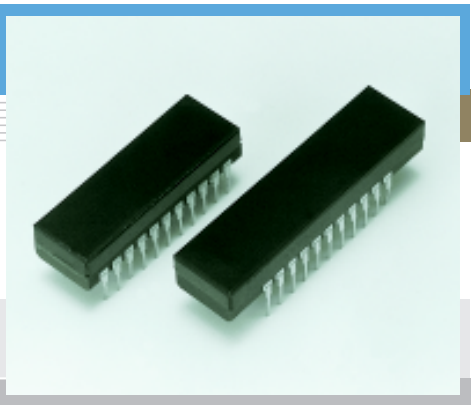


NMOS linear image sensor
S3901-FX series

Image sensor highly sensitive to X-rays from 10 k to 100 keV

NMOS linear image sensors are self-scanning photodiode arrays designed specifically as detectors for multichannel spectroscopy. The scanning circuit is made up of N-channel MOS transistors, has low power consumption and is easy to handle. Each photodiode has a large active area, high UV sensitivity yet very low noise, delivering a high S/N even at low light levels. Current output type NMOS linear image sensors also offer excellent output linearity and wide dynamic range.

S3901-FX series image sensors are variants of S3901-F series NMOS image sensors. Having a phosphor-coated fiber optic plate (FOP) as the light input window, the S3901-FX series was developed for detection of X-rays and electrons. The S3901-FX offers particularly high sensitivity to X-rays from 10 k to 100 keV. The phosphor material used is gadolinium ox sulfide ($Gd_2O_2S \cdot Tb$) whose composition is carefully selected to provide optimum sensitivity and resolution with a peak emission at 550 nm wavelength.

The S3901-FX series active area consists of a photodiode array with pixels formed at 50 µm pitches and a height of 2.5 mm. The number of pixels can be selected from 256 or 512.

Hamamatsu S3902/S3903/S3904 series NMOS linear image sensors are also available with FOP windows coated with the same phosphor material as S3901-FX series.

Using photodiodes with no phosphor and FOP window also allows direct detection of X-rays at energy levels below 10 keV.

Features

- Wide active area
  Pixel pitch: 50 µm
  Pixel height: 2.5 mm
- Low dark current and high saturation charge allow a long integration time and a wide dynamic range at room temperature
- Excellent output linearity and sensitivity spatial uniformity
- Low power consumption: 1 mW Max.
- Start pulse and clock pulse are CMOS logic compatible

Applications

- Test equipment using X-ray and electron beam transmission
- X-ray non-destructive inspection
- X-ray and electron beam detector

Figure 1 Equivalent circuit

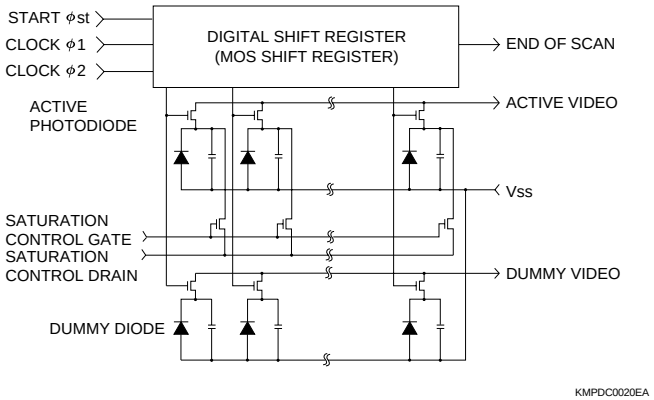
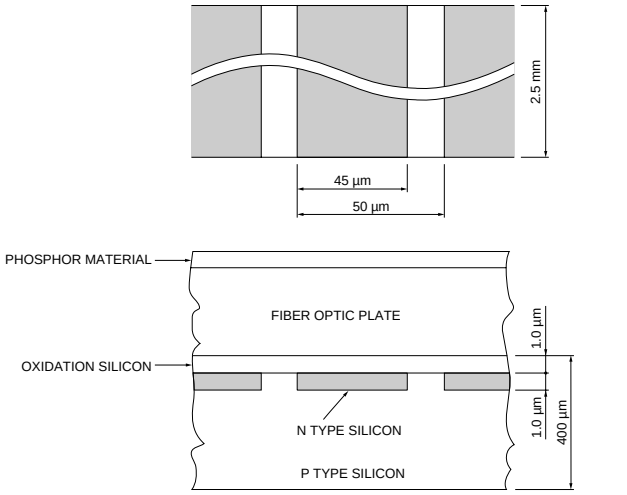


Figure 2 Active area structure



■ Absolute maximum ratings

Parameter	Symbol	Value	Unit
Input pulse (φ1, φ2, φst) voltage	Vφ	15	V
Power consumption *1	P	1	mW
Operating temperature *2	Topr	-30 to +60	°C
Storage temperature	Tstg	-40 to +80	°C

*1: Vφ=5.0 V
*2: No condensation

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■ Shape specifications

Parameter	S3901-256FX	S3901-512FX	Unit
Number of pixels	256	512	-
Package length	31.75	40.6	mm
Number of pin	22		-
Window material *3	Fiber optic plate		-
Weight	8.0	10.0	g

*3: To prevent unwanted effects from stray light, S3901-FX series is supplied with an aluminum cover fitted on the phosphor-coated FOP.

■ Specifications (Ta=25 °C)

Parameter	Symbol	Min.	Typ.	Max.	Unit
Pixel pitch	-	-	50	-	μm
Pixel height	-	-	2.5	-	mm
Spectral response range (20 % of peak)	λ	10 to 100			keV
Photo sensitivity	S	-	14	-	pC/mR
Photodiode dark current *4	ID	-	0.2	0.6	pA
Photodiode capacitance *4	Cph	-	20	-	pF
Saturation exposure *4	Esat	-	2.8	-	mR
Saturation output charge *4	Qsat	-	50	-	pC
Photo response non-uniformity *5	PRNU	-	-	±10	%

*4: Vb=2.0 V, Vϕ=5.0 V

*5: Measured under the following conditions including uniformity in the phosphor emission (but excluding dark current components).
Tungsten cathode X-ray tube: 40 keV
Distance between S3901-FX series and X-ray tube: 30 cm
Phosphor material: $Gd_2O_2S \cdot Tb$ (thickness=200 μm, λp=550 nm, decay time=1 ms)

■ Electrical characteristics (Ta=25 °C)

Parameter		Symbol	Condition	Min.	Typ.	Max.	Unit
Clock pulse (ϕ1, ϕ2) voltage	High	Vϕ1, Vϕ2 (H)		4.5	5	10	V
	Low	Vϕ1, Vϕ2 (L)		0	-	0.4	V
Start pulse (ϕst) voltage	High	Vϕs (H)		4.5	Vϕ1	10	V
	Low	Vϕs (L)		0	-	0.4	V
Video bias voltage *6		Vb		1.5	Vϕ - 3.0	Vϕ - 2.5	V
Saturation control gate voltage		Vscg		-	0	-	V
Saturation control drain voltage		Vscd		-	Vb	-	V
Clock pulse (ϕ1, ϕ2) rise / fall time *7		trϕ1, trϕ2 tfϕ1, tfϕ2		-	20	-	ns
Clock pulse (ϕ1, ϕ2) pulse width		tpwϕ1, tpwϕ2		200	-	-	ns
Start pulse (ϕst) rise / fall time		trϕs, tfϕs		-	20	-	ns
Start pulse (ϕst) pulse width		tpwϕs		200	-	-	ns
Start pulse (ϕst) and clock pulse (ϕ2) overlap		tϕov		200	-	-	ns
Clock pulse space *7		X1, X2		trf - 20	-	-	ns
Data rate *8		f		0.1	-	2000	kHz
Video delay time		tvd	50 % of saturation *8, *9	-	120 (-256 FX)	-	ns
				-	160 (-512 FX)	-	ns
Clock pulse (ϕ1, ϕ2) line capacitance		Cϕ	5 V bias	-	36 (-256 FX)	-	pF
				-	67 (-512 FX)	-	pF
Saturation control gate (Vscg) line capacitance		Cscg	5 V bias	-	20 (-256 FX)	-	pF
				-	35 (-512 FX)	-	pF
Video line capacitance		CV	2 V bias	-	11 (-256 FX)	-	pF
				-	20 (-512 FX)	-	pF

*6: Vϕ is input pulse voltage

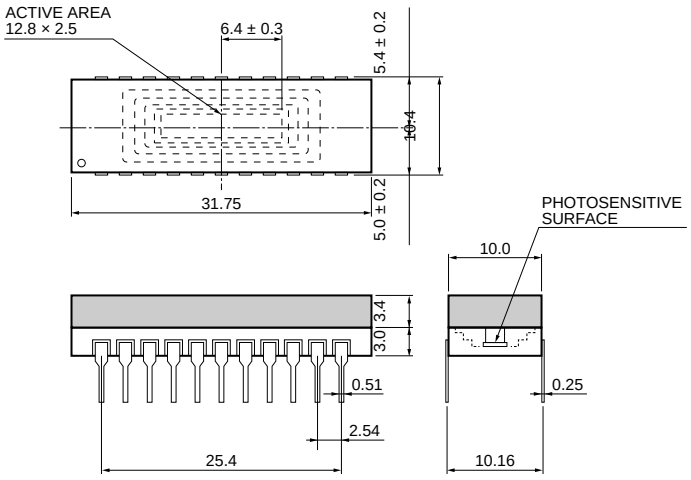
*7: trf is the clock pulse rise or fall time. A clock pulse space of “rise time/fall time - 20” ns (nanoseconds) or more should be input if the clock pulse rise or fall time is longer than 20 ns.

*8: Vb=2.0 V, Vϕ=5.0 V

*9: Measured with C7883 driver circuit.

Figure 3 Dimensional outlines (unit: mm)

S3901-256FX



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S3901-512FX

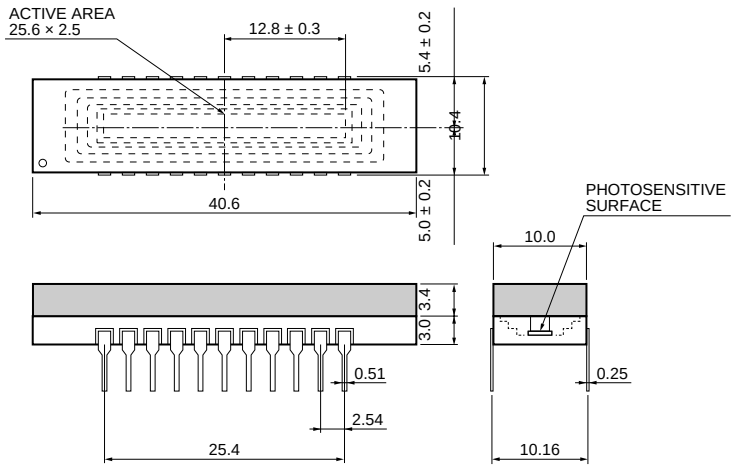

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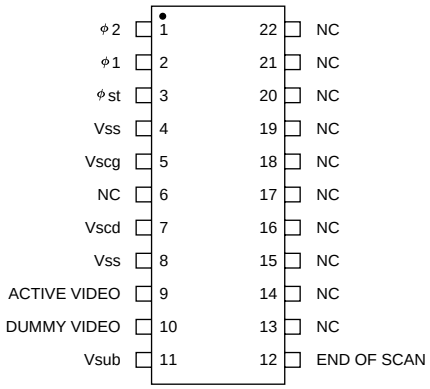
Figure 4 Pin connection



Vss, Vsub and NC should be grounded.

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