

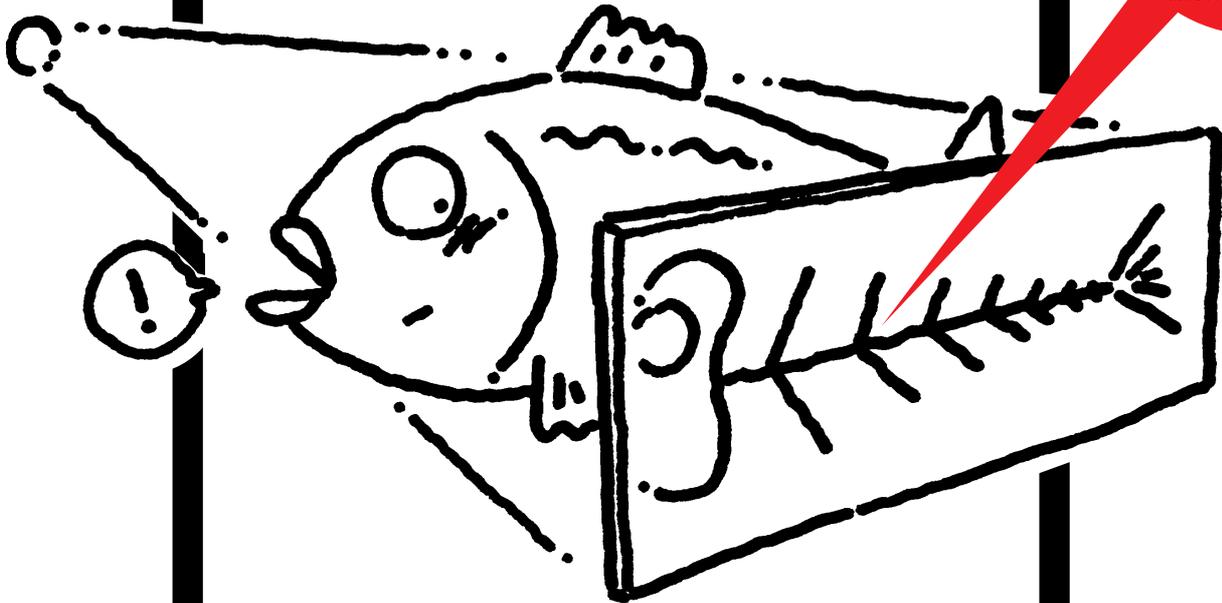
An X-ray imaging device for the next generation

FOS

FIBER OPTIC PLATE WITH
X-RAY SCINTILLATOR



X-Ray Source



"Compact"

"High Quality Image"

"Handy"

Features

High-quality digital image that far surpasses phosphor screen

An X-ray imaging device for the next generation

Hamamatsu now introduces the "FOS" an X-ray imaging device for the next generation that provides higher sensitivity and resolution than phosphor screen currently used. The FOS also allows real-time digital radiography when coupled to a CCD.

Compared to phosphor screen, the FOS offers clear, sharp X-ray images with high contrast. When used with an image readout device such as a high-resolution CCD, the X-ray image obtained can be easily digitized, saved, managed and transferred as electronic image data, thus paving the way to "fully digital X-ray imaging".

The fiber optic plate used in the FOS has excellent X-ray absorption characteristics, so that the X-rays which penetrate the X-ray scintillator and transpire enter the CCD are reduced to less than 1%. (Note 1) This protects the CCD from "deterioration" and "increase noise" caused by X-ray irradiation, assuring a long CCD service life and maintaining high image quality.

Note 1: Measured with an X-ray tube operated at 60kVp.

Protective film

This film protects the X-ray scintillator from scratches and dirt. In addition, a special coating is provided for the CsI(Tl) scintillator in order to reduce hydroscopic failure.

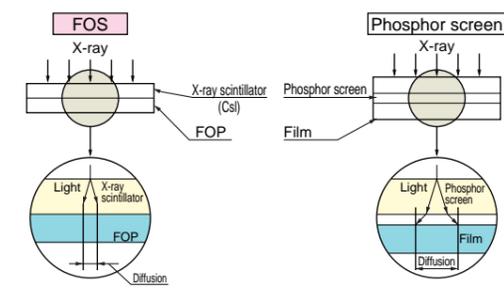
X-ray scintillator

The X-ray scintillator converts an X-ray image into a visible, optical image. There are two types of X-ray scintillators: the CsI(Tl) type composed of prismatic crystals and the GOS:Gd₂O₃(Tb) type made up of a high-density deposition of fine particles. Please select the desired type according to your application.

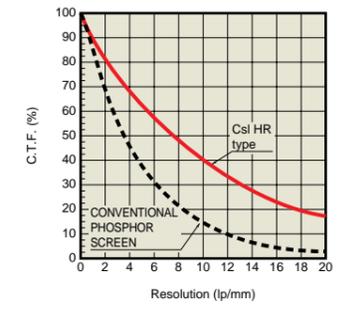
High Resolution : 20 lp/mm (at CTF > 15%, CsI(Tl) HR type)

Phosphor screen is relatively thick since it contains materials other than luminescent materials. In contrast, the X-ray scintillator used in the FOS can be a thin coat since it consists only of luminescent materials. When X-rays strike and light is emitted from a luminescent material, the light tends to diffuse more in the phosphor screen since the distance to the film is longer. In the FOS, however, less light diffuses due to the thin layer and the fact that there is no space between the scintillator and the FOP. The smaller the light diffusion, the smaller the crosstalk, resulting in higher spatial resolution.

Light diffusion occurring in X-ray scintillators (with same amount of luminescent materials)



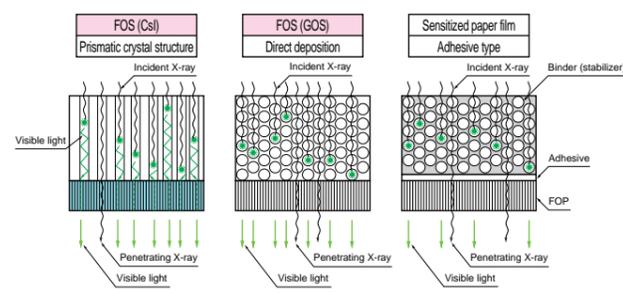
Spatial resolution



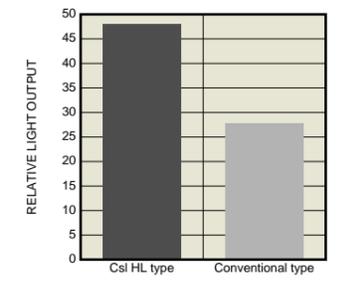
High Light Output : 80 % Up (compared to conventional phosphor screen)

The X-ray (conversion) efficiency (sensitivity) greatly depends on the "structure" of the scintillator used. The FOS X-ray imaging devices use two types of scintillators: one is a phosphor material called the "GOS type" composed of the high-density deposition of Gd₂O₃(Tb) without impurities and the other is a CsI (TI) type having a needle-like fine crystal structure that resembles optical fibers. Unlike conventional phosphor screen no adhesive is used between the FOP and the scintillator. This significantly prevents "loss of light" and "degradation of image quality" thus assuring even higher sensitivity.

Structure of phosphor screen



Light output characteristics



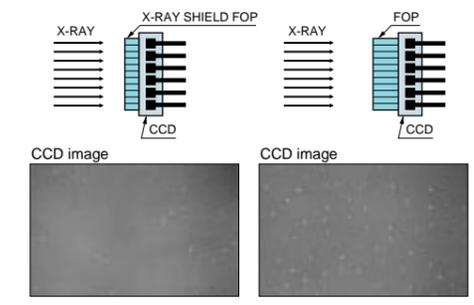
Available in various sizes and shapes

To meet diverse needs, the FOS are available in various sizes ranging from 1 to 100 square millimeters and also in various shapes including square, rectangular and circular configurations. In addition to standard products listed on page 6, we manufacture custom devices. Please contact our sales office for more details.

Allows more compact design for the detector unit

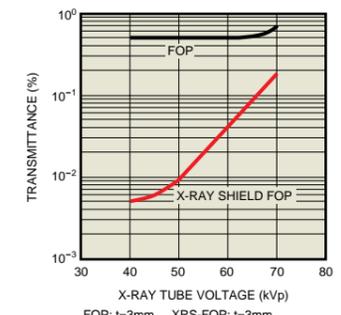
While transferring an optical image, the FOP absorbs 99 % of X-rays which have not been converted into visible light by the X-ray scintillator, so this prevents X-rays from damaging the subsequent imaging devices. Hamamatsu also provides X-ray shield fiber optic plates (XRS-FOPs) that ensure a much higher X-ray absorption coefficient even in thin configurations, so that the detector unit can be made thinner and more compact.

CCD damage and noise due to X-ray penetration



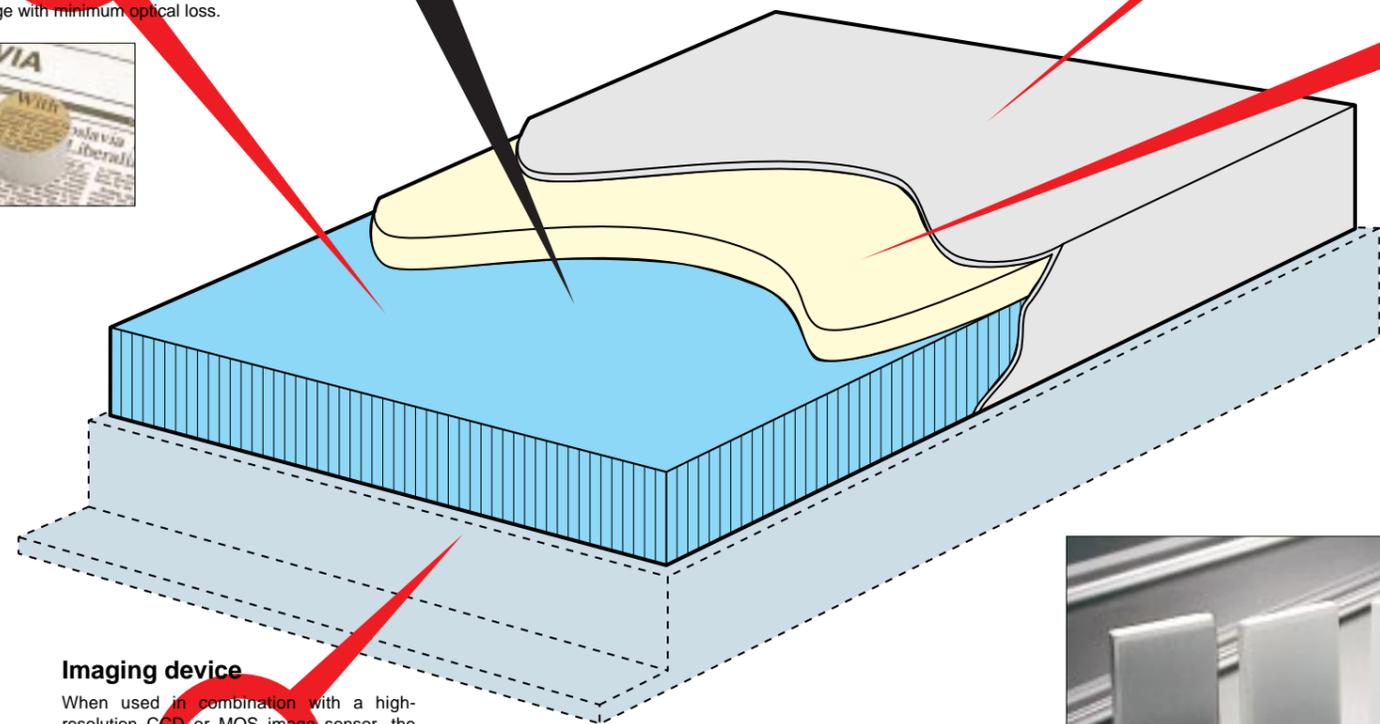
Measurement conditions X-ray tube : 60kVp
FOP : 2mm thick
XRS-FOP : 1mm thick

X-ray transmittance



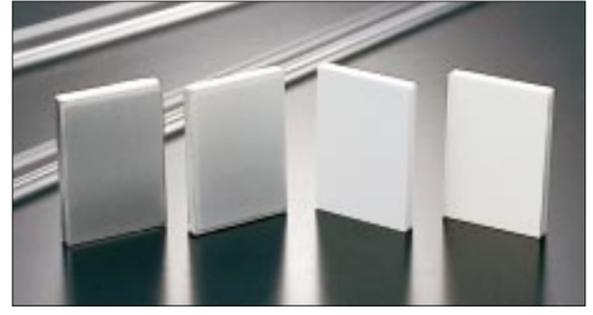
Fiber optic plate (FOP)

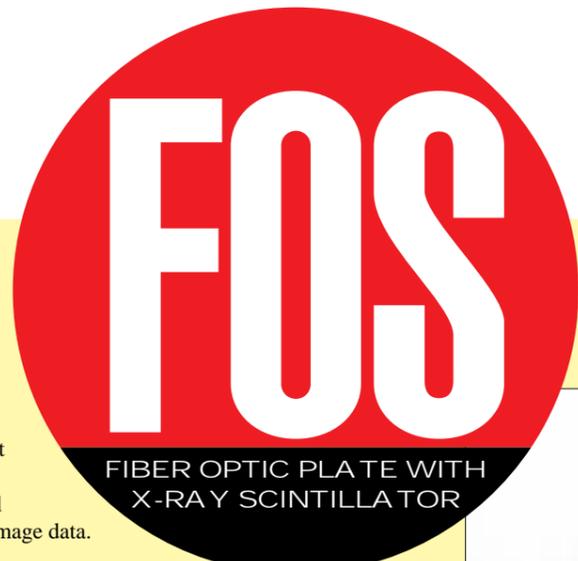
The FOP is an optical device consisting of 20 million glass fibers, 6 micrometers in diameter, bundled parallel to one another. An optical image, converted from an X-ray image by the X-ray scintillator, is transmitted to the imaging device through each fiber. The FOP transfers light while maintaining a clear image with minimum optical loss.



Imaging device

When used in combination with a high-resolution CCD or MOS image sensor, the image obtained can be handled as electronic data. Hamamatsu also manufactures FOS/image sensor assemblies, so please feel free to consult our sales office for details.



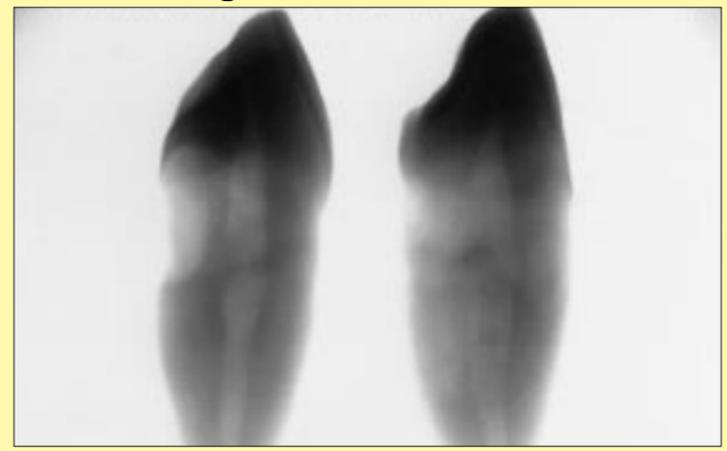


● Medical field

Compared to conventional phosphor screen, the FOS offers the following advantages.

- High sensitivity ————— reduces X-ray dosage of the human body.
- High resolution ————— permits early diagnosis of small diseased sections.
- Real-time image diagnosis — allows diagnosis and examination while monitoring the X-ray image of interest in real-time.
- Filmless ————— The X-ray image can be obtained as video data from the CCD, allowing digital processing of image data, including saving, managing and transferring of the image data.

■ Dental diagnosis : Reduction in X-ray dosage of the human body



▲ Visible light image

X-ray tube voltage : 60 kVp

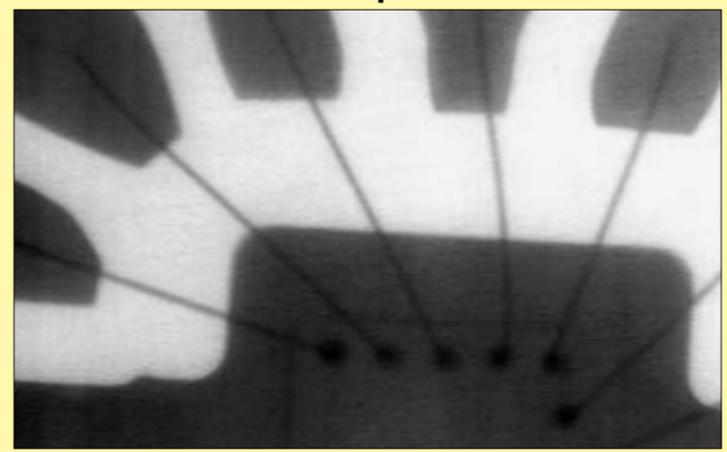
■ Mammography : Early diagnosis of small cancer lesions Removal of sample cells while monitoring the X-ray image in real-time

● Industrial field

Compared to conventional X-ray photography, the FOS has the following advantages.

- High resolution ————— allows you to locate smaller defective positions; provides clear image of minute structures with good accuracy.
- Compactness ————— facilitates direct coupling to a CCD, making the detector unit more compact and lightweight.

■ Non-destructive inspection of semiconductor devices



▲ Visible light image

X-ray tube voltage : 50 kVp

● Other fields

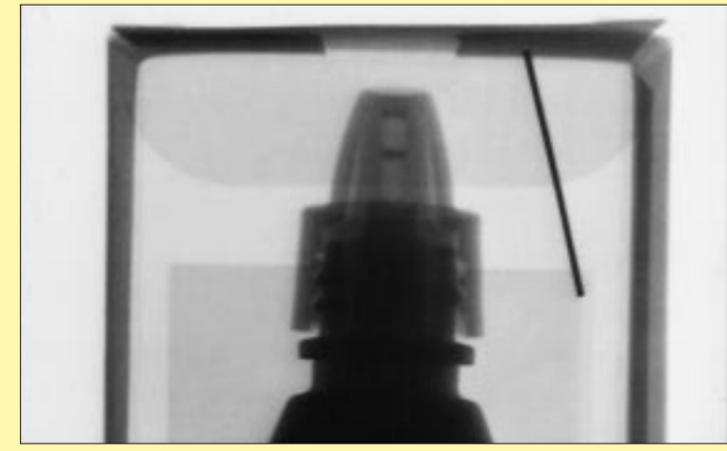
■ Currency : Both front and back patterns of an aluminum coin are imaged.



▲ Visible light image

X-ray tube voltage : 35 kVp

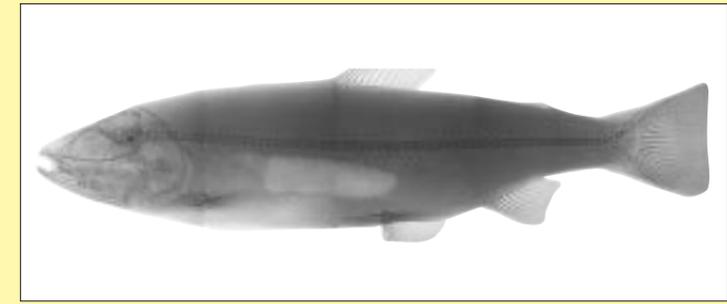
■ Packaging : An instruction manual made of paper and metallic needle are imaged.



▲ Visible light image

X-ray tube voltage : 25 kVp

■ Fish (trout) : Even fine bones are imaged.



▲ Visible light image

X-ray tube voltage : 55 kVp

FOS

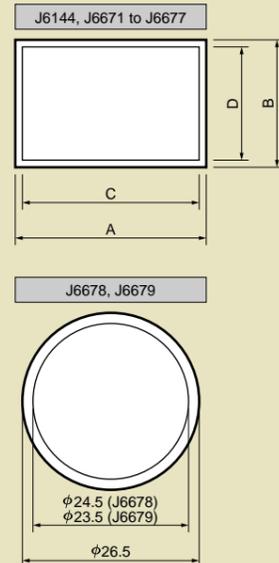
FIBER OPTIC PLATE WITH X-RAY SCINTILLATOR

FIBER OPTIC PLATE WITH X-RAY SCINTILLATOR

● FOS

Type No.	Scintillator type	Outer dimension AxB (mm)	Effective area CxD (mm)	Thickness [®] (mm)	Relative light output [©] (% min.)	Resolution [®] (lp/mm min.)
J6144	Gd ₂ O ₂ S (Tb) (GOS)	30X20	28X18	3	120	14
J6671 [®]	CsI (TI)		27X17 or 27X19	3	180 105	13 22
J6672	Gd ₂ O ₂ S (Tb) (GOS)	50X10	48X8	3	120	14
J6673 [®]	CsI (TI)		47X7 or 47X9	3	180 105	13 22
J6674	Gd ₂ O ₂ S (Tb) (GOS)	18X18	16X16	3	120	14
J6675 [®]	CsI (TI)		15X15 or 15X17	3	180 105	13 22
J6676	Gd ₂ O ₂ S (Tb) (GOS)	50X50	48X48	3	120	14
J6677 [®]	CsI (TI)		47X47 or 47X49	3	180 105	13 22
J6678	Gd ₂ O ₂ S (Tb) (GOS)	φ26.5	φ24.5	3	120	14
J6679 [®]	CsI (TI)		φ23.5	3	180 105	13 22

Dimensional Outline

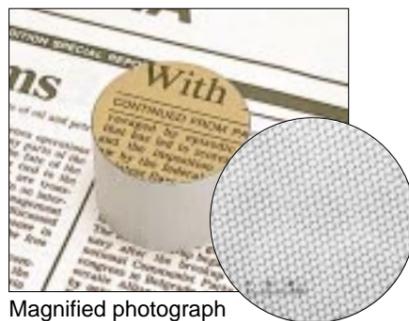


- Ⓐ Specify the size of CsI(Tl) type scintillator.
- Ⓑ 25 mg/cm² for the GOS scintillator; 40 mg/cm² for the CsI(Tl) scintillator.
- Ⓒ Relative values, with 100 % being equal to the light output from conventional phosphor screen, Light output was measured with a photodiode under the following conditions :
(Gd₂O₂S(Tb) : X-ray tube voltage 70 kVp, aluminum filter 4.8 mm thick)
(CsI(Tl) : X-ray tube voltage 28 kVp, aluminum filter 1.8 mm thick)
- Ⓓ The values in the upper columns of the CsI(Tl) scintillators are for the HL (high light output) type, and values in the lower columns are for the HR (high resolution) type. Please select the desired type according to your particular application.
- Ⓔ Values at 10 % CTF (contrast transfer function), measured under the following conditions.
(Gd₂O₂S(Tb) : X-ray tube voltage 70 kVp, without aluminum filter)
(CsI(Tl) : X-ray tube voltage 40 kVp, without aluminum filter)

WHAT'S FOP?

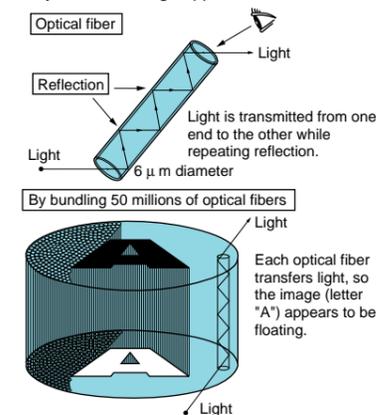
Fiber Optic Plate: FOP

The FOP is a next-generation optical device consisting of millions of glass fibers of 6 micrometers in diameter, bundled parallel to one another. Since light is transmitted through each fiber, an image appears to float. The image can be transferred from one end of the fiber to the other without any distortion. FOPs are widely used as optical devices that replace optical lens.



The reason is the "optical fiber structure".

Why does the image appear to float?



● Tapered FOS

Hamamatsu offers tapered FOS with a maximum size ratio of 3 : 1 (between both ends). Tapered FOS reduces the size of the X-ray image that was input, allowing a smaller CCD to be used.

Type No.	Scintillator type	Dimensions		Effective area		Thickness (mm)	Relative light output [Ⓐ] (% Min.)	Resolution [Ⓑ] (lp/mm)	Tapered ratio
		Input surface	Output surface	Input surface	Output surface				
J6756	Gd ₂ O ₂ S(Tb) (GOS)	φ22	φ7.3	φ20	φ6.6	25	80 [Ⓐ]	14	3 : 1
J6757	CsI(Tl)	φ22	φ7.3	φ19	φ6.3	25	180	10	3 : 1

- Ⓐ Relative values, with 100 % being equal to the light output from conventional phosphor screen, Light output was measured with a photodiode under the following conditions :
(Gd₂O₂S(Tb) : X-ray tube voltage 70 kVp, aluminum filter 4.5 mm thick)
(CsI(Tl) : X-ray tube voltage 28 kVp, aluminum filter 1.8 mm thick)
- Ⓑ Values at 10 % CTF (contrast transfer function), measured under the following conditions :
(Gd₂O₂S(Tb) : X-ray tube voltage 70 kVp, without aluminum filter)
(CsI(Tl) : X-ray tube voltage 40 kVp, without aluminum filter)



● FOS/Image Sensor Assemblies

The followings are examples of FOS/image sensor assemblies available from Hamamatsu.

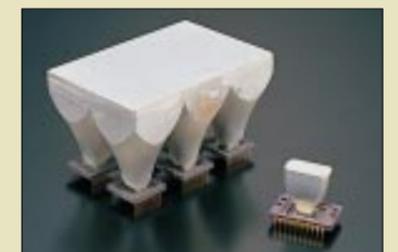
Example 1 Linear X-ray image sensor

Slant type FOSs are coupled to MOS linear image sensors, to form a long, rectangular X-ray image sensor. This assembly can be used for industrial CT applications using gamma rays, without causing damage to the image sensors.



Example 2 Two-dimensional X-ray image sensor

This assembly serves as a compact X-ray imaging device. Since the FOS is directly coupled to the CCD, there is no distortion and no light leakage, delivering precise, sharp images.



● X-ray shield fiber optic plate (XRS-FOP)

XRS-FOPs provide enhanced X-ray absorption rate about 50 times higher than normal FOPs. Almost all X-rays which have penetrated the scintillator and have not been converted into light are absorbed in the XRS-FOP. This eliminates X-ray damage of image sensors such as CCDs. XRS-FOPs are available in sizes up to 50 mmx50 mm.

Type No.	Fiber diameter	Numerical aperture (N.A.)	Resolution (lp/mm)	Absorption material	Thermal expansion coefficient (×10 ⁻⁷ /°C)	Transmittance (%)	Dimensions (mm)	Thickness (mm)
J6745-01	6μm	1.0	90.5	Included	96	60	30X21	3



FIBER OPTIC PLATE WITH
X-RAY SCINTILLATOR

HAMAMATSU

HAMAMATSU PHOTONICS K.K., Electron Tube Center

314-5, Shimokanzo, Toyooka-village, Iwata-gun, Shizuoka-ken, 438-0193 Japan, Telephone:(81)539/62-5248, Fax:(81)539/62-2205, Telex:4225-186HAMAHQ

U.S.A.: Hamamatsu Corporation: 360 Foothill Road, P.O.Box 6910, Bridgewater, N.J. 08807-0910, U.S.A., Telephone:(1)908-231-0960, Fax:(1)908-231-1218

Germany: Hamamatsu Photonics Deutschland GmbH: Arzbergerstr. 10, D-82211 Herrsching am Ammersee, F.G. Germany, Telephone:(49)08152-3750, Fax:(49)08152-2658

France: Hamamatsu Photonics France: S.A.R.L.: 8, Rue du Saule Trapu, Parc du Moulin de Massy, 91882 Massy Cedex, France, Telephone: 33-(1) 69 53 71 00, Fax: 33-(1) 69 53 71 10

United Kingdom: Hamamatsu Photonics UK Limited: Lough Point, 2 Gladbeck Way, Windmill Hill, Enfield, Middlesex EN2 7JA, United Kingdom, Telephone:(44)0181-367-3560, Fax:(44)0181-367-6384

North Europe: Hamamatsu Photonics Norden AB: Färögatan 7, S-164 40 Kista, Sweden, Telephone:(46)08-703-2950, Fax:(46)08-750-5895

Italy: Hamamatsu Photonics Italia S.R.L.: Via della Moia, 1/E 20020 Arese, (Milano), Italy Telephone: (39)2-935 81 733 Fax: (39)2-935 81 741

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