diffractometer. It can perform qualitative and quantitative analysis of polycrystalline materials. In qualitative analysis, the instrument is used to identify unknown substances (chemical compounds or "phases") by comparing experimental diffraction data against a database of known phases. In quantitative analysis, it is used to characterize solid mixtures to determine relative abundance of crystalline compounds.

Two detector choices



The red pattern illustrates background reduction when using the monochromator.



2D data example from HyPix-400 MF detector.

D/teX Ultra
1D silicon strip detector

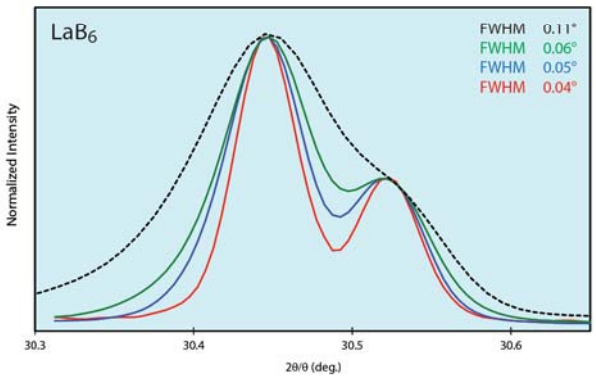
MiniFlex is equipped with the D/teX Ultra high-speed 1D (one dimensional) silicon strip detector to obtain intensity a few tens to roughly 100 times greater than a conventional scintillation counter. D/teX Ultra measures data faster because it can measure a wide range of 2θ simultaneously with high angular resolution.

D/teX Ultra may be operated in 0D mode equipped with an optional graphite monochromator (shown above) to maximize sensitivity by optimizing peak-to-background ratios. In addition, this option eliminates fluorescence from materials containing Fe, Ni, Co, and Mn.

HyPix-400 MF
2D hybrid pixel array detector

MiniFlex can also be configured with the HyPix-400 MF 2D (two dimensional) hybrid pixel array detector (HPAD). This new direct photon counting detector enables high-speed, high-dynamic range, low-noise data collection in 0D, 1D, and 2D modes. This highly versatile detector is ideal for the widest range of applications, including conventional powder XRD, micro-XRD, and the measurement of complex materials with coarse grain size and/or preferred orientation.

Choice of optical components for optimal resolution



MiniFlex X-ray diffractometer

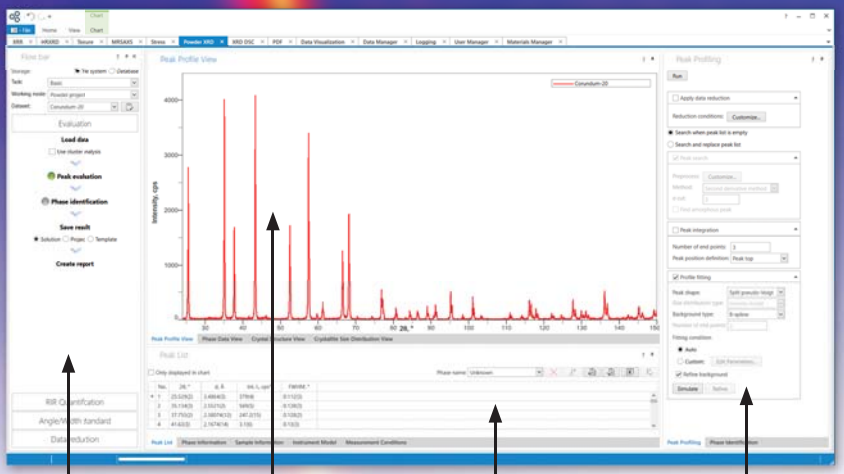
Analysis software

SmartLab Studio II is a new software package with a user-friendly GUI that integrates all measurements and analyses. Users can choose desired modules from various plugins, such as "XRD Measurement", "Powder XRD", and "Data Manager", and operate them on a single platform with an improved analysis environment and operability.

SmartLab Studio II employs a workflow bar to guide users through the necessary steps from setup and measurement to analyzing and reporting, so instrument operation is always straightforward.

SmartLab Studio II has a rich feature list:

- Search/Match analysis
- Percent crystallinity
- Cell refinement
- Indexing
- *Ab initio* structure solving
- Quantitative analysis
- Crystallite size and strain
- Whole pattern profile fitting
- Rietveld refinement
- Lattice parameter refinement



Options and accessories

D/teX Ultra: 1D Si strip detector
High-speed, 1D silicon strip detector standard for fast, high-resolution scanning in 0D and 1D modes.

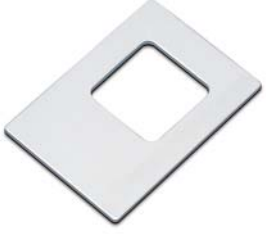
Graphite monochromator for the D/teX Ultra
The graphite monochromator optimizes sensitivity by lowering the background level. It improves signal-to-noise by eliminating fluorescence from materials containing Mn, Fe, Co, and Ni.

HyPix-400 MF: 2D HPAD detector
Optional advanced hybrid pixel array detector (HPAD) with zero background noise, an active area of 400 mm^2, spatial resolution of 100 µm, and maximum count rate of 10^6 cps/pixel or more. HyPix-400 MF can operate in 0D, 1D or 2D modes.

ASC-8 automated sample changer
Automatic 8-position sample changer with spinner.

Sample spinner
The sample spinner allows continuous rotation to minimize the effects of preferred orientation.

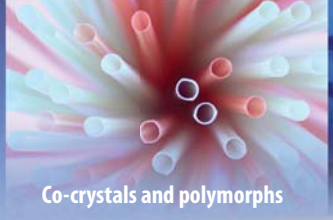
BTS 500 and BTS 150 heating and cooling temperature attachments
The high temperature attachment can heat a sample to perform *in situ* powder diffraction measurements under high temperature conditions from ambient to 500°C.



Sample holders
Various sample holders are available to meet the specific needs of each lab.

Air-sensitive sample holder
An air-sensitive sample holder is available for users studying materials that might degrade in the presence of air.

Software


Co-crystals and polymorphs


Exploration and petrochemicals


Geology, mining and cement

SmartLab Studio II software

SmartLab Studio II is a new Windows-based software suite developed for the flagship Rigaku SmartLab X-ray diffractometer that integrates user privileges, measurements, analyses, data visualization and reporting. Newly available for the MiniFlex, the modular (plugin) architecture of this software delivers state-of-the-art interoperability between the functional components. Just one click switches from measurement to analysis. Watch real-time scans from one experiment while simultaneously analyzing other data on the same desktop by selecting an appropriate layout. The software provides various analysis tools such as automatic phase identification, quantitative analysis, crystallite-size analysis, lattice constants refinement, Rietveld analysis, *ab initio* structure determination, etc.

Powder XRD: phase identification with a variety of available databases[*1]

Peak position, FWHM, integrated intensity and crystallite size are calculated by profile fitting. Rigaku's optional "Hybrid Search/Match" uses peak-base qualification, which detects heavily distorted lattices, to identify solid solution phases that are difficult to identify. It also can determine whether preferred orientation exists based on decomposed peak intensities.

Database name	Contents	Number of entries[*2]	Structure parameters[*3]	License term[*4]
ICDD PDF-2	Mainly inorganic compounds	304,114	None	Five years
ICDD PDF-4+	Mainly inorganic compounds	412,083	70%	One year
ICDD PDF-4/ Minerals	Mainly inorganic compounds (minerals)	46,101	75%	One year
ICDD PDF-4/ Organics	Mainly organic compounds	535,600	20%	One year
ICDD PDF-4/ Axiom	Mainly inorganic compounds	87,988	70%	Three years
COD	Inorganic 25%, organic 75%	353,972	100%	Unlimited (Free of charge)
Rigaku cement DB	Cement based compounds	72	100%	Unlimited (for purchase)

*1 These databases do not support network licenses, and must be purchased for every PC in use.
*2 Number of entries are as of 2019.
*3 The rate of structure parameters stored in each database.
*4 Each database may be renewed.

Powder XRD: quantification package

This option supports internal standard, external standard, and standard addition calibration methods. Calibration curves are used to quantify specific phases in the sample.

Powder XRD: comprehensive analysis package

This optional package can provide analysis results such as crystalline size, lattice strain, lattice parameters refinement, % crystallinity based on fully automated profile fitting executed after loading measured data. Results obtained aid in understanding the relationship between structure and physical properties, and allow users to compare results across different samples.

Powder XRD: direct derivation analysis package

The direct derivation (DD) method was invented by Professor Hideo Toraya of Rigaku Corporation in 2016. It quantifies phases from all integrated diffraction intensities and the chemical formulas of each phase found. Compared to the classical RIR method, where a single integrated peak intensity and RIR number are used, the DD method is less affected by preferred orientation and peak overlap.

Powder XRD: Rietveld analysis package

The package performs phase identification followed by Whole Powder Pattern Fitting (WPPF). The Rietveld analysis refines crystal structure or quantifies the phases directly from measured data, requiring neither reference samples nor a calibration curve. The whole powder pattern decomposition (Pawley method) is based on both the measured peak positions, and peaks shapes.

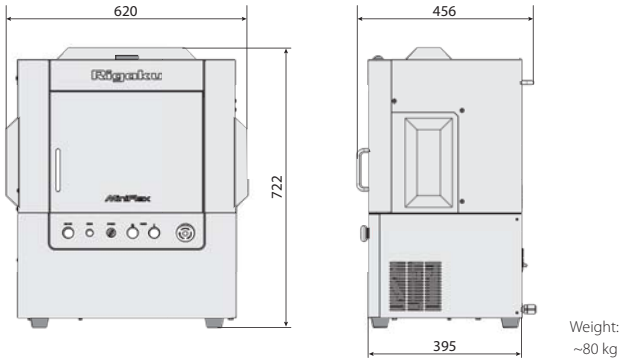
Legacy of innovation

The Rigaku MiniFlex X-ray diffractometer is historically significant in that it was the first commercial benchtop (tabletop) X-ray diffraction instrument. When introduced in 1973, the original Miniflex™ XRD was about one-tenth the size of, and dramatically less expensive than, conventional X-ray diffraction (XRD) equipment of the period. The original instrument (Gen 1), and its successor that was introduced in 1976 (Gen 2), employed a horizontal goniometer with data output provided by an internal strip chart recorder. The third generation (Gen 3) instrument, introduced in 1995, was called Miniflex+. It provided a dramatic advance in X-ray power to 450 W (by operating at 30 kV and 15 mA) and Windows® PC computer control. Both the Miniflex+ and the succeeding generation products employ a vertical goniometer and allow the use of an automatic sample changer. The fourth generation (Gen 4) MiniFlex II instrument was introduced in 2006 and offered the advance of a monochromatic X-ray source and a D/teX Ultra 1D silicon strip detector. The fifth generation (Gen 5) MiniFlex600 system, introduced in 2012, built upon this legacy with 600 W of available power and new PDXL powder diffraction software.

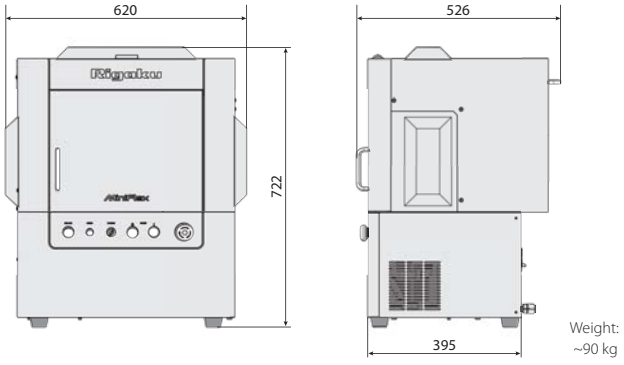
Specifications		
Software	Control	SmartLab Studio II
	Data analysis	SmartLab Studio II
Generator	Maximum power	600 W
	Tube voltage	40 kV
	Tube current	15 mA
	Shutter	Rotary shutter linked to interlock
	X-ray tube	Cu
Optics	Divergence slit	Fixed or Variable
	Scattering slit	Fixed
	Receiving slit	Fixed
	Filter	K_β Foil filter
Goniometer	Type	Vertical
	Radius	150 mm
	Scanning range	-3 to 145° (θ-2θ)
	Scanning speed	0.01 to 100°/min (2θ)
	Minimum step width	0.005° (2θ)
	Accuracy	±0.02°
Detector	D/teX Ultra	1D High speed silicon strip detector
Power	MiniFlex600	1ϕ AC100 to 240V ±10% 50/60 Hz ±1% 1.0 kVA
	MiniFlex600-C	1ϕ AC100 to 240V ±10% 50/60 Hz ±1% 1.1 kVA
	PC	1ϕ AC100 to 240V ±10% 50/60 Hz ±1% 0.7 kVA
Options	X-ray tube	Co, Fe or Cr
	Attachment	Sample spinner Automatic sample changer for 8 samples BTS 150, BTS 500 temperature attachment
	Sample holder	Air-sensitive sample holder Zero background sample holder Bulk sample holder
	Monochromator	Graphite for detector
	Detector	HyPix-400 MF 2D hybrid pixel array detector

Versions

MiniFlex600 External chiller



MiniFlex600-C Internal chiller



Unit: mm

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