High resolution X-ray imaging system

Obtain high-resolution images with submicron resolution

HAMAMATSU

PHOTON IS OUR BUSINESS

Easily and flexibly,
build an X-ray imaging system tailored to your needs

A high-resolution X-ray imaging system combines an imaging unit that visualizes the incident X-ray beam with a phosphor and a camera.

By simply selecting the main body of the X-ray imaging system (M11427), the phosphor screen*, and the optical system*, you can easily acquire X-ray images. You can freely choose a camera from the lineup and build a system by combining the optical system and camera according to your application.

Additionally, the optical design considers the durability and maintainability of the device, making it suitable for imaging using strong X-rays used in synchrotron radiation facilities.

*Options

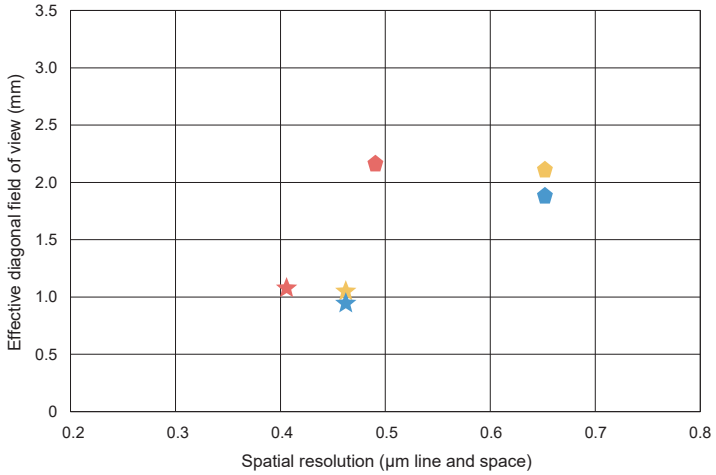
APPLICATIONS

- Synchrotron imaging
- X-ray beam alignment
- X-ray CT
- X-ray microscope
- X-ray topography
- XAFS

High-resolution images

A microscopic type that specializes in spatial resolution and is able to identify 1 µm line and space or less.

Correlation diagram of spatial resolution and effective field of view (reference data)

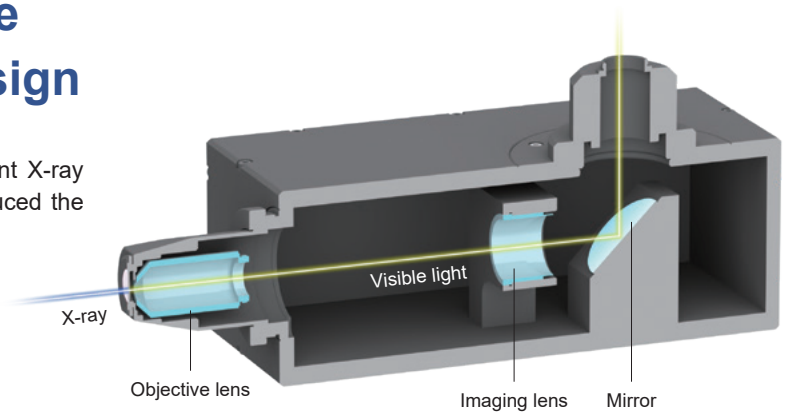


	Imaging unit	Camera
⬟	M11427-57 AA51	ORCA®-Quest
⬟		ORCA-Flash4.0 V3
⬟		ORCA-Fusion
★	M11427-58 AA51	ORCA-Quest
★		ORCA-Flash4.0 V3
★		ORCA-Fusion

* The spatial resolution and effective field of view in the left diagram are examples of actual values measured with visible light without a phosphor. Please refer to it as reference data. Please contact Hamamatsu for detailed measurement conditions.

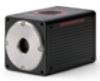
Reduce camera damage with X-ray resistant design

By adopting an L-shaped optical design to prevent X-ray beams from directly entering the camera, we reduced the damage to the camera caused by X-rays.



Easily replace the camera as needed

For the microscopic type, a camera is attached with a C-mount or F-mount (option).
You can choose a suitable camera from our lineup of scientific cameras according to your requirements for readout speed and readout noise.

Camera	ORCA-Quest 2 qCMOS® camera		ORCA-Fire Digital CMOS camera		ORCA-Fusion BT Digital CMOS camera		ORCA-Flash4.0 V3 Digital CMOS camera	
Product number	C15550-22UP		C16240-20UP		C15440-20UP		C13440-20CU	
								
Effective number of pixels (H×V)	4096 × 2304		4432 × 2368		2304 × 2304		2048 × 2048	
Pixel size [μm (H) × μm (V)]	4.6 × 4.6		4.6 × 4.6		6.5 × 6.5		6.5 × 6.5	
Effective area [μm (H) × μm (V)]	18.841 × 10.598		20.387 × 10.892		14.976 × 14.976		13.312 × 13.312	
Full well capacity (electrons, typ.) *1	7000		20 000		15 000		30 000	
Readout speed (frames/s, typ.) *1	Standard scan	120	Full resolution	115	Fast scan	89.1	Standard scan	100
	Ultra quiet scan	25.4	Vertical 4 line	19 500	Standard scan	23.2	Slow scan	30
	–		–		Ultra quiet scan	5.42	–	
Readout noise (electrons, rms, typ.) *1	Standard scan	0.43	Full resolution	1.0	Fast scan	1.6	Standard scan	1.6
	Ultra quiet scan	0.30	–		Standard scan	1.0	Slow scan	1.4
	–		–		Ultra quiet scan	0.7	–	

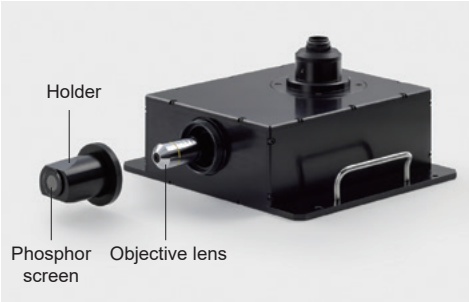
*1 It varies depending on the conditions. Please contact Hamamatsu for details.

Focus adjustment with a controller

Focus adjustment of the images is done using a dedicated controller.
The cable connecting the main unit and the controller is 15 meters long, making it possible to perform adjustments from a location away from the main unit.

Parts can be replaced due to the attachment structure

The phosphor screen and objective lens are mounted by detaching the holder. They can be easily replaced without using tools, allowing you to freely combine them according to the sample or application.



Easily replace without using tools

Phosphor screens Options

Three types of phosphor screens are available: direct bonding type, glue bonding type, and free standing type.
Among these, the direct bonding type has high X-ray durability and enables stable imaging even at high doses.

Bonding method	Product number	Phosphor material	Peak emission wavelength	Decay time	Phosphor thickness	Phosphor diameter	Phosphor effective diameter	Base material of phosphor	Space ring
Direct bonding See page 5	A15150-LU010DB	LuAG *1 ($Lu_3Al_5O_{12}$: Ce+)	535 nm	70 ns	10 µm	15 mm	10 mm	Amorphous carbon Diameter 20 mm Thickness 1 mm	Black plastic Outer diameter 20 mm Inner diameter 16 mm Thickness 2 mm
	A15150-LU050DB				50 µm				
	A15150-LU100DB				100 µm				
	A15150-GA010DB	GAGG *1 ($Gd_3Al_2Ga_3O_{12}$: Ce+)	520 nm	92 ns	10 µm				
	A15150-GA050DB				50 µm				
	A15150-GA100DB				100 µm				
Glue bonding	A15150-LU010GB	LuAG *1 ($Lu_3Al_5O_{12}$: Ce+)	535 nm	70 ns	10 µm				
	A15150-LU050GB				50 µm				
	A15150-LU100GB				100 µm				
	A15150-GA010GB	GAGG *1 ($Gd_3Al_2Ga_3O_{12}$: Ce+)	520 nm	92 ns	10 µm				
	A15150-GA050GB				50 µm				
	A15150-GA100GB				100 µm				
Free standing*2	A15141-LU	LuAG *1 ($Lu_3Al_5O_{12}$: Ce+)	535 nm	70 ns	1000 µm	20 mm	16 mm	–	
	A15141-GA	GAGG *1 ($Gd_3Al_2Ga_3O_{12}$: Ce+)	520 nm	92 ns					

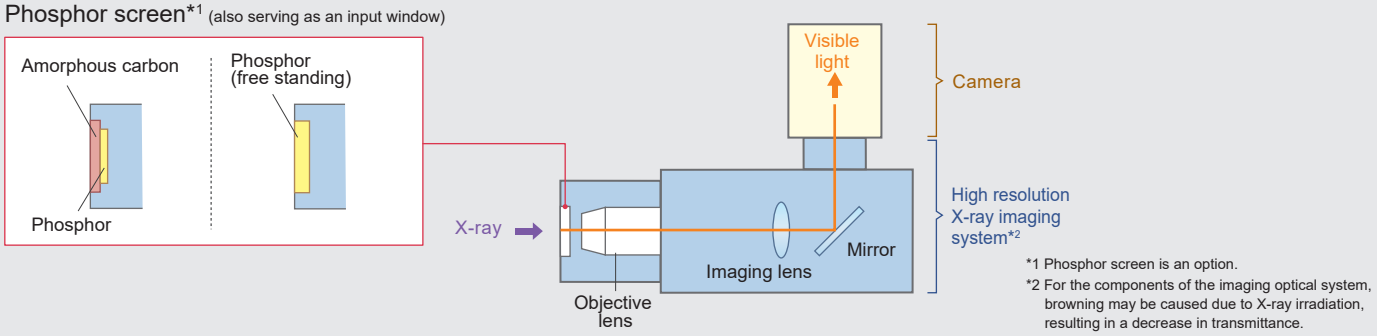
*1 For LuAG and GAGG, a streak and white spots may occur. These are due to the characteristics of the single-crystal phosphor and are not a defect.
*2 It is necessary to block the ambient visible light in the operating environment.

Optical components Options

Product number	Product name	Note
A15614-01	Objective lens 10× for AA51	Additional lens for M11427-58S or -58B
A15614-02	Objective lens 20× for AA51	Additional lens for M11427-57S or -57B
A15614-03	F-mount camera adapter for AA51	For F-mount camera

Light path

Phosphor screen*1 (also serving as an input window)



*1 Phosphor screen is an option.
*2 For the components of the imaging optical system, browning may be caused due to X-ray irradiation, resulting in a decrease in transmittance.

High-durability single-crystal phosphor screen revolutionizes conventional imaging

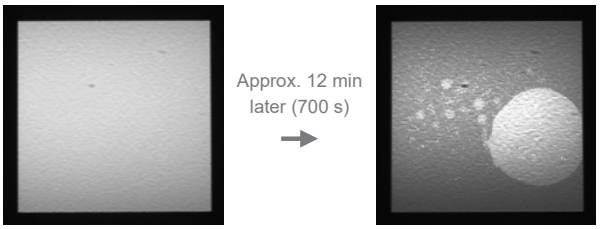
Direct bonding

The direct bonding type phosphor screen that can be selected as an option is a single-crystal phosphor screen with extremely high X-ray durability.
It suppresses the destruction of a phosphor screen by X-rays and realizes stable imaging and measurement for a long period of time.

High-durability single-crystal phosphor screen

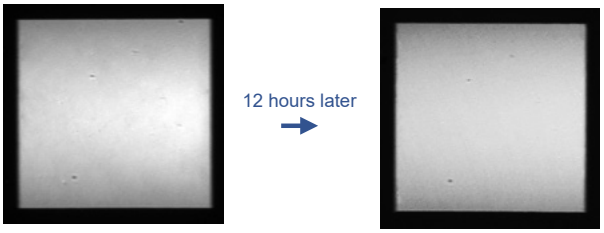
X-ray durability evaluation ❶ Synchrotron radiation white X-ray

Conventional phosphor (Glue bonding type)



Destruction taking place

High-durability single-crystal phosphor screen
(Direct bonding type)



No changes

Even with prolonged exposure to white X-rays, which usually causes destruction in conventional phosphor, this product remains undamaged.

Measurement conditions

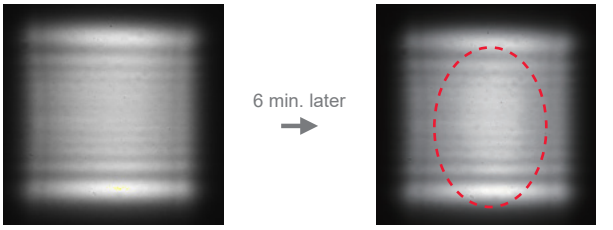
Beam line	SPring-8 BL28B2
X-ray energy	White
Attenuator	Air (9 m), Aluminum (0.034 mm) Be window (1 mm thick on the beam line side + 0.5 mm thick on the detector side)
Beam size	3 mm × 3 mm
Detector	Glue bonding type: AA40 (f = 50 mm) + ORCA-Flash2.8 (f = 35 mm) Direct bonding type: AA40 (f = 50 mm) + ORCA-Flash4.0 (f = 50 mm)
Pixel resolution	Glue bonding type: 5.1 µm / pixel, Direct bonding type: 6.5 µm / pixel
Phosphor screen	LuAG (Thickness: Glue bonding type about 20 µm, Direct bonding type about 20 µm)

Data courtesy of:
JASRI (Japan Synchrotron Radiation Research Institute)
Industrial application Division
Dr. Kentaro Kajiwara

* The measurement condition and data are at the time of evaluation and may not apply to all cases. Please consider as a reference case.

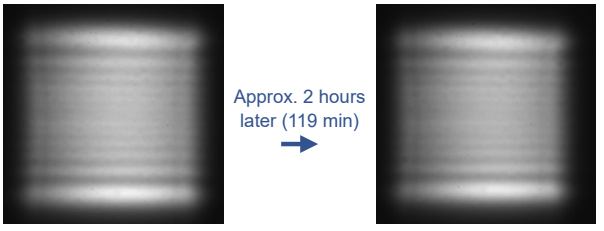
X-ray durability evaluation ❷ Flux density 4.7 ×10^{13} photons/s/mm^2

Conventional phosphor (Glue bonding type)



Destruction taking place

High-durability single-crystal phosphor screen
(Direct bonding type)



No changes

Even with prolonged exposure to X-rays with high flux density, which usually causes destruction in conventional phosphor, this product remains undamaged.

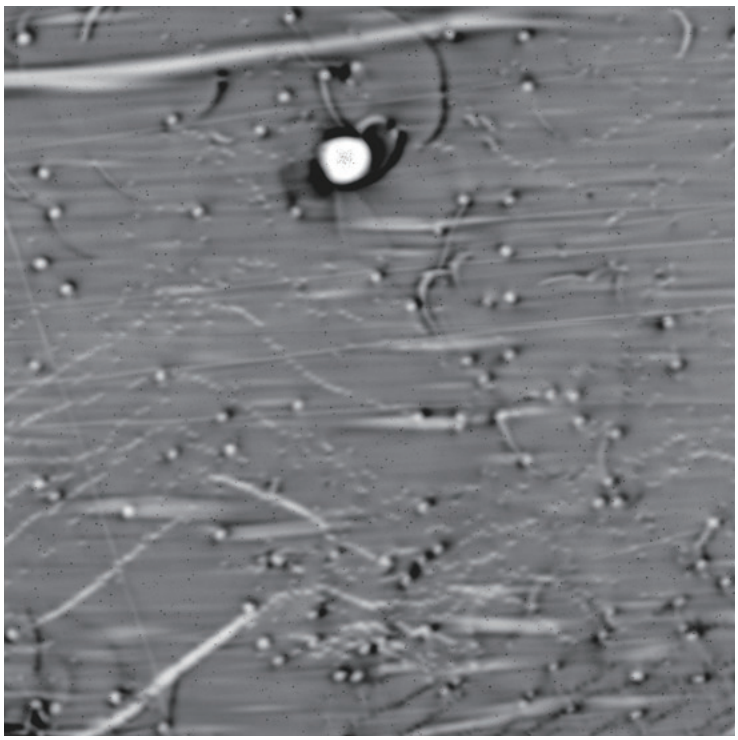
Measurement conditions

Beam line	SPring-8 BL47XU
X-ray energy	8 keV
Attenuator	None
Flux density	4.7×10^{13} photons/s/mm^2
Beam size	350 µm × 350 µm
Detector	AA50 (objective lens10×/NA 0.3) + C13949-50U
Pixel resolution	0.21 µm/pixel
Phosphor screen	LuAG (Thickness: Glue bonding type 22.3 µm, Direct bonding type 21.4 µm)

Data courtesy of:
JASRI (Japan Synchrotron Radiation Research Institute)
Dr. Kentaro Uesugi

* The measurement condition and data are at the time of evaluation and may not apply to all cases. Please consider as a reference case.

SiC defect observation

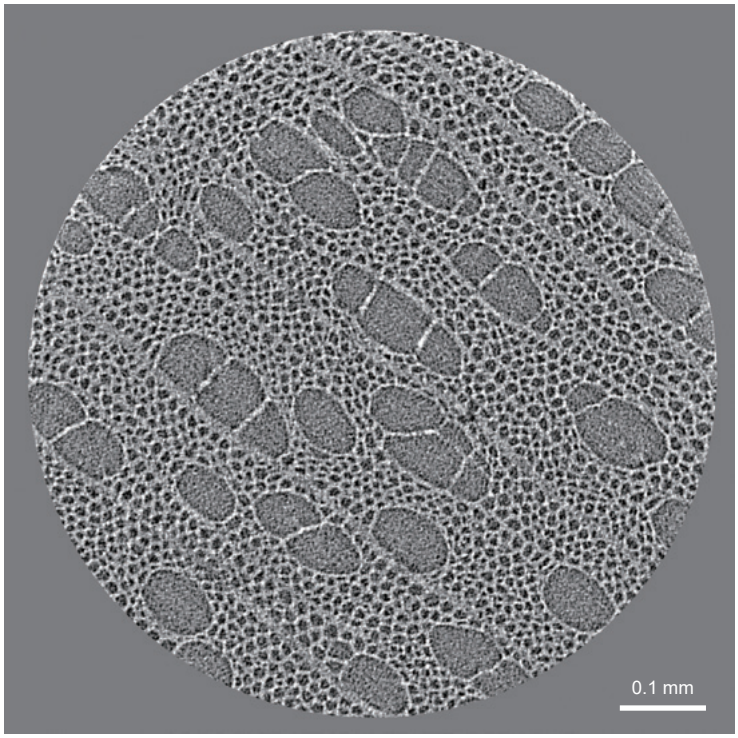


Test conditions

Method	X-ray topography
Camera	ORCA-Flash4.0 V3
Sample	SiC single crystal substrate (dislocations in the crystal)
X-ray energy	9 keV
Pixel size	0.65 µm
Magnification	×10
Exposure time	10 s
Number of pixels in the target image	1970 pixels × 1970 pixels (1.28 mm × 1.28 mm)
Phosphor screens	LuAG 10 µm

Data courtesy of:
Innovation Center for Semiconductor and Digital Future,
Mie University
Yongzhao Yao, Ph.D

Internal observation of wood



Cross-sectional view after 3D image reconstruction

Test conditions

Method	X-ray CT
Camera	ORCA-Fusion BT
Sample	Toothpick
Exposure time	100 ms/projection
Number of projections	1800
X-ray energy	15 keV
Pixel size	0.65 µm

Data courtesy of: Photon Science Innovation Center

Specifications

In addition, the cable connection position can be selected from two patterns, side panel and back panel, depending on the space for installation.

- M11427-57B, -58B: Back panel
- M11427-57S, -58S: Side panel

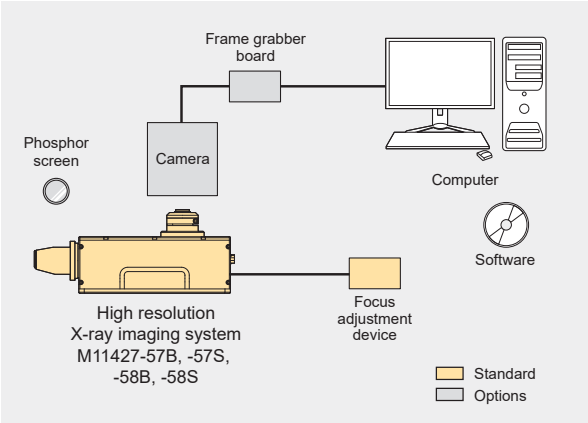
High resolution X-ray imaging system AA51

Product number	M11427-57B, -57S	M11427-58B, -58S
X-ray energy	6 keV or higher	
Phosphor effective diameter	Refer to specifications for phosphor screens (below)	
Phosphor material		
Peak emission wavelength		
Decay time		
Thickness of phosphor (typ.)		
Base material of phosphor		
Spatial resolution *1	1 µm or less	800 nm or less
1st lens	10× (NA 0.45)	20× (NA 0.75)
2nd lens	200 mm	

*1 Reference value with ORCA-Flash4.0 V3. It varies depending on the system configuration.

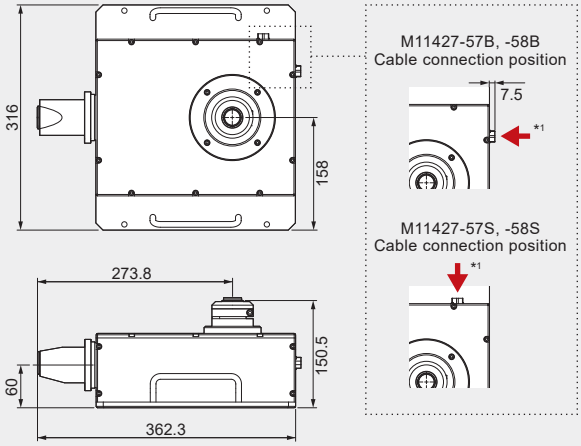
System configuration examples

Frame grabber board and their cables are available with options depending on the camera used. For details, please contact your Hamamatsu representative or distributor.



Dimensional outlines (unit: mm)

- High resolution X-ray imaging system AA51
  M11427-57B, -57S, -58B, -58S (Approx. 7.5 kg)



*1 Cable Length: 15 m

ORCA-Quest2

The dawn of a new era for scientific measurement cameras

The ORCA-Quest 2 is a camera that leverages the design technology cultivated at Hamamatsu Photonics to achieve an extremely low noise performance of 0.30 electrons rms and high-speed readout. It is ideal for quantitative imaging under extremely low light conditions.

URL https://www.hamamatsu.com/all/en/product/cameras/qcmos-cameras/C15550-22UP.html

X-ray CMOS cameras

High-resolution and high-sensitivity X-ray sCMOS camera

The camera is suitable for micro object by achieving 33 lp/mm high resolution image. Also the product is compact that is suitable as embedded devices for Micro CT/Nano CT system.

URL https://www.hamamatsu.com/all/en/product/cameras/x-ray-cmos-cameras/C12849-111U.html

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