

NANOPIX

Small angle and wide angle
X-ray scattering instrument system

Advanced SAXS/WAXS for nanostructure analysis



Advanced nanoscale structural measurement of particle size, crystallinity, and protein in solution

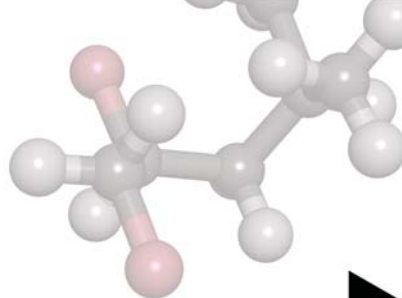
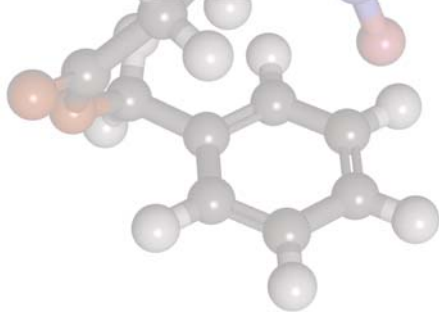
NANOPIX

- High-performance small- and wide-angle X-ray scattering (SAXS/WAXS) measurement system, Rigaku NANOPIX is designed with an emphasis on easy-to-use operability.
- Rigaku NANOPIX is applicable to variety of specimens such as polymers, liquid crystals, gels, nanoparticles as well as proteins and biopolymers.



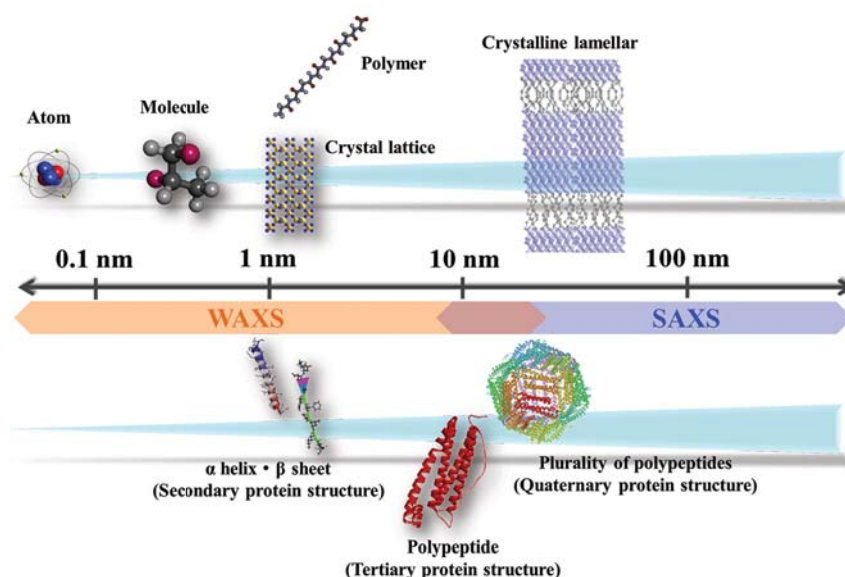
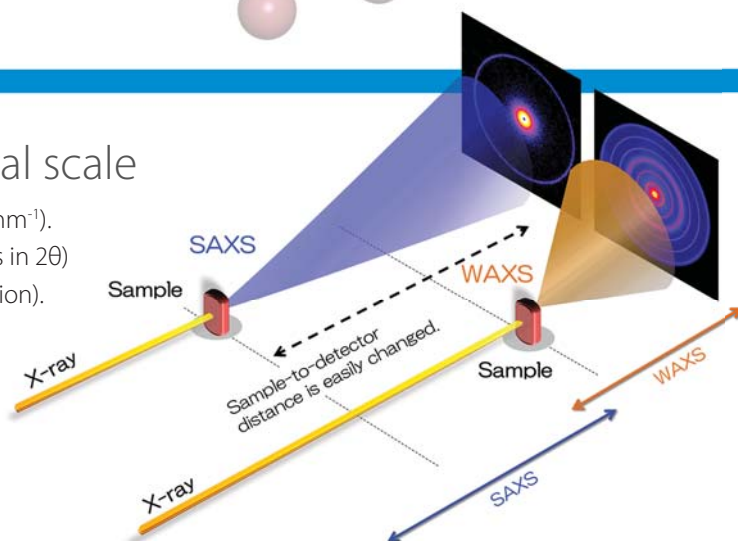
Superior operability

NANOPIX is fully motorized and completely controlled by software. This makes complex SAXS/WAXS experiments and measurements easier than ever to implement.



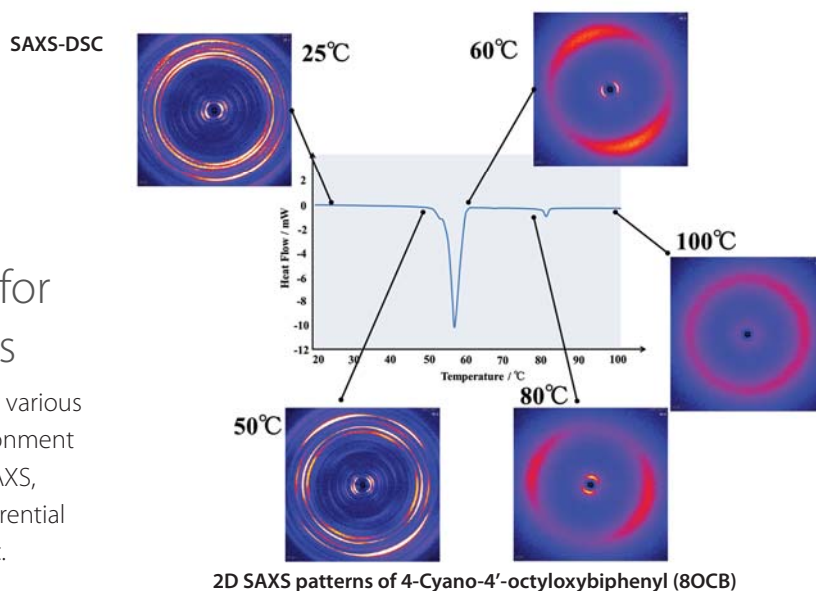
NANOPIX supports a broad structural scale

Optics are designed for focusing onto the detector ($Q_{\min} \sim 0.02 \text{ nm}^{-1}$).
NANOPIX is equipped for WAXS measurement (up to 70 degrees in 2θ)
and simultaneous SAXS/WAXS (available with Imaging Plate option).
Sample-to-detector distance is easily changed.



Variable sample environment for complex *in-situ* measurements

X-ray scattering experiments can be performed under various sample environments. A wide variety of sample environment controls are supported by the system, including: GI-SAXS, temperature and humidity control, simultaneous differential scanning calorimetry (DSC), vacuum environment, etc.



2D SAXS patterns of 4-Cyano-4'-octyloxybiphenyl (8OCB)

High performance with optimized usability

- **High-brilliance, high-power X-ray source with high-performance multilayer optics and ultimate pinhole slits**

State-of-the-art microfocus rotating anode X-ray generator (1,200 W) equipped with ultimate multilayer mirror optics and pinhole unit delivers superior performance for small angle X-ray scattering measurements. The high-performance small angle scattering optics ($Q_{\min} = 0.02 \text{ nm}^{-1}$ ($d \sim 200 \text{ nm}$)) is ideal for measuring a sample that exhibits anisotropy in sub-nm scale structures.

- **Intelligent system control software**

- NANOPIX control software enables to calibrate the optical system.
- Sample stages and optional attachments are automatically recognized and changed by a one-touch operation.

- **Advanced HyPix series 2D photon counting X-ray area detector**

Available HyPix-3000 or HyPix-6000 detectors have a small $100 \mu\text{m}^2$ pixel size. It is thus possible to achieve very high spatial resolution for superior SAXS/WAXS measurements.

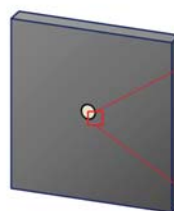
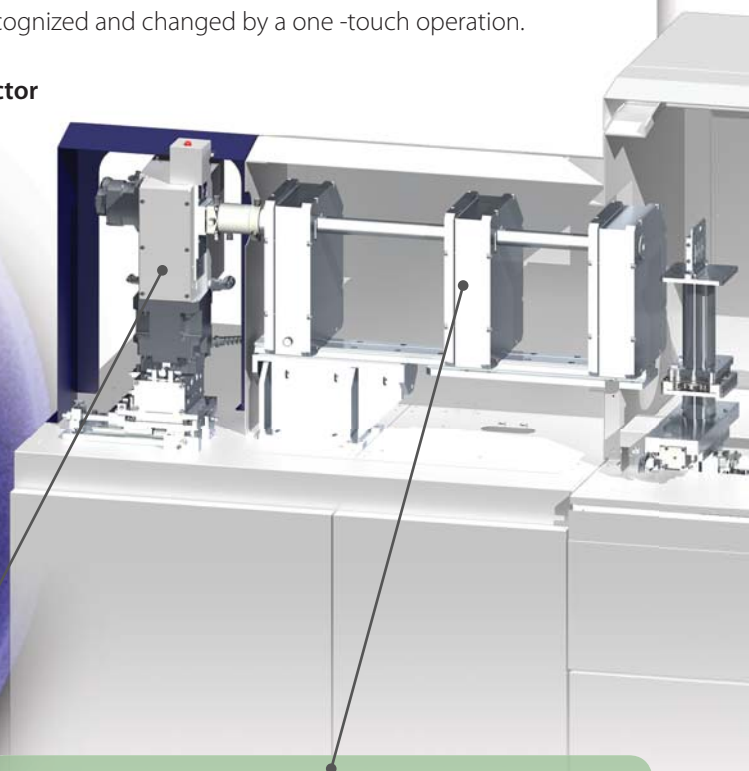
Rigaku's fundamental technologies



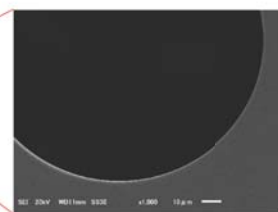
MicroMax-007 HF + Confocal Mirror

Beam module

- The Beam module is composed of a microfocus rotating anode X-ray generator (MicroMax-007 HF) and confocal MaxFlux (CMF) optic.
- MicroMax-007 HF: Smallest focal spot size available on a rotating anode generator.
- The CMF mirror was designed for the NANOPIX and is integrated and aligned to source for maximum beam acceptance.



Pinhole slit



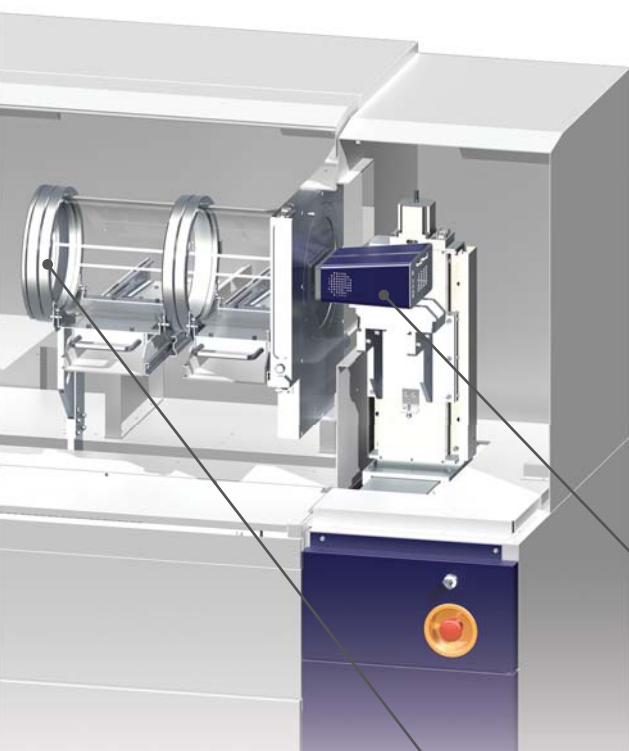
SEM image

Low scattering pinhole slit (Option)

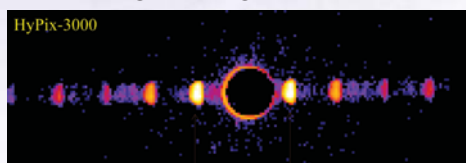
- The use of high performance pinhole slits effectively reduces parasitic scattering
- The NANOPIX supports 2 pinhole collimation and 3 pinhole collimation.

High resolution over a broad scale range

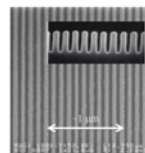
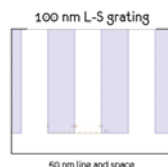
Optics is designed for focusing onto the detector ($Q_{\min} \sim 0.02 \text{ nm}^{-1}$).



High small angle resolution

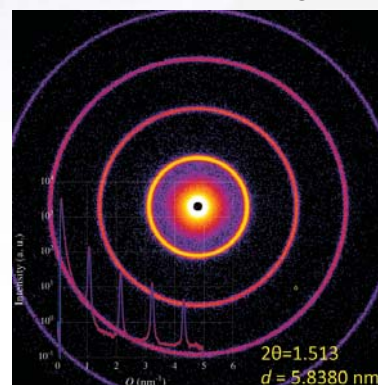


$d = 100 \text{ nm}$



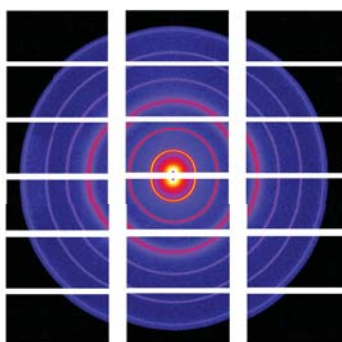
Gratings

Wide measurement range

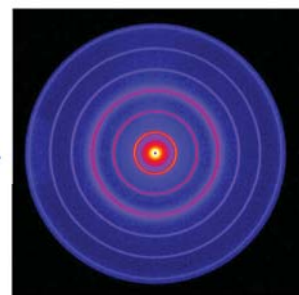


Silver behenate

The extended image processing function creates a single extended image from three separate images.



Integration



Single extended image

Module size
 $77.5 \times 38.5 \text{ mm}^2$



Sample stage • Vacuum path

- The sample stages are mounted in kinematic base to simplify their installation and removal from sample stage base.
- The vacuum path can be easily installed and removed as needed by the experiment.



HyPix-3000



HyPix-6000

High performance 2D photon counting X-ray area detector

HyPix-3000 is a next-generation two-dimensional semiconductor detector designed specifically to meet the needs of the home lab diffraction experiment. One of the HyPix-3000's unique features is its large active area of approximately 3000 mm^2 with a small pixel size of $100 \mu\text{m} \times 100 \mu\text{m}$, resulting in a detector with high spatial resolution. The NANOPIX is optionally available with the two module HyPix-6000.

Optional measurement environments

GI-SAXS/GI-WAXS

Grazing-Incidence SAXS (GI-SAXS) is a unique tool for characterizing the nanostructural features of materials at surface and interface.



Tensile

In-situ SAXS and WAXS measurement is a powerful tool for investigating the dynamic behaviors of polymer morphology, phase transition during drawing.



Manual tensile machine

System length

The system performance is selectable by the target of measurement.



2.0 m



3.5 m

Differential Scanning Calorimetry (DSC)



DSC is widely used for the determination of thermodynamical states (*cf.* phase transition, melt/crystallization). Simultaneous measurement of SAXS(WAXS) and DSC is configured.

Temperature and humidity

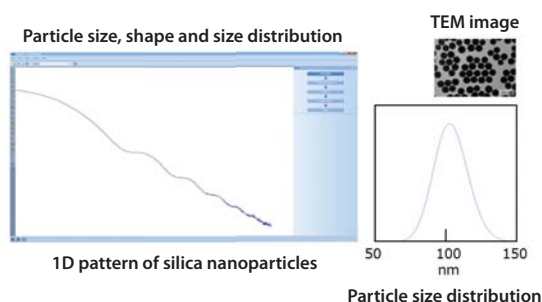


Temperature and humidity control unit is a key device for advanced functional materials in the fuel cell, etc.

Applications

Particle sizing and morphologies

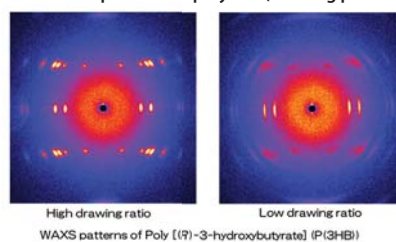
SAXS enables to determine the particle size, shape and size distribution of nanoscale particles.



Kinetics in hierarchy

SAXS and WAXS are a powerful tool for structure characterization in polymer having structural hierarchy. The crystallographic symmetry, unit cell parameter, crystallinity and orientation are obtained.

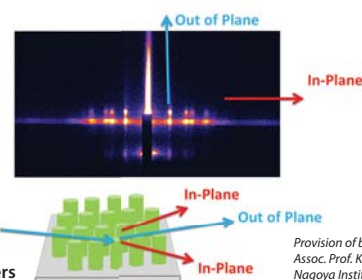
2D WAXS patterns of polymer (drawing process)



Surface structure

GI-SAXS is good approach to investigate surface structure. The measurement provides information about surface crystallography. GI-SAXS is used to investigate the anisotropic cylinder nanostructures on a substrate.

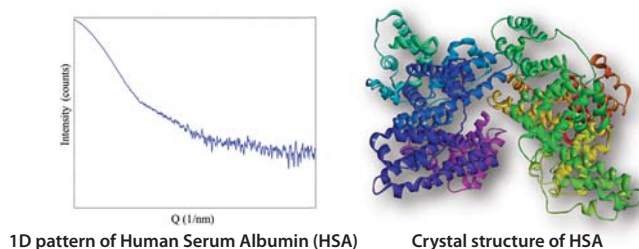
2D GI-SAXS pattern of anisotropic cylinder nanostructures



Provision of block copolymer sample:
Assoc. Prof. K. Yamamoto,
Nagoya Institute of Technology

Solution scattering/Protein solution

SAXS is an established method for the structural characterization of biological macromolecules in protein solution.



Specifications

Backed by Rigaku

Since its inception in 1951, Rigaku has been at the forefront of analytical and industrial instrumentation technology. Today, with hundreds of major innovations to our credit, the Rigaku Group of Companies are world leaders in the field of analytical X-ray instrumentation. Rigaku employs over 1,400 people worldwide in operations based in Japan, the U.S., Europe, South America and China.

X-ray source (Microfocus rotating anode X-ray generator)

	FR-X	MicroMax-007 HF MR
Brilliance	67.3 kW/mm ²	31.0 kW/mm ²
Source size	φ70 μm	φ70 μm
X-ray power	2.97 kW	1.2 kW
Voltage/Current	45 kV 66 mA	40 kV 30 mA

Beam units

Confocal optics	Confocal Max-Flux for Cu
Collimation	Pinhole configuration 2 pinhole / 3 pinhole selectable

Sample holder and stage (Option)

GI-SAXS attachment	T _z , R _y and R _x axis (3 axis stage) T _z , R _y , R _x and Φ axis (4 axis stage)
Rapid heating and cooling temperature control attachment	Temperature control range: -150°C ~ 400°C*
Multipurpose attachment	Linkam temperature control stage series Linkam tensile control stage series Linkam shear control stage series Mettler hot-stage series
Vacuum attachment	Vacuum chamber
Multiple sample vacuum attachment	Vacuum chamber for for multiple samples
Temperature and Humidity attachment	Temperature: RT ~ 60°C*, Humidity: 90% RH*
SAXS-DSC attachment	Heat-Flux type DSC, -30°C ~ 300°C*
Tensile attachment	Manual tensile machine

* Actual performance depends on the installed environment.

Base stage

Base YZ stage	Horizontal direction: ±35 mm Vertical direction: ±25 mm
Withstand load	< 5 kg
Mounting	Kinematic base

Digital telescope camera for sample (Option)

CCD camera

Detector(2D Hybrid Pixel Array Detector)

	HyPix-3000	HyPix-6000
Sensors	Semiconductor pixel sensor	
Active area	2984 mm ²	5968 mm ²
Number of pixels	775 × 385 pixels	775 × 770 pixels
Pixel size	100 μm × 100 μm	
Global count rate	>2.9 × 10 ¹¹ (1 × 10 ⁶ cps/pixel)	
Internal counter bit	Max 31-bit/pixel (Normal 16-bit/pixel)	
Energy range	5.4 keV ~ 30 keV	
Energy resolution	Better than 25% at Cu Kα	
Readout time	3.7 ms (0 ms for zero dead time mode)	
Detector stage	Horizontal/Vertical direction ±100 mm	

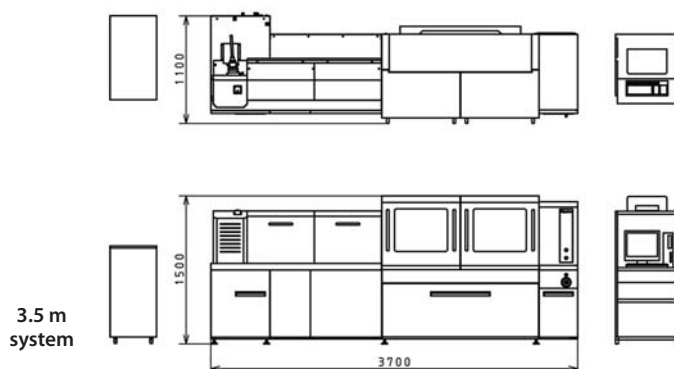
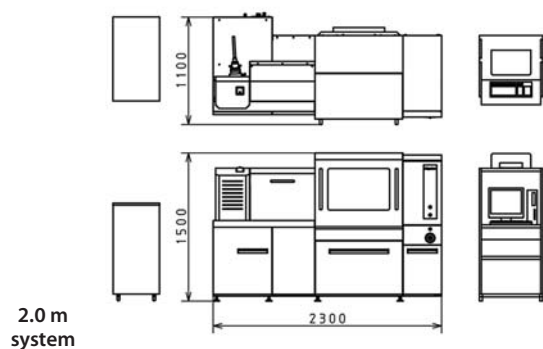
Power supply

Power	3φ AC 200 V±10% 50/60 Hz
Power consumption	13 A 4.5 kW
Grounding resistance	Earth resistance ≤100 Ω

Measurable range

		Camera Length mm	Q _{min} nm ⁻¹	Q _{max} nm ⁻¹	2θ _{min} deg.	2θ _{max} deg.	d _{min} nm	d _{max} nm
NANOPIX 2.0 m system	NANOPIX 3.5 m system	60	0.5094	40.16	0.716	59.0	0.16	12
		150	0.2038	23.62	0.286	33.7	0.27	31
		350	0.0873	11.30	0.123	15.9	0.56	72
		500	0.0611	8.03	0.086	11.3	0.78	103
		650	0.0470	6.21	0.066	8.7	1.01	134
		750	0.0408	5.40	0.057	7.6	1.16	154
		1200	0.0255	3.39	0.036	4.8	1.85	247
		1400	0.0218	2.91	0.031	4.1	2.16	288

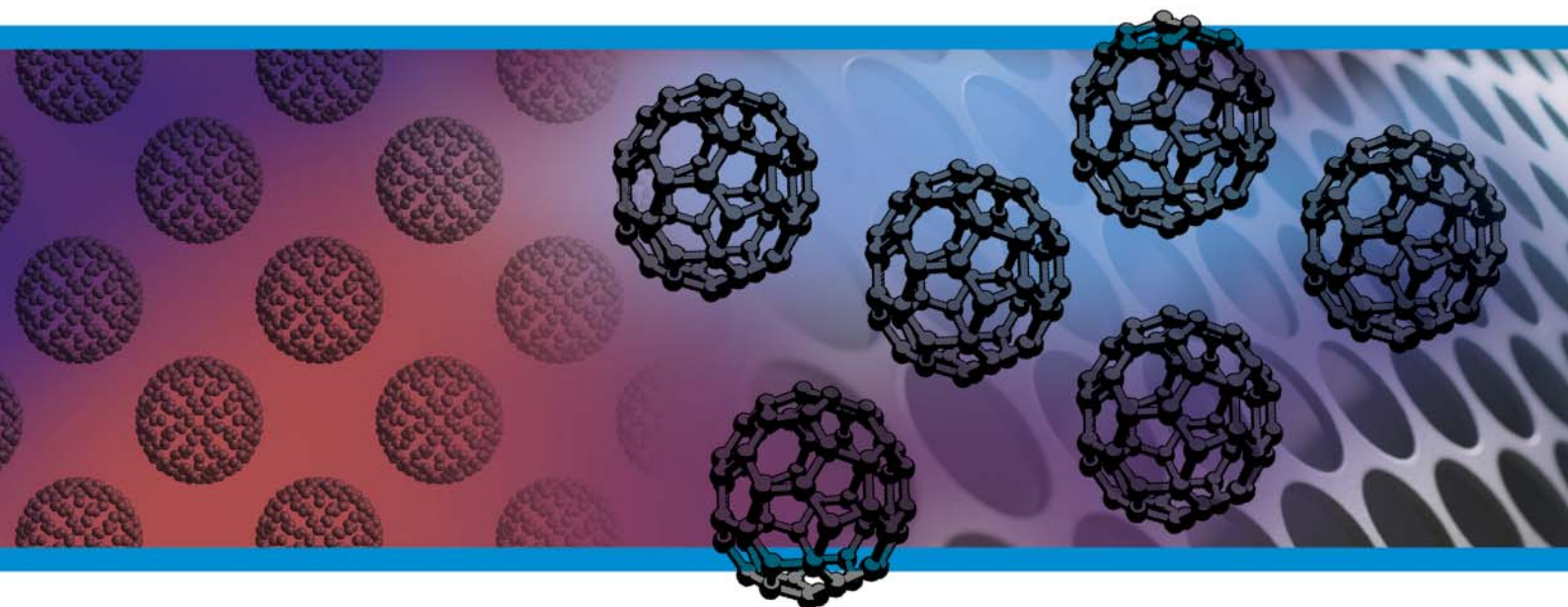
Dimensions



NANOPIX

Small angle and wide angle
X-ray scattering instrument system

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