ALROSA GROUP

INNOVATION CENTER

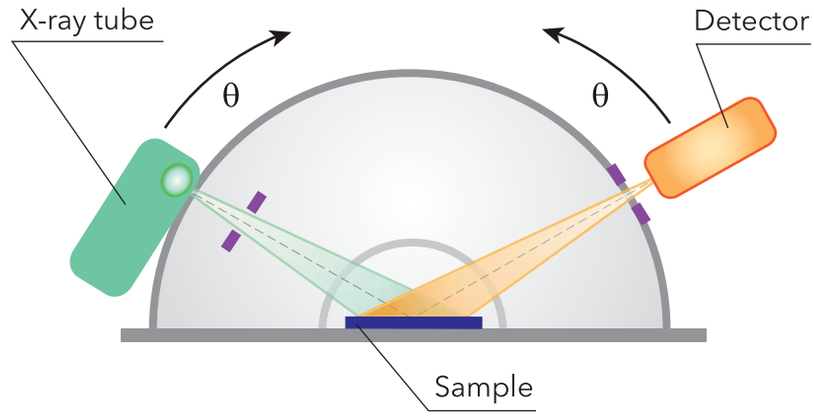
BOUREVESTNIK

RESEARCH ✦ DESIGN ✦ PRODUCTION

DRON-7M and DRON-8/8T X-ray Diffractometers

DRON-8/8T X-ray Multifunctional Diffractometer

- High-precision wide-angle vertical goniometer with changeable radius
- Automated alignment of sample plane
- Implementation of various X-ray diffraction techniques
- Flexible design and wide range of options
- Variety of X-ray optical schemes
- Remote control of all devices and systems



DRON-8/8T X-ray general purpose diffractometer with vertical θ–θ goniometer and horizontal sample plane enables to perform X-ray diffraction analysis of phase composition, structural state and orientation of wide range of crystalline objects with different shape and size.

Technical data

Technical parameter		DRON-8/8T	DRON-7M
Goniometer type		Vertical θ–θ	Horizontal 2θ–θ
X-ray optical scheme		Bragg-Brentano/Debye-Sherrer/parallel-beam	
Radius R, mm		180 – 250	200
Angular range, deg	2θ	from -10 to 165	from -100 to 165
	θ		from -180 to 180
	θ_F	from -5 to 165	
	θ_D	from -5 to 95	
Scanning modes		discrete/ continuous	
Scanning methods		θ–θ, θ_F, θ_D, Ω, 2θ-Ω, ψ, $\sin^2\psi$	θ–2θ, 2θ, θ, 2θ-Ω
Smallest addressable increment, deg		0.0005/0.0001	0.001
Scanning rate, deg/min		0.1 - 50	
Reproducibility, deg		±0.001/±0.0001	±0.0025
Maximum angular speed, deg/min		600/2000	720
Radiation doze rate, mSv/h		Not more than 1	

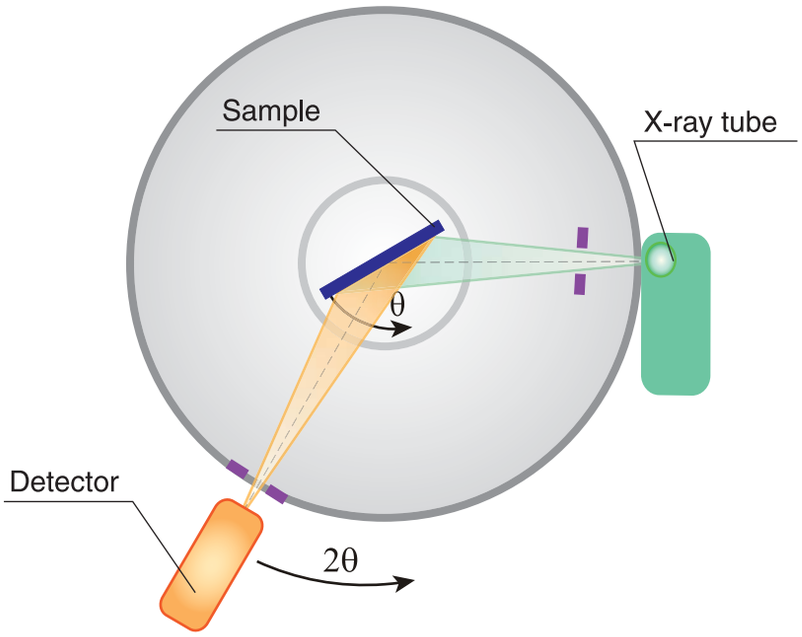
DRON-7M X-ray General Purpose Diffractometer

Horizontal two-circle 2θ–θ goniometer

High reliability and user-friendly operation

Flexible design and wide range of options

High automation for setting and measurements

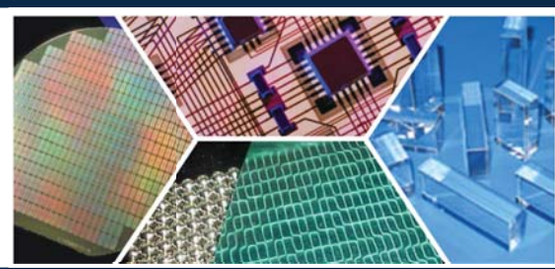
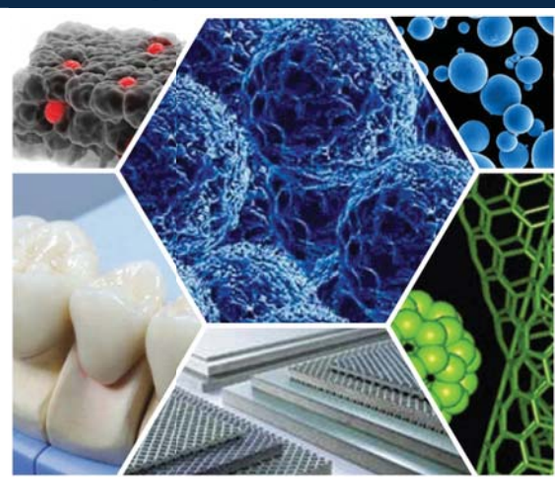


DRON-7M X-ray diffractometer is capable to solve a wide variety of tasks for powder diffraction analysis. Independent control of 2θ and θ movements allows research of single crystals.

Basic configuration includes:

- Protective cabinet with interlock system of doors
- Two-circle goniometer
- High-voltage power supply for X-ray tube
- X-ray tube with Cu anode
- Scintillation NaI detector
- Rotating sample holder for powders
- X-ray collimation system with a set of changeable slits
- Beta-filter : Ni (for copper radiation)
- Reference sample of polycrystalline quartz
- Data Collection software package for control and data collection
- Set of spares tools, accessories and replacement parts
- Personal computer

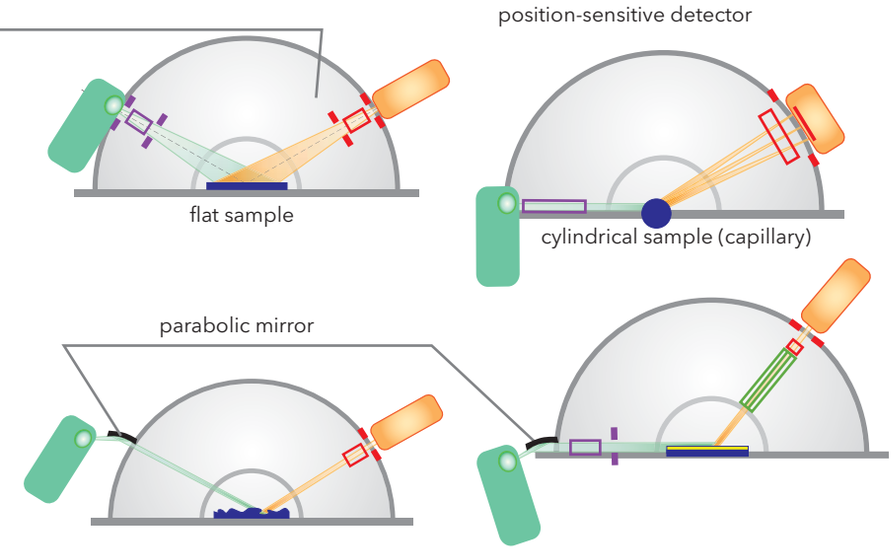
Applications of DRON-7M and DRON-8/8T X-ray Diffractometers

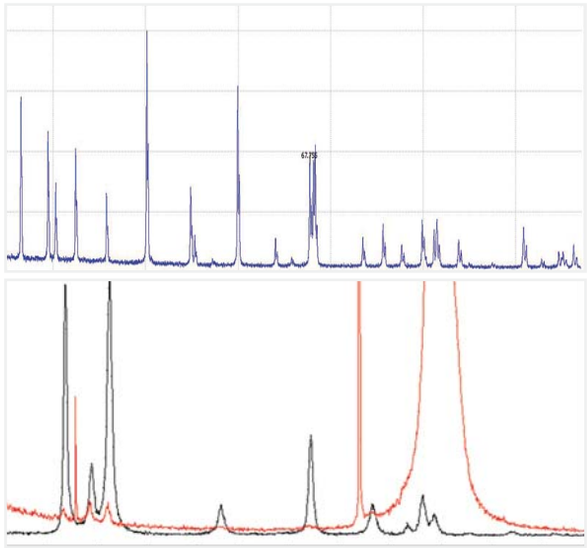
Application fields	Problems	Samples
Powder diffraction analysis in Bragg-Brentano,		
Mining industry Mineralogy Construction Machinery Energetics Oil and gas industry Chemistry Electronics Criminalistics Forensics Pharmaceuticals Crystallography Nanotechnology Examination of cultural valuables Ecology	• Qualitative and quantitative phase analysis of polycrystalline materials and objects including coatings and thin films. • Determination of crystallinity, crystallite sizes and microstrains of lattice. • Determination of lattice type and dimensions, crystal structure refinement. • Tracing of phase transitions, chemical reactions and thermal deformations of lattice in variable environment (temperature, pressure, humidity, gaseous medium or vacuum).	
Analysis of residual stresses, textures		
Metallurgy Machinery Electronics Technical crystals	• Analysis of preferred orientation of particles in metals and in other polycrystalline materials. • Determination of linear, planar and volumetric stresses in welded seams, parts and frameworks. • Determination of orientation of single crystals and different articles made of them.	
Analysis of thin films structure and		
Micro- and nano-electronics	• Determination of composition, thickness, mismatch and defects of layers in thin films, epitaxial and nanoheterostructures. • Quality control of materials for micro- and nanoelectronics.	
Structure investigation of nanomaterials		
Catalysis Colloid chemistry Electronics Molecular biology Automotive- and aircraft industry (plastics and polymers) Protection of main pipelines and cable industry Packaging industry (nanocomposites and films)	• Determination of shape, size, phase composition, internal structure, orientation and distribution of nanoparticles in surface-active material, emulsions (including in biological mediums), fibres, catalysts, polymers, nanocomposites, liquid crystals and other disperse systems.	

X-ray optical schemes

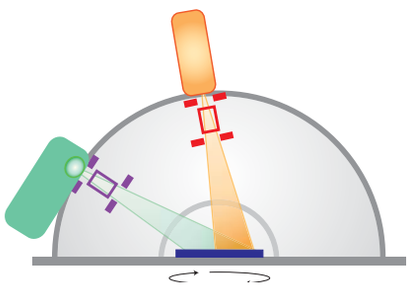
Typical diffraction patterns

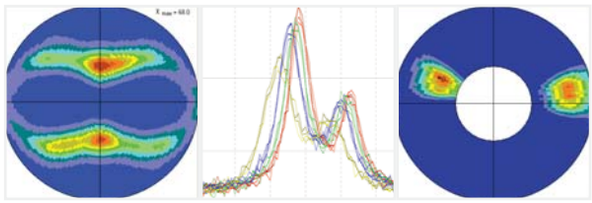
Debye-Sherrer, grazing incidence and parallel-beam geometries.



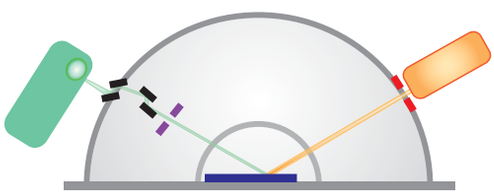


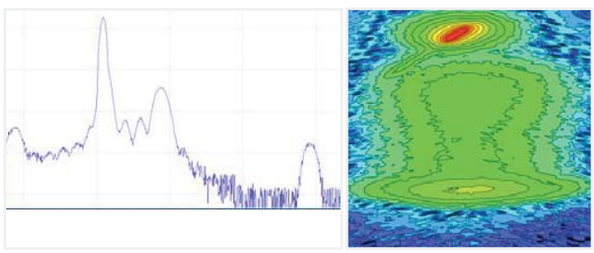
determination of crystal orientation



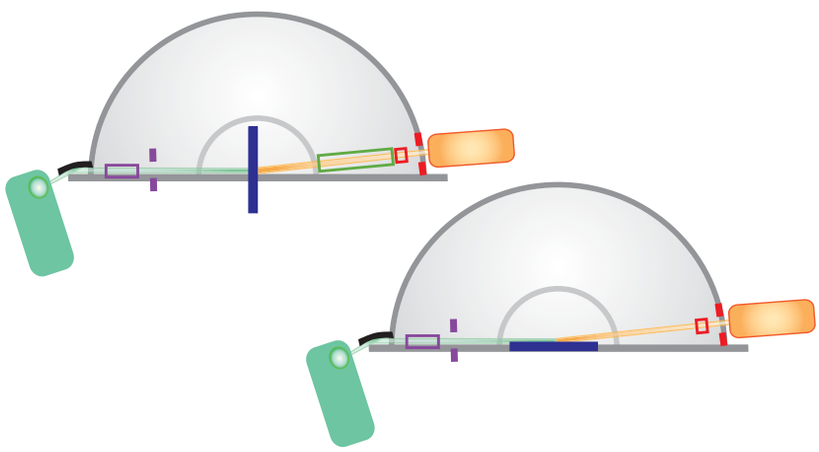


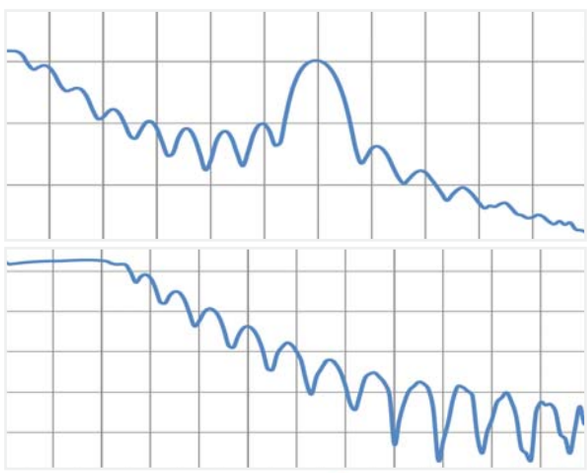
single crystals in high resolution geometry



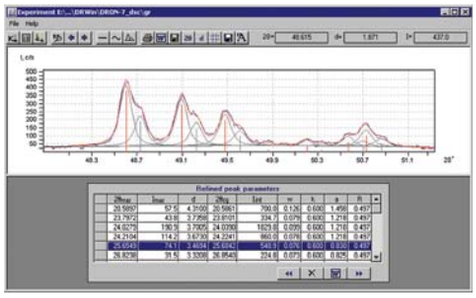


by small-angle X-ray scattering and reflectometry





Software for DRON-7M and DRON-8/8T X-ray Diffractometers

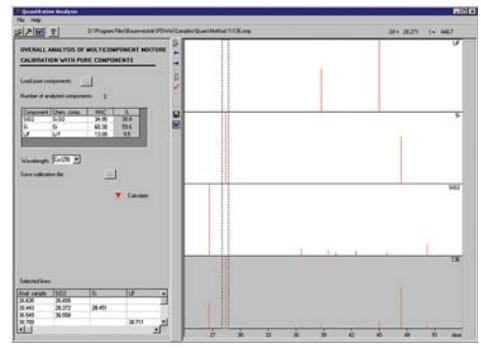


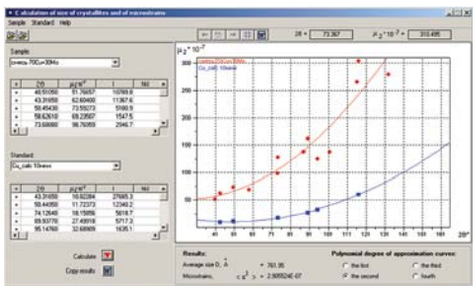
Data processing - DrWin

- Processing of diffraction pattern or selection
- Background approximation (by polynomial or user curve)
- Separation of Kα-doublets
- Peak seach and determination of their anglular positions
- Approximation of reflection profiles by pseudo-Voigt function (for the entire array or independently for each peak)
- Calculation of peak heights and their integral intensities
- Calculation of FWHM of reflections

Quantitative phase analysis - Quan

- Overall analysis of multicomponent mixture
- Analysis of n-component system
- Analysis of sample with known mass absorption coefficient
- Method of internal standard
- Method of Reference Intensity Ratios (RIR's)
- Method of additives
- Method of reduction



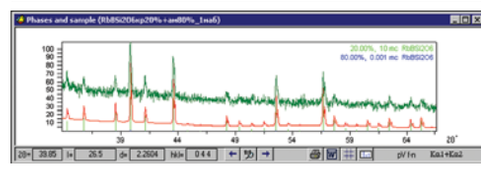


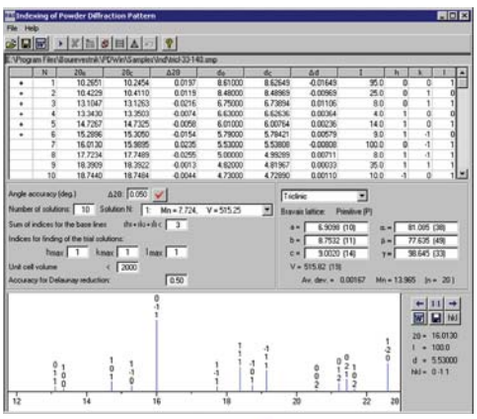
Calculation of average size of coherent domains and of microstrains - Size&Strain

- Calculation of size of coherent domains and microstrains by the method of second central moments
- Calculation of instrumental line broadening
- Application of absorption correction to the samples with another composition

Calculation of theoretical diffraction pattern - TheorPattern

- Simulation of diffraction patterns of multicomponent mixtures from structural data
- Account for of instrumental factor
- Account for texture and crystalline size for each component
- Comparison of simulated and measured diffraction patterns
- Integrated package of geometrical crystallography

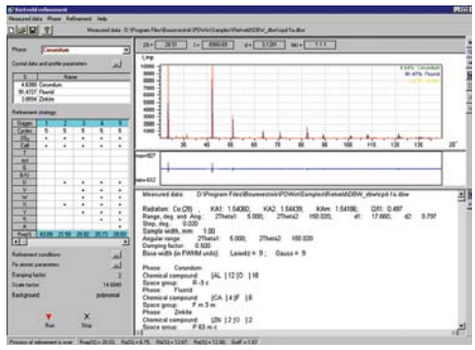




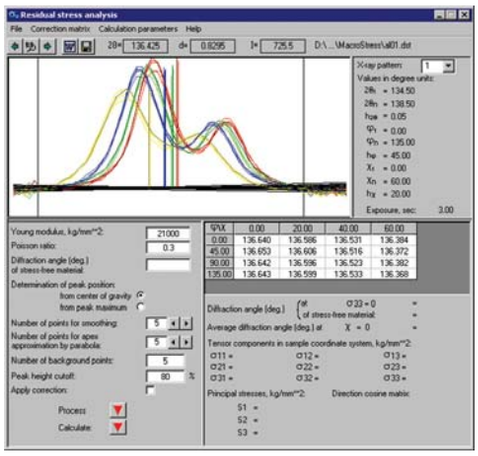
Auto indexing of Powder Diffraction Pattern - Ind

- Determination of Bravais lattice type
- Choice of unit cell
- Computation of Miller indices for selected lines
- Bar graph of input diffraction pattern

Full profile analysis by Rietveld method - Rietveld



- Refinement of crystal structures from X-ray powder diffraction data of single crystalline phases and mixtures
- Calculation of polynominal and physical background
- Independent refinement of U, V, W, X, Y profile for different phases and for different groups of reflections
- Refinement of unit cell parameters, atomic and thermal parameters, occupations of atomic positions for each phase
- Choice of refinement strategy
- Control of Refinement conditions
- Calculation of five R-factors

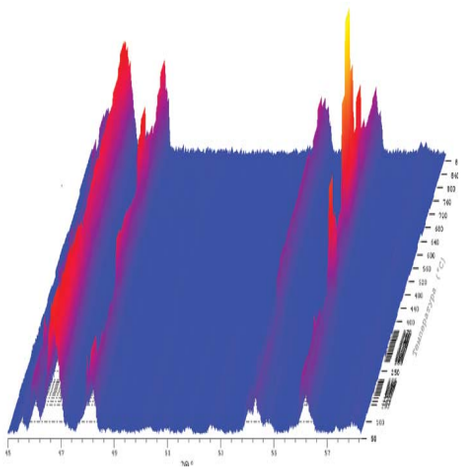


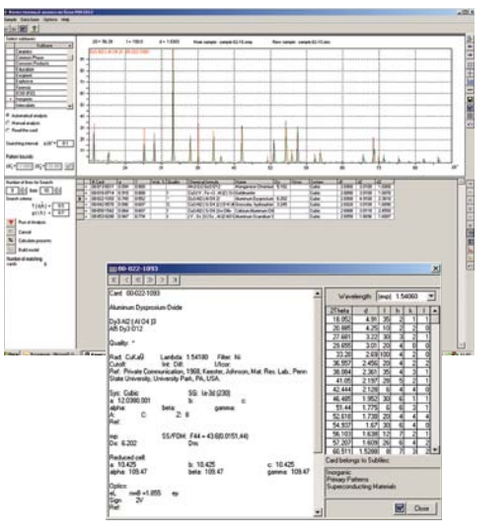
Residual stress analysis - MacroStress

- Calculation of peak angular position from center of gravity or from peak topapex
- Application of correction matrix
- Calculation of linear, planar and volumetric stresses
- Calculation of stress deviations

High temperature-X-ray diffraction - Thermo

- 3D-imaging of measured data in “diffraction angle - intensity - temperature” co-ordinates
- Calibration of the measured data set by internal or external standard
- Refinement of unit cell parameters of the calibrated data set
- Determination of phase transition points
- Determination of thermal expansion coefficients (TEC) in different directions and thermal deformation tensors
- Building of TEC figures



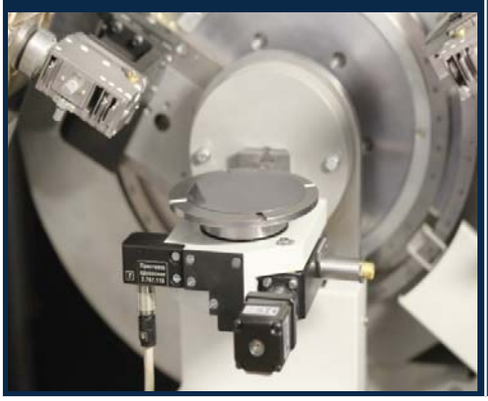
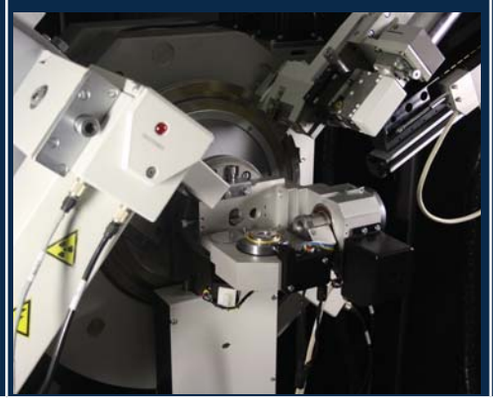
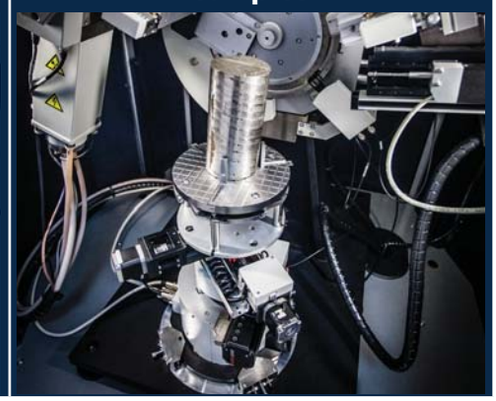


Qualitative phase analysis and access to the Powder Diffraction File database - Retrieve and Search-Match

- Use of PDF-2/PDF-4 database of International Center of Diffraction Data (ICDD) for qualitative analysis
- Automatic or manual search algorithm
- Creation of user subbases for search facilitation
- Addition of user standards into subbases
- Qualitative phase analysis by different criteria, bases (subbases)
- Analysis of lines matched by angular position and intensity
- Quantitative phase analysis by Reference Intensity Ratios (RIR’s) method
- Access to the data base including search by selected criteria

Options for DRON-7M and DRON-8/8T Diffractometers

Multidrive attachments and sample stages

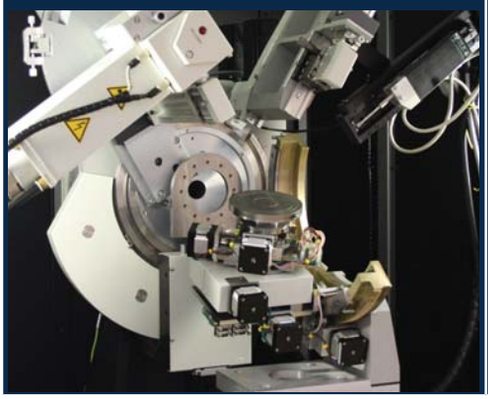
Single-axis φ-attachment	Two-axis φχ-attachment	Four-axis xyzφ holder for large samples
		
for DRON-8/8T	for DRON-7M, DRON-8/8T	for DRON-8/8T

Analysis of textures and residual stresses in polycrystalline materials, determination of single crystal orientation, study of phase composition and structural characteristics of powder and bulk objects.

Analysis of lattice dimensions and quality of single crystals in different crystallographic directions.

Mapping of phase composition and structural characteristics across sample surface, analysis of layer composition and structure in thin films.

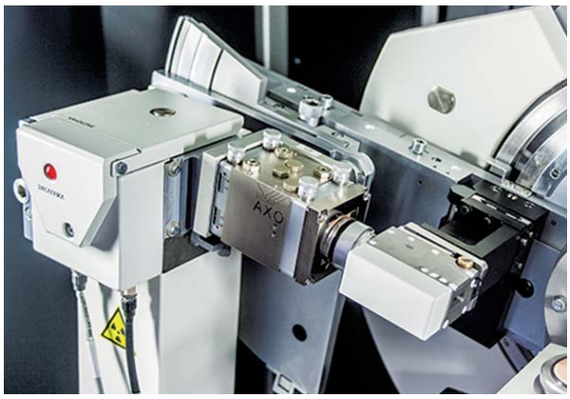
Maximal sample weight		
1 kg	0.3 kg	50 kg
Maximal sample dimensions (Ø x h)		
100x20 mm	28x10, 15x100 mm	300x250 mm
Automatic alignment of sample plane, accuracy		
5 µm	-	5 µm
Smallest selectable step of φ-rotation		
0.001 deg.	0.1 deg.	0.001 deg.
Smallest selectable step of χ-inclination		
-	0.001 deg.	-
Range of χ-inclination		
-	from -3 to +70 deg.	-
Range of xy-movement		
-	-	±100 mm
Smallest selectable step of xy-movement		
-	-	0.1 mm
Scanning modes		
Ω, Ω–ϕ, 2θ–Ω, ψ, $\sin^2\psi$	Ω, Ω–ϕ, χ–ϕ 2θ–Ω, ψ, $\sin^2\psi$	Ω, Ω–ϕ, 2θ–Ω, ψ, $\sin^2\psi$

Multi-purpose five-axis xyzφχ-attachment	Autosampler	Stage for cylindrical samples
		
for DRON-8/8T	for DRON-7M, DRON-8/8T	for DRON-7M, DRON-8/8T
Analysis of textures and residual stresses in polycrystalline materials, determination of single crystal orientation, study of phase composition and structural characteristics of powder and bulk objects. Mapping of phase composition and structural characteristics across sample surface, analysis of layer composition and structure in thin films. Analysis of lattice dimensions and quality of single crystals in different crystallographic directions, mapping of reciprocal space.	Continuous measurement of powder and bulk samples in automatic mode. Speed of sample rotation: 0.5 or 1 rps.	Measurements of cylindrical samples (capillaries) of 0.1-1.0 mm in diameter in Debye-Sherrer geometry (transition mode).

Maximal sample weight		
1 kg	-	-
Maximal sample dimensions (Ø x h)		
100x10 mm	28x25 mm	Ø 0,1-1,0 mm;length up to 100 mm
Automatic alignment of sample plane, accuracy		
5 µm	5 µm	-
Smallest selectable step of φ-rotation		
0.001 deg.	-	-
Smallest selectable step of χ-inclination		
0.001 deg.	-	-
Range of χ-inclination		
from -5 to +95 deg.	-	-
Range of xy-movement		
±20 mm	-	-
Smallest selectable step of xy-movement		
0.1 mm	-	-
Scanning modes		
Ω, Ω–ϕ, χ–ϕ 2θ–Ω, ψ, $\sin^2\psi$	θ–θ(DRON-8/8T); 2θ–θ(DRON-7M)	2θ

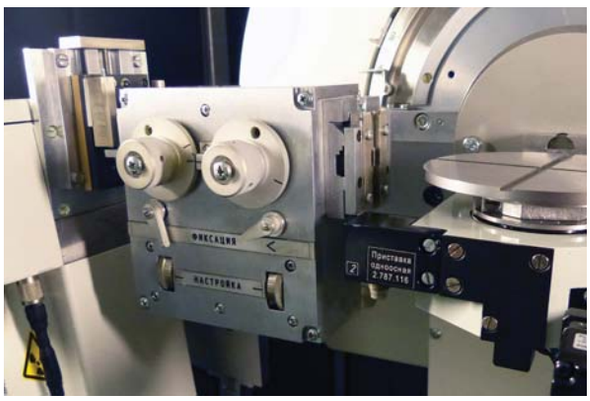
Options for DRON-7M and DRON-8/8T Diffractometers

X-ray optical elements



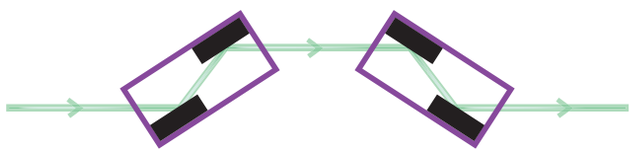
One-dimensional parabolic mirror for DRON-7, DRON-8/8T.
Converts a divergent primary beam to a parallel one, makes it monochromatic and enhances intensity.
Application:

- Measurements of samples with uneven surface.
- Small-angle X-ray scattering (SAXS).
- Grazing-incidence X-Ray diffraction (GIXRD).
- X-Ray reflectivity (XRR).



4-bounce channel-cut Ge 220 x 4 monochromator of Bartels type for DRON-8/8T

- Converts to high-resolution geometry.
- Singles out pure monochromatic Kα1 line with the angular resolution of 12 arc. sec.

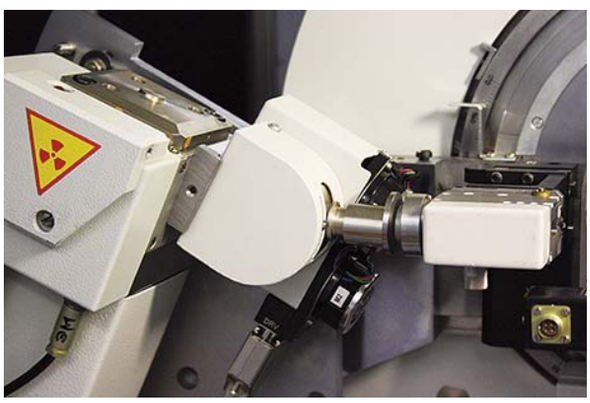


Polycapillary lenses for DRON-8/8T
Focusing lens provides:

- Intensity gain of primary beam 50-100 times.
- beam spot on sample surface is 50-100 μm.
- Microanalysis in different points of sample surface.

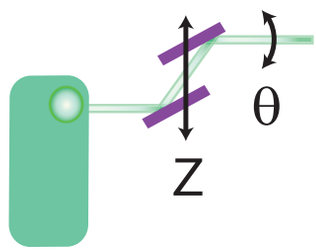
Collimating semi-lens forms quasi-parallel beam of Ø 10 mm to perform:

- Measurement of uneven surfaces in parallel-beam geometry
- Analysis of texture and residual stress.

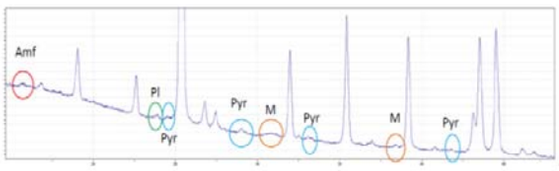


Versatile motorized monochromators for DRON-7M, DRON-8/8T

- Plate or channel-cut crystals.
- Any material (Ge, Si, SiO_2, LiF, graphite, etc.).
- Any crystallographic orientation (111, 100, 110 etc.).
- Any radiation (from Mo to Cr).
- Cuts background and beta-line.
- Singles out monochromatic Kα1 line.
- Remote adjustment of crystal.



Fast registration system



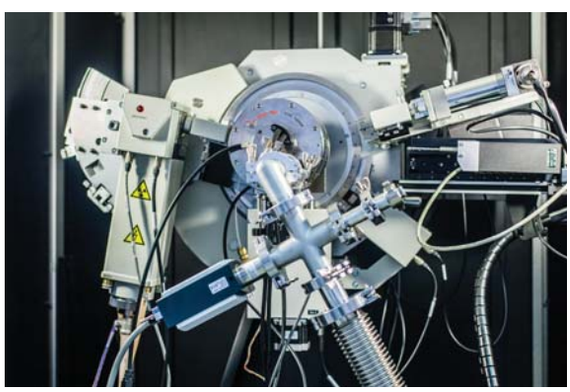
Fast registration system with linear stripped PSD Mythen2 R 1D и Mythen2 R 1K (Dectris, Switzerland) for DRON-7M, DRON-8/8T.

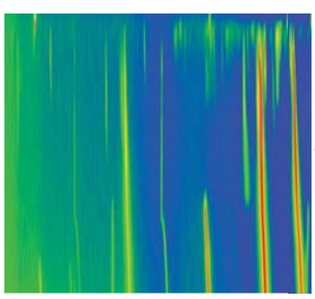
- Strip width, μm: 50 ± 3.
- Number of channels: 1280 (2 R 1K) and 640 (2 R 1D).
- Active area, mm^2: 8 x 64 (2R 1K) and 8 x 32, 4 x 32 (2R 1D).
- Measurement time is 100 times less.
- Angular resolution is the same as for scintillation counter.
- Increase of signal/noise ratio, especially for the weak reflections.
- Increase of sensitivity limit.
- Suppression of X-ray fluorescence background.
- Automatic calculation of strip aperture, goniometer radius and zero angle during alignment and calibration of PSD.

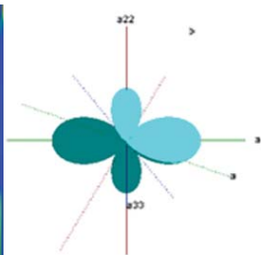
Application:

- Measurements of large number of samples in a limited period of time.
- Analysis of residual stress.
- Study of poorly crystallized and quickly decomposed materials.
- Real-time studies of phase transformations and chemical reactions.
- Identification of minor impurities.
- Measurements of small quantities of material.

Non-ambient chambers







HTK-1200N oven-chamber for DRON-7M, DRON-8/8T
Operation temperatures: from +25 to +1200 ºC
Atmospheres: vacuum (10^{-4} mbar), air, inert gases

HTK-16N/2000N strip-heater chambers for DRON-8/8T
Tungsten (W) heater (in vacuum): from +25 to +2300 ºC
Platinum (Pt) heater (in vacuum, on air, or in atmosphere of inert gas): from +25 to +1600 ºC

TTK-600 Low-temperature chamber for DRON-8/8T
Operation temperatures: from -190 to +600 ºC
Atmospheres: vacuum (10^{-2} mbar), air, inert gases

CHC$^+$ cryo & humidity chamber for DRON-8/8T
Operation temperatures (in vacuum): from -5 to +400 ºC
Humidity range: 5 – 95% at temperatures from +10 to +60 ºC

Vacuum equipment for DRON-8/8T

Application: tracing of phase transitions and chemical reactions, polymorh screening, analysis of thermal deformations of lattice in variable environment (temperature, pressure, humidity, gaseous medium or vacuum).

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