

X-ray Imaging

HAMAMATSU

X-ray Source & Camera Selection Guide

More and more factories and research labs, faced with ever stricter demands for quality and safety in all types of food and industrial products, are finding that 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 whatsoever.

Hamamatsu Photonics has a full line of X-ray sources and cameras 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.

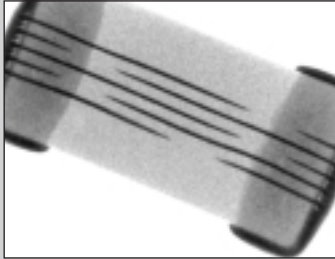
This pamphlet introduces typical items from our large product lineup and will prove a convenient selection guide for finding the precise answer to your specific application needs.

For more information on any of the products please contact your local Hamamatsu office.

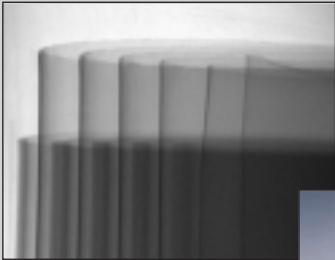
Imaging Examples

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.

Semiconductor & Electronic Component



▲Chip condenser (0402 size)
Taken with the microfocus X-ray source



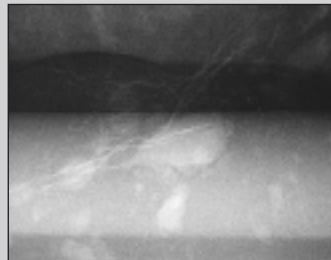
▲Electrode structure in
Lithium ion battery
Taken with the C7716 (3-inch mode) and
microfocus X-ray source



Industrial Products



▲Aluminum bottle with cap
Taken with the C7876 and microfocus X-
ray source



▲Torque converter
(aluminum die casting: 20 mm thick)
Taken with a microfocus X-ray source
Photo courtesy of Shimadzu Mechem

Security



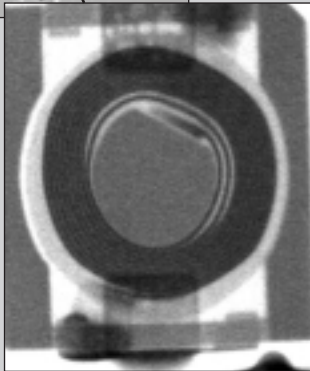
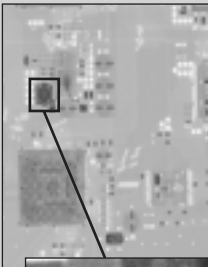
▲Interior of bag
Taken with an X-ray line scan camera

Scientific Research



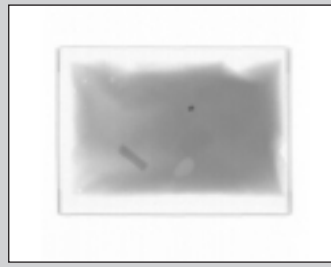
▲Flower
Taken with the C7876

SMT

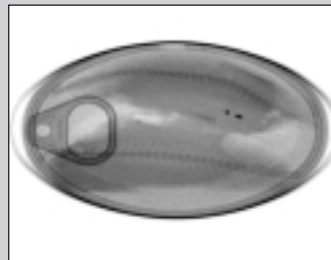


▲Mounted board
Taken with an X-ray TDI camera.

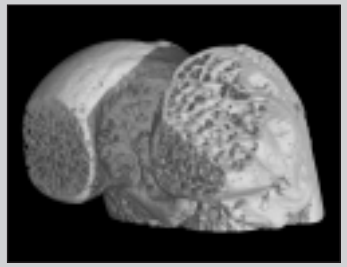
Food



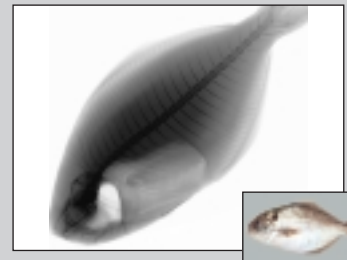
▲Foreign matter in packed food
Taken with an X-ray line scan camera



▲Foreign matter in can
Taken with an X-ray line scan camera



▲Rat femur
Taken with a microfocus X-ray source



▲Fish
Taken with an X-ray flat panel sensor



X-ray sources

Microfocus X-ray sources

FEATURES

- Micro focal spot
- RS-232C interface
- Easy handling

APPLICATIONS

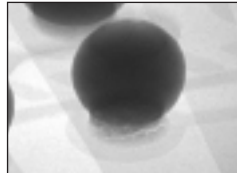
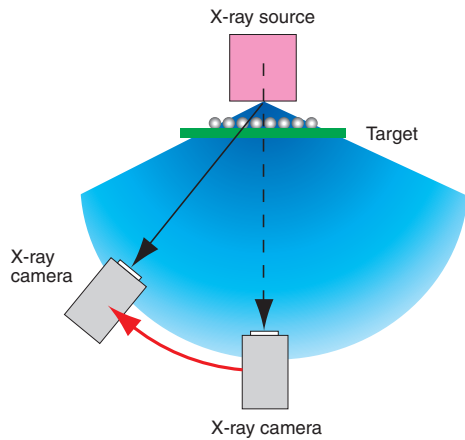
- Non-destructive inspection
- X-ray CT system
- In-line X-ray inspection system

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 of several micro meter to 10 micro meter capable of producing a clear X-ray image even at a high magnification. The RS-232C interface is provided as a standard feature, allowing automatic operation by external control. 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.)

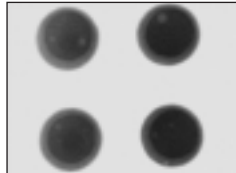
Type No.	Tube Voltage	X-ray Focal Spot Size (Min.)	X-ray Beam Angle (Max.)	FOD*
L9421-02	20 kV to 90 kV	5 μ m	39 °	9.5 mm
L10101	20 kV to 100 kV	5 μ m	42 °	6.8 mm
L10321	20 kV to 100 kV	5 μ m	118 °	7.3 mm
L9631	40 kV to 110 kV	15 μ m	62 °	16.8 mm
L10951	40 kV to 110 kV	15 μ m	62 °	16.8 mm
L9181-02	40 kV to 130 kV	5 μ m	45 °	13 mm
L8121-03	40 kV to 150 kV	5 μ m	43 °	17 mm
L9931	20 kV to 110 kV	4 μ m	120 °	0.5 mm
L9191	20 kV to 160 kV	1 μ m	120 °	0.5 mm
L10711	20 kV to 160 kV	0.25 μ m	120 °	0.5 mm

* Focus to object distance

Suitable for observation of solid forms



Oblique view fluoroscopy



Vertical view-conventional fluoroscopy

Sealed type



▲ 90 kV Type
L9421-02



▲ 100 kV Type
L10101, L10321



▲ 110 kV Type
L9631



▲ 110 kV Type
L10951



▲ 130 kV Type
L9181-02



▲ 150 kV Type
L8121-03

Open type



▲ 110 kV Type
L9931



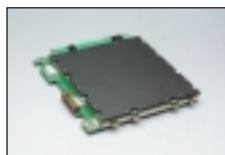
▲ 160 kV Type
L9191



▲ 160 kV Type
L10711

X-ray Flat panel sensors / CCD cameras / line scan cameras

X-ray Flat panel sensors



FEATURES

- High quality image
- High speed imaging
- Wide dynamic range
- No image distortion
- Digital output (12 bit-14 bit)
- Lightweight and compact

These are digital X-ray image sensors capable of capturing high-resolution and high quality X-ray images in real time. 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
C10900D	124.8 mm × 124.8 mm	100 μm* ¹	20 kVp to 90 kVp
C9252DK-14	249.6 mm × 124.8 mm	200 μm* ²	20 kVp to 90 kVp
C9730DK-10	52.8 mm × 52.8 mm	50 μm	17 keV (Mo source)
C9732DK	120 mm × 120 mm	50 μm	17 keV (Mo source)
C7942CA-22	120 mm × 120 mm	50 μm	20 kVp to 100 kVp

*¹ At fine mode
*² At whole scan mode

X-ray line scan camera C9750 series



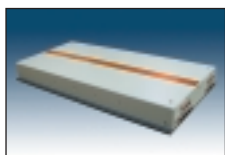
FEATURES

- 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 7.4 m as option), allowing internal observation of large objects which have been difficult to inspect.

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

Dual-Energy X-ray Line Scan Camera C10800 series



FEATURES

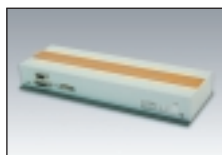
- Extract a target material from multi-energy image data
- High resolution and a wide dynamic range
- Very good energy separation accuracy with well aligned dual energy images

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

Using the commercial frame grabber board, the 12-bit digital output enables easy connection to a computer or other external instrument. Acquired image processing, data processing and filing can be performed, allowing the configuration of any system.

Type No.	Field of View	Resolution	Sensitivity Range
C10800-04ECM	409.6 mm wide	800 μm	60 kV to 100 kV
C10800-04ECH	409.6 mm wide	800 μm	110 kV to 160 kV

X-ray TDI camera C10650 series



FEATURES

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

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 sensor 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.	Field of View	Resolution	Sensitivity Range
C10650-221	146 mm × 6 mm	48 μm	25 kVp to 85 kVp
C10650-321	220 mm × 6 mm	48 μm	25 kVp to 85 kVp

X-ray camera with fiber optics window



FEATURES

- On-chip signal integration
- Digital output
- High sensitivity
- Wide dynamic range

This is a digital CCD camera coupled with a scintillator-coated fiber plate designed for low level X-ray imaging. A wide area can be viewed by using a tapered type fiber plate. When the fiber plate is not coated with scintillator materials, this type of CCD camera can be readily coupled to an image intensifier for low-light-level imaging.

Type	Field of View	Resolution	Sensitivity Range
High Dynamic Range	36 mm × 36 mm	24 μm	10 keV to 100 keV
High Resolution	47.4 mm × 31.2 mm	5.9 μm	10 keV to 100 keV

X-CUBE Compact X-ray CCD cameras H8953, H8481, H8480



FEATURES

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

X-CUBEs are compact X-ray CCD Cameras designed for non-destructive inspection. There are three different models in the X-CUBE family-the H8480, H8481 and H8953. The H8480 and H8953 use a 2/3-inch CCD coupled to a large-diameter tapered FOP. This FOP is 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	16.7 mm × 12.5 mm	50 μm	More than 3 keV
H8481	8.4 mm × 6.3 mm	38 μm	More than 3 keV
H8480	φ 25 mm	62 μm	More than 3 keV

X-ray I. I. camera units

4-inch X-ray I. I. digital camera unit C7336 series



FEATURES

- Digital output: Camera Link compliance
- High resolution, High contrast
- Low distortion

The C7336-03/04 consist of a high resolution, high contrast 4-inch X-ray image intensifier (X-ray I.I.) and a 1.45 megapixel digital CCD camera.

The X-ray I.I. used has a fixed field-of-view of 100 mm diameter and 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.

Type No.	Field of View	Resolution	Sensitivity Range
C7336-03	73 mm × 55 mm	71 μm	More than 20 keV
C7336-04	66 mm × 50 mm	71 μm	More than 20 keV

4-inch beryllium window X-ray I. I. camera unit C7876



FEATURES

- Real time imaging
- Analog output

The C7876 is an X-ray I. I. (image intensifier) camera unit incorporating a 4-inch beryllium window X-ray I. I. and a CCD camera. The C7876 offers greatly improved X-ray detection efficiency even at low energy levels by using an X-ray I. I. having a beryllium window instead of conventional aluminum windows. Clear, sharp X-ray images can be captured even from light element materials such as plastics. Also available is the C7336 X-ray image intensifier camera unit that uses an aluminum input window. Digital output type is also available.

Type No.	Field of View	Resolution	Sensitivity Range
C7876	72 mm × 54 mm	109 μm	More than 3 keV

Other related products

X-ray Scintillators (ACS, ALS, FOS)



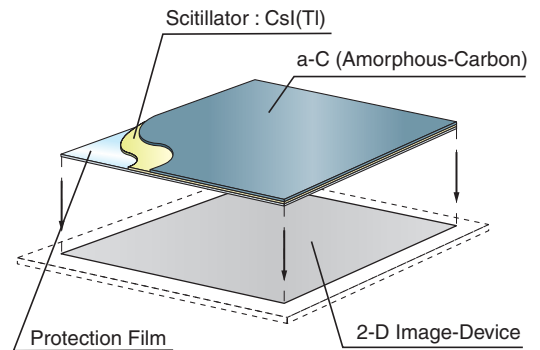
FEATURES

- Available in various shapes and size
- 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
ACS (amorphous carbon type)	High resolution
ALS (aluminum type)	High light output
FOS (fiber optic type)	Low energy X-ray detection, high X-ray shielding

STRUCTURE (ACS)



X-ray Source & Camera Selection Guide

■ Selection guide by field of view and resolution

Resolution \ Field of view	5.9 μm	24 μm	25 μm	38 μm	48 μm	50 μm	62 μm
8.4 mm × 6.3 mm				X-CUBE H8481			
8.8 mm × 6.5 mm			X-ray CCD camera C6086-03				
16.7 mm × 12.5 mm						X-CUBE H8953	
φ25 mm							X-CUBE H8480
36 mm × 36 mm		X-ray camera with fiber optics window					
47.4 mm × 31.2 mm	X-ray camera with fiber optics window						
52.8 mm × 52.8 mm						X-ray flat panel sensor C9730DK-10	
66 mm × 50 mm							
72 mm × 54 mm							
73 mm × 55 mm							
120 mm × 120 mm						X-ray flat panel sensor C9732DK C7942CA-22	
124.8 mm × 124.8 mm							
249.6 mm × 124.8 mm							
146 mm × 6 mm					X-ray TDI camera C10650-221		
220 mm × 6 mm					X-ray TDI camera C10650-321		
256 mm wide							
401 mm wide							
512 mm wide							

■ Major features of cameras

Products \ Features	On-chip signal integration	Real-time imaging	Image processing	Compact size	Analog output	Digital output
X-ray flat panel sensors	●	●		●		●
X-ray line scan camera C9750 series		●				●
Dual-energy X-ray line scan camera C10800 series		●	●			●
X-ray TDI camera C10650 series		●	●			●
X-ray camera with fiber optics window	●	●	●			●
X-CUBE™ Compact X-ray CCD cameras H8953, H8481, H8480		●		●	●	
4-inch X-ray I. I. digital camera unit C7336 series		●				●
4-inch beryllium window X-ray I. I. camera unit C7876		●			●	(●*)

 X-ray flat panel sensor / CCD camera / Line scan camera / TDI camera
 X-ray I. I. camera unit

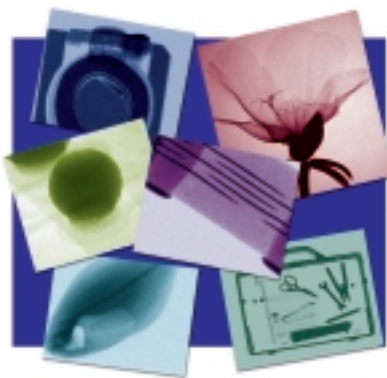
* Digital output type is also available.

71 μm	100 μm	109 μm	200 μm	400 μm	800 μm	Resolution
						Field of view
						8.4 mm × 6.3 mm
						8.8 mm × 6.5 mm
						16.7 mm × 12.5 mm
						φ25 mm
						36 mm × 36 mm
						47.4 mm × 31.2 mm
						52.8 mm × 52.8 mm
X-ray I. I. digital camera unit C7336-04						66 mm × 50 mm
		X-ray I. I. camera unit C7876				72 mm × 54 mm
X-ray I. I. digital camera unit C7336-03						73 mm × 55 mm
						120 mm × 120 mm
	X-ray flat panel sensor C10900DK*1					124.8 mm × 124.8 mm
			X-ray flat panel sensor C9252DK-14*2			249.6 mm × 124.8 mm
						146 mm × 6 mm
						220 mm × 6 mm
			X-ray line scan camera C9750-10TC	X-ray line scan camera C9750-05FC		256 mm wide
					Dual-energy X-ray line scan camera	401 mm wide
			X-ray line scan camera C9750-20TC	X-ray line scan camera C9750-10FC		512 mm wide

*1 At fine mode

*2 At whole scan mode

X-ray Imaging



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