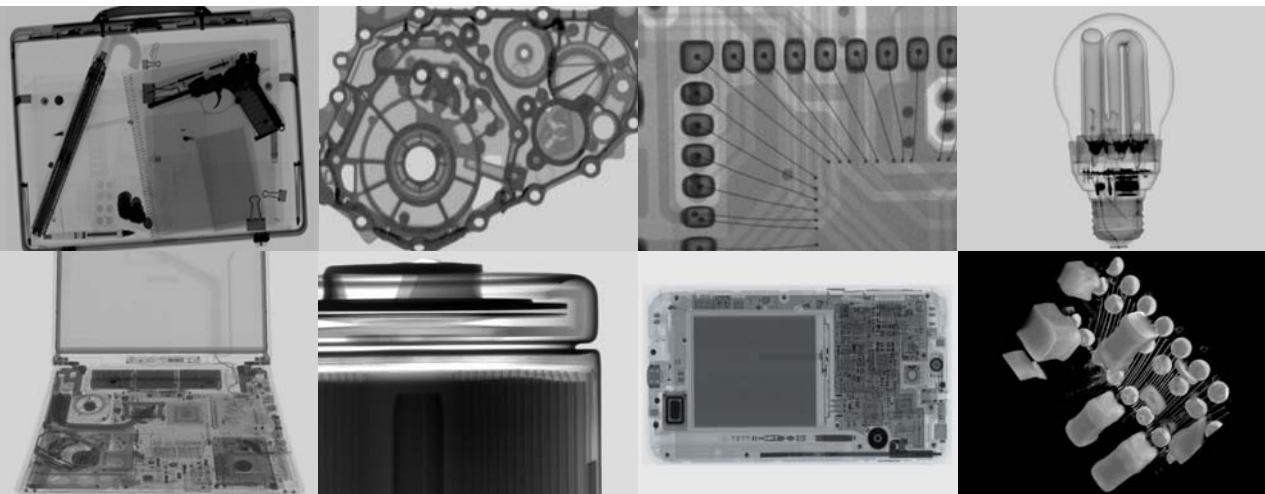


HAMAMATSU

PHOTON IS OUR BUSINESS



X-ray Sources & Imaging Devices

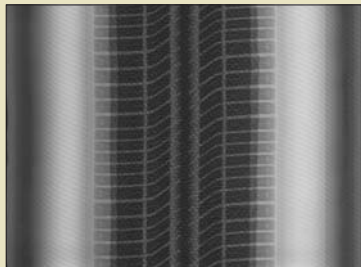
The non-contact, non-destructive X-ray inspection is extremely effective in upgrading quality and safety since it detects tiny product structural flaws and foreign object contamination with no product damage.

Hamamatsu Photonics has a wide line-up for X-ray sources and imaging devices for X-ray inspection of electronic components, industrial products as well as for a wide range of fields to meet needs in food processing, medical treatment and security.

Imaging Example

These photos show just some examples of X-ray imaging. Image quality depends on the conditions such as inspection environments, object materials and system configurations.

Industrial Product



▲Tire

Taken with the X-ray line scan camera



▲Lithium ion battery

Taken with the microfocus X-ray source and X-ray I.I. camera unit



▲Aluminum die-cast

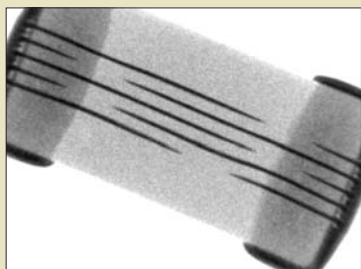
Taken with the X-ray line scan camera



▲Cellular phone

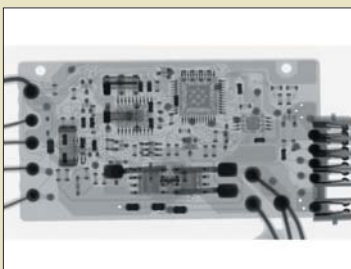
Taken with the microfocus X-ray source

Semiconductor & Electronic Component



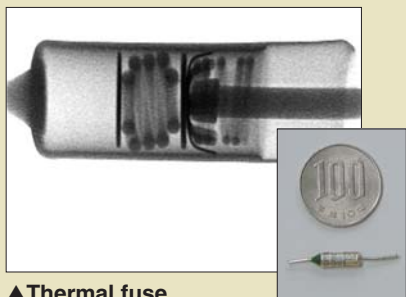
▲Chip condenser

Taken with the microfocus X-ray source



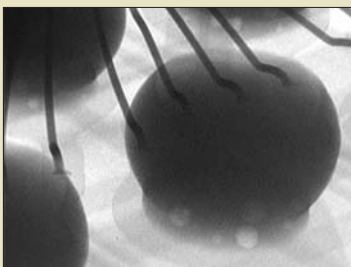
▲Mounted board

Taken with the microfocus X-ray source and X-ray TDI camera



▲Thermal fuse

Taken with the microfocus X-ray source



▲BGA (Ball Grid Array)

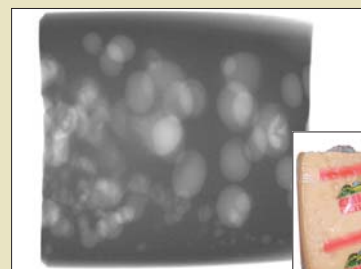
Taken with the microfocus X-ray source and X-ray I.I. camera unit

Food



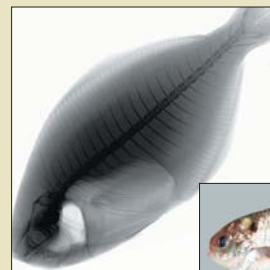
▲Cookies

Taken with the X-ray line scan camera



▲Cheese

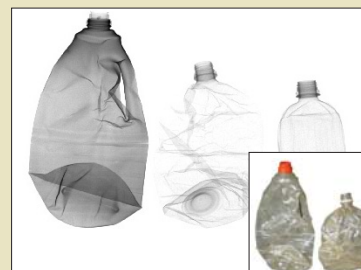
Taken with the X-ray line scan camera



▲Fish

Taken with the microfocus X-ray source and X-ray flat panel sensor

Recycle



▲PET bottle (Separation)

Taken with the X-ray line scan camera

X-ray Source

Microfocus X-ray source

FEATURES

- World finest level resolution (L12351)
- High power: 230 kV 1 mA (L10801)
- Minimum resolution: 0.25 μm (L10711-03)
- Geometric magnification: 1000 times or higher (L11091, L10711-03)
- Transmission target: 0.5 mm FOD
- High output: 75 W (L12161-07)
- No high voltage cable connection required
- High voltage power supply is integrated with the main unit.
- Externally control via RS-232C interface

APPLICATIONS

- Non-destructive inspection
- X-ray CT
- In-line X-ray inspection

[Applicable objects]

- Electronic component
- Printed circuit board
- Plastic component
- Metal component
- Food
- Beverage
- Medicine & drug
- Bioproduct

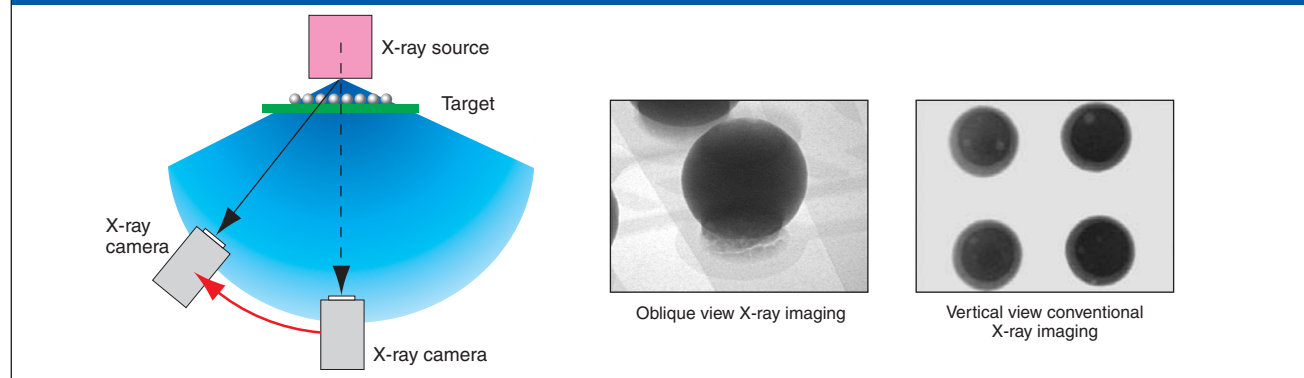
The Hamamatsu microfocus X-ray sources were developed specifically for X-ray non-destructive inspection. These X-ray sources use an X-ray tube with a small focal spot which is capable of producing a clear X-ray image even at a high magnification. The X-ray tube has an air-cooled and hermetically sealed structure, and is integrated with its high voltage power supply for easy handling. (High voltage cables are not required.)

Even for observation of solid forms, magnified X-ray transmission images can be clearly obtained.

	Type No.	Tube Voltage	Maximum Output	X-ray Focal Spot Size ^① (Min.)	X-ray Beam Angle (Approx.)	FOD ^② (Approx.)
Sealed type	L9421-02	20 kV to 90 kV	8 W	5 μm	39°	9.5 mm
	L10101	40 kV to 100 kV	20 W	5 μm	42°	6.8 mm
	L10321	40 kV to 100 kV	20 W	5 μm	118°	7.3 mm
	L9631	40 kV to 110 kV	50 W	15 μm	62°	16.8 mm
	L9181-02	40 kV to 130 kV	39 W	5 μm	45°	13 mm
	L12161-07	40 kV to 150 kV	75 W	5 μm	43°	17 mm
	L12531	40 kV to 110 kV	16 W	2 μm ^③	120°	1 mm
Open type	L11091	20 kV to 160 kV	8 W	1 μm ^③	120°	0.5 mm
	L10711-03	20 kV to 160 kV	8 W	0.25 μm ^{③④}	140°	0.5 mm
	L10801	20 kV to 230 kV	200 W	4 μm ^③	40°	5 mm

NOTE: ① Nominal value ② Focus to object distance ③ Minimum resolution when X-ray chart is used.
④ Suitable measurement conditions (environment and equipments) are necessary.

Suitable for observation of solid forms



Sealed type



▲90 kV type
L9421-02



▲100 kV type
L10101, L10321



▲110 kV type
L9631



▲130 kV type
L9181-02



▲150 kV type
L12161-07

Transmission target sealed type



▲110 kV type
L12531

Open type



▲160 kV type
L11091



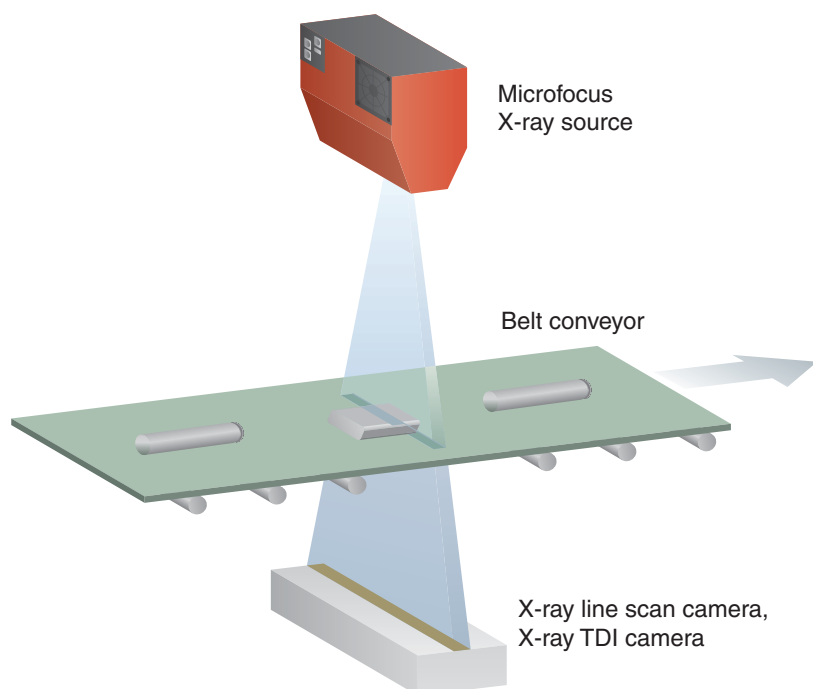
▲160 kV type
L10711-03



▲230 kV type
L10801

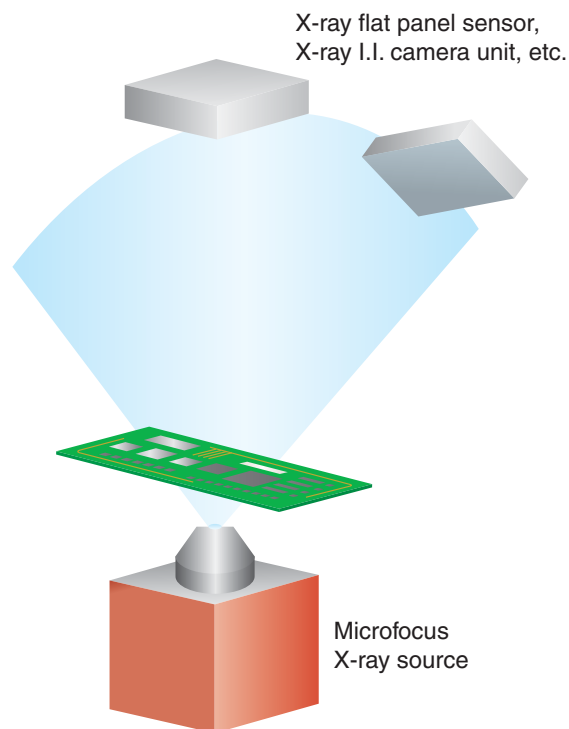
System Configuration

1D sensor (Line sensor)



X-ray line sensor can capture a large field of image with high speed, and are extensively used in in-line inspection such as food, battery and PCB.

2D sensor (Area sensor)



Hamamatsu provides X-ray cameras (area image sensors) with high sensitivity, high resolution, and a wide dynamic range. These X-ray cameras are used for inspection and analysis of semiconductor components and PCB.

■Features of X-ray imaging devices

Products	Features	On-chip signal integration	Real-time imaging	Compact size	Digital output	Analog output
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1D sensor (Line sensor)

X-ray line scan camera		●		●	
X-ray TDI camera		●		●	
Dual-energy X-ray line scan camera		●		●	
C-shaped X-ray line scan camera		●		●	

2D sensor (Area sensor)

X-ray sCMOS camera	●	●	●	●	
Digital CCD camera for direct X-ray imaging system	●	●		●	
High resolution X-ray imaging system	●	●		●	
X-ray I.I. digital camera unit		●		●	
X-CUBE™ compact X-ray CCD camera		●	●		●
X-ray flat panel sensor	●	●	●	●	

X-ray Imaging Device

1D sensor (Line sensor)

X-ray line scan camera



FEATURES

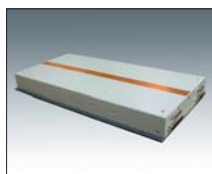
- Digital output
- Wide field of view
- Ideal for production line inspection

The C9750 series is an X-ray line scan camera using a sensor head of 50 mm thickness that can be installed inside a conveyor line. The sensor has a standard detection width of 512 mm or 256 mm (up to 6.5 m as option), allowing internal observation of large objects which have been difficult to inspect.

Pixel pitch (pixel to pixel spacing) can be selected from 200 μm , 400 μm , 800 μm or 1600 μm .

Type No.	Field of View	Resolution	Sensitivity Range
C9750-05FCN	256 mm wide	400 μm	25 kV to 160 kV
C9750-10FCN	512 mm wide	400 μm	25 kV to 160 kV
C9750-10TCN	256 mm wide	200 μm	25 kV to 160 kV
C9750-20TCN	512 mm wide	200 μm	25 kV to 160 kV

Dual-energy X-ray line scan camera



FEATURES

- Extract a target material from multi-energy image data
- High resolution
- Wide dynamic range
- Very good energy separation accuracy with well aligned dual energy images

The C10800 series is a high-speed and high-resolution dualenergy X-ray line scan camera that can be used to effectively differentiate materials in a variety of nondestructive testing applications.

It is possible to optimize for different object and X-ray conditions in order to cover a wide range of applications from high energy range applications such as mineral resources sorting to middle or low energy applications such as drug detection, meat inspection, foods inspection.

Pixel pitch (pixel to pixel spacing) can be selected from 400 μm or 800 μm .

Type No.	Field of View	Resolution	Sensitivity Range
C10800-04ECM	409.6 mm wide	800 μm	Approx. 50 kV to 110 kV
C10800-04ECH	409.6 mm wide	800 μm	Approx. 100 kV to 160 kV
C10800-08FCM	409.6 mm wide	400 μm	Approx. 50 kV to 110 kV

X-ray TDI camera



FEATURES

- High resolution
- High speed imaging combined with high sensitivity
- Real time dark current / shading correction function

The C12200 and C10650 series X-ray TDI camera is useful for in-line application requiring high-speed operation with high sensitivity.

A problem of the conventional line scan camera, low brightness under high resolution usage, is improved on this X-ray TDI camera. This X-ray TDI camera is applicable for an application which requires high resolution.

Type No.①	Field of View	Resolution	Sensitivity Range
C12300-321	221 mm wide	48 μm	25 kV to 130 kV
C12200-321	221 mm wide	48 μm	25 kV to 90 kV
C12200-461	293 mm wide	48 μm	25 kV to 90 kV
C10650-221	145 mm wide	48 μm	25 kV to 90 kV
C10650-321	221 mm wide	48 μm	25 kV to 90 kV
C10650-461②	293 mm wide	48 μm	25 kV to 90 kV

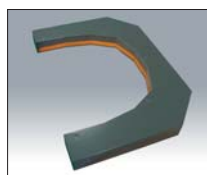
① C12300 is high speed readout type (approx. 86.4 m/min).

C12200 is high speed readout type (approx. 36.8 m/min).

C10650 is standard speed readout type (approx. 10.7 m/min).

② C10650-461 has vertical installation type and double the field of view type.

C-shaped X-ray line scan camera



FEATURES

- Captures internal tire image (exploded view)
- Wide detection width of 1382.4 mm

The C-shaped X-ray line scan camera is to meet the demands in the tire inspection. It is based on the Hamamatsu C9750 series X-ray line scan camera technologies, and it offers an image of 3456 pixels resolution horizontally with no gap (<1 pixel) for whole effective area while the tire rotate one revolution.

Type No.③	Field of View	Resolution	Sensitivity Range
C9750-27FCC	1382.4 mm wide	400 μm	Approx. 25 kV to 160 kV
C9750-27FCD			

③ The difference of C9750-27FCC and C9750-27FCD depends on the location of connectors.

Selection guide by field of view and resolution

1D sensor (Line sensor)

Field of view \ Resolution	48 μm	200 μm	400 μm	800 μm
145 mm	X-ray TDI camera C10650-221			
221 mm	X-ray TDI camera C12300-321 C12200-321 C10650-321			
256 mm		X-ray line scan camera C9750-10TCN	X-ray line scan camera C9750-05FCN	
293 mm	X-ray TDI camera C12200-461 C10650-461			
409.6 mm			Dual-energy X-ray line scan camera C10800-08FCM	Dual-energy X-ray line scan camera C10800-04ECM C10800-04ECH
512 mm		X-ray line scan camera C9750-20TCN	X-ray line scan camera C9750-10FCN	X-ray line scan camera C9750-05ECN
1382.4 mm			C-shaped X-ray line scan camera C9750-27FCC C9750-27FCD	

* We offer products other than listed above. Please feel free to contact us.

X-ray Imaging Device

2D sensor (Area sensor)

X-ray sCMOS camera



FEATURES

- Resolution: 30 Lp/mm (C12849-101U)
- Effective number of pixels: 2048 (H) × 2048 (V)
- Frame rate: 30 frames/s (2048 (H) × 2048 (V))
- Compact size
- Interface: USB 3.0

The C12849 series is a high resolution and high sensitivity X-ray sCMOS camera. The camera is suitable for micro object by achieving 30 lp/mm high resolution image. Also the product is compact that is suitable as embedded devices for Micro CT/Nano CT system.

Type No.	Scintillator
C12849-101U	Gadox 10 μ m
C12849-102U	Gadox 20 μ m

X-ray I. I. digital camera unit



FEATURES

- Digital output
- High resolution, high contrast
- High-speed readout
- Low noise
- Low distortion

Camera units C7336-06/-07 consist of a high resolution, high contrast 4-inch X-ray image intensifier (X-ray I.I.) and a 2.35 mega-pixel or 3 mega-pixel CMOS image sensor respectively.

The X-ray I.I. has an input window made of thin aluminum which is excellent in X-ray transmission and causes less scattering of X-rays. These features allow real-time detection at X-ray energy levels from about 20 keV.

The captured images can be transferred to PC directly by interface of Mini CameraLink or USB3.0.

Type No.	Field of View	Resolution	Sensitivity Range
C7336-06	75 mm × 48 mm	63 μ m	More than 20 keV
C7336-07	72 mm × 54 mm	63 μ m	More than 20 keV

Digital CCD cameras for direct X-ray imaging system



FEATURES

- Allows EUV imaging
- Available with various vacuum flanges or beryllium window

The digital CCD camera use a back-thinned CCD for direct X-ray imaging. Silicon used to fabricate CCD chips internally generates electrons when irradiated by X-rays, so CCDs can be used as X-ray sensors with very high sensitivity. Two types of camera heads are available: one with a beryllium window intended for use in air and the other with a vacuum flange for easy connection to a vacuum chamber.

Type No.	Field of View	Resolution	Sensitivity Range
C8000-30CD	8.96 mm × 6.72 mm	14 μ m	20 eV to 10 keV

High resolution X-ray imaging system



FEATURES

- X-ray proof design(adopting a quartz glass plate and L-shaped optics)
- High resolution
- Easy to exchange scintillators
- Possible to detect low X-ray energy

The high resolution X-ray imaging system is designed for X-ray beam alignment. Adopting a unique mechanism, it allows combining various types of CCD cameras for real-time X-ray beam alignment. The beryllium input window transmits a wide range of X-ray energies, and the coupled L-shaped quartz optics allows high X-ray radiation tolerance. Suitable for high resolution X-ray beam alignment in large synchrotron radiation facilities. The M11427-42 and -62 use a P-43 scintillator, and the M11427-53 uses an LSO (lutetium oxyorthosilicate) scintillator.

Type No.	Field of View	Resolution	Sensitivity Range
M11427-42	13.3 mm × 13.3 mm	10 μ m	4 keV to 15 keV
M11427-53	1.3 mm × 1.3 mm	1 μ m	4 keV to 10 keV
M11427-62	27.9 mm × 27.9 mm	to 10 μ m	4 keV to 15 keV

* The above field-of-view and resolution are measured when an ORCA-Flash4.0 V2 (4 mega-pixel sensor) is used. The field-of-view and resolution differ depending on the connected camera.

X-CUBE™ Compact X-ray CCD camera



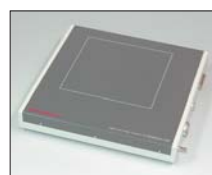
FEATURES

- High sensitivity: CsI scintillator
- Compact
- Low power consumption

X-CUBEs are compact X-ray CCD camera designed for non-destructive inspection, which make X-ray imaging as easy as an ordinary CCD camera in handling. The H8480 and H8953 use a 2/3 type CCD coupled to large-diameter tapered FOPs which are coated with CsI. The H8481 uses a straight type FOP instead of the large FOP, achieving a high resolution of 20 Lp/mm.

Type No.	Field of View	Resolution	Sensitivity Range
H8953-13	16.7 mm × 12.5 mm	30 μ m	More than 8 keV
H8481-15	8.4 mm × 6.3 mm	25 μ m	More than 8 keV
H8480-13	ϕ 25 mm	50 μ m	More than 8 keV

X-ray flat panel sensor



FEATURES

- High quality image
- High frame rate
- Wide dynamic range
- No image distortion
- Digital output
- Lightweight and compact

This is a digital X-ray image sensor capable of capturing high-resolution and high quality X-ray images in real time (off-line). The sensor unit consists of a high-resolution scintillator and a large-area CMOS image sensor operating at high speeds, and is housed in a thin and compact case.

Type No.	Field of View	Resolution	Sensitivity Range
C7942CA-22	120 mm × 120 mm	50 μ m	20 kVp to 100 kVp

X-ray scintillator plate



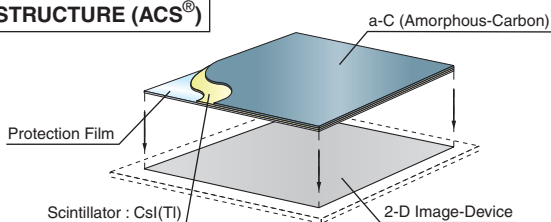
FEATURES

- Available in various shapes and size (from 14 mm square to 440 mm square)
- Allow a more compact design of the detector unit

Hamamatsu offers various types of X-ray scintillators fabricated with amorphous carbon, aluminum or fiber optic plates. These X-ray scintillators can be used for real-time digital radiography when used with commercially available area image sensors or CCDs for image readout.

Type	Features
GPXS® (aluminum type)	High light output, Large format
ACS® (amorphous carbon type)	High resolution, Large format
ALS® (aluminum type)	Large format
FOS® (fiber optic type)	Low energy X-ray detection, high X-ray shielding

STRUCTURE (ACS®)



■ Selection guide by field of view and resolution

2D sensor (Area sensor)

Field of view	Resolution	Less than 5 μm	6 μm to 30 μm	31 μm to 50 μm	51 μm to 110 μm
1.3 mm \times 1.3 mm		High resolution X-ray imaging system M11427-53			
8.4 mm \times 6.3 mm			X-CUBE H8481-15		
8.96 mm \times 6.72 mm			Direct X-ray imaging system C8000-30D		
13.3 mm \times 13.3 mm			High resolution X-ray imaging system M11427-42 X-ray sCMOS camera C12849		
16.7 mm \times 12.5 mm			X-CUBE H8953-13		
ϕ 25 mm				X-CUBE H8480-13	
27.9 mm \times 27.9 mm			High resolution X-ray imaging system M11427-62		
72 mm \times 54 mm					X-ray I.I. digital camera unit C7336-07
75 mm \times 48 mm					X-ray I.I. digital camera unit C7336-06
120 mm \times 120 mm				X-ray flat panel sensor C7942CA-22	



PRECAUTIONS TO USE

- This microfocus X-ray source generates X-rays harmful to the human body. Use sufficient caution when handling the equipment to avoid direct or inadvertent exposure to X-rays.
Install the X-ray source or the X-ray tube unit in an X-ray shielded cabinet or room equipped with safety interlock functions to prevent accidental exposure to X-rays.

OPERATIONAL CAUTION

- This microfocus X-ray source generates X-rays and must therefore be used only under the supervision of qualified personnel.
- This microfocus X-ray source shall be used in compliance with health and safety regulations enforced in order to prevent health hazards problems due to ionizing radiation.

* GPXS, ACS, ALS, FOS are registered trademarks of Hamamatsu Photonics K.K. in Japan, U.S.A, EU, and other countries.

* For detailed information on the products listed in this document, refer to the individual product catalogs.

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