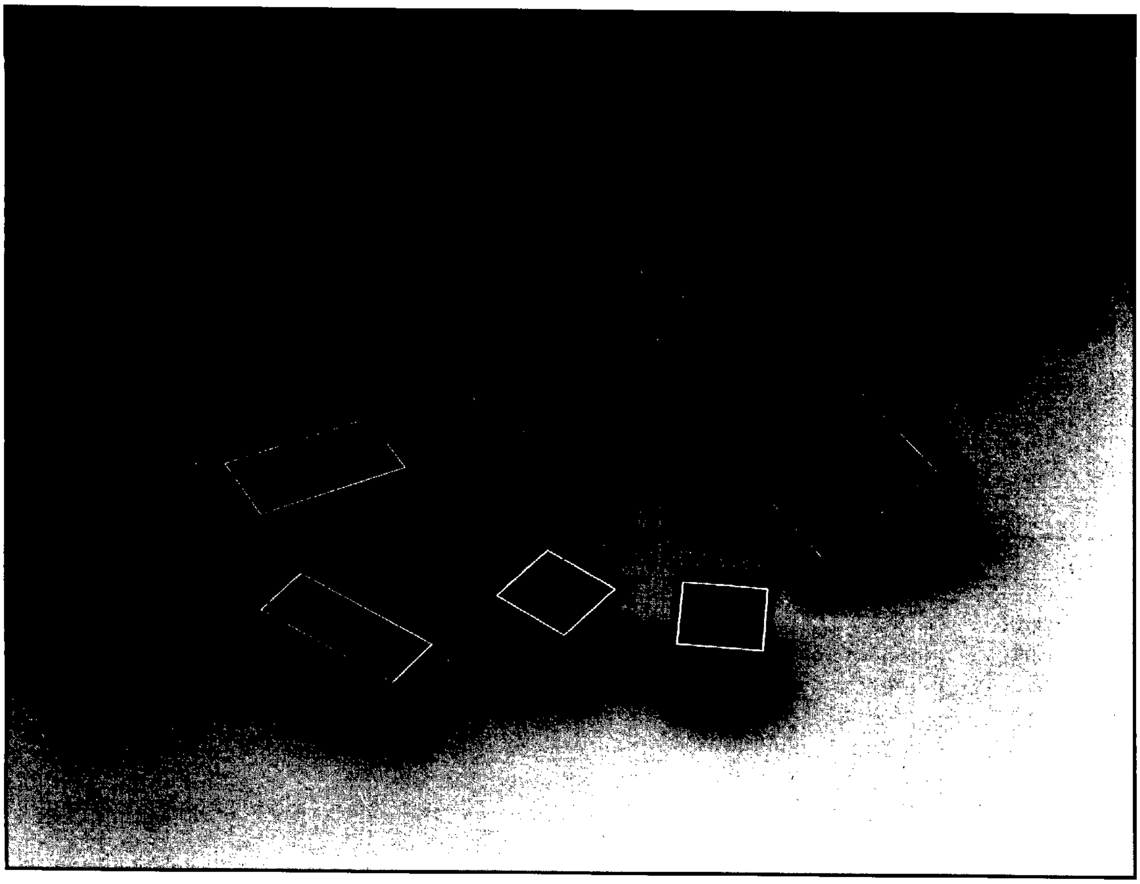
# Large-Area PIN Silicon Photodiodes



## FEATURES

- **Large active area:**
  **10 × 10 mm, 10 × 20 mm, 30 × 30mm, etc.**
- **High quantum efficiency**
- **Low dark current**
- **Low bias voltage operation**
- **Sensitivity matching with BGO scintillators**
- **High-speed time response**
- **Low noise and high stability**
- **Good energy resolution**

## APPLICATIONS

- **Scintillation detectors**
- **Calorimeters**
- **Hodoscopes**
- **TOF counters**
- **Air shower counters**
- **Particle detectors etc.**

Silicon photodiodes are promising devices for scintillation detectors in high energy physics experiments and nuclear physics. They are very compact, have low power demand, high quantum efficiency and are insensitive to magnetic fields.

Hamamatsu offers a variety of PIN silicon photodiodes specifically designed for scintillation detectors in high energy physics experiments and nuclear physics. These photodiodes have large, uniform active areas of square or rectangular shapes. In spite of large active areas, they exhibit low dark current, low terminal capacitance and low series resistance, assuring high-speed response, low noise and long-term high stability. Package configurations are well designed for good optical coupling to scintillators such as BGO and CsI crystals. Windowless types are also provided for direct high energy particle detection.

Standard types are made of a high-resistivity silicon wafer with 300 $\mu$m tichkness that provides low terminal capacitance at a low bias voltage. Also, smaller area types are available with a 200 $\mu$m thick wafer that enables low capacitance at even lower bias operation. 500 $\mu$m thick wafer is also used for 10 × 10 mm and larger area types that can be operated at a higher bias voltage, and are suited for direct particle detection.

# Large-Area PIN Silicon Photodiodes

| Type No. | Remarks | Out-line*1 | Window*2 Material | Active*3 Area (mm) | Spectral Response Range λ (nm) | Peak Sensitivity Wavelength λp (nm) | Characteristics (Ta=25℃) Photo Sensitivity S Typ. Peak (A/W) | BGO 480nm (A/W) | CsI (Tl) 540nm (A/W) |
|---|---|---|---|---|---|---|---|---|---|
| **300 μm Wafer Thickness Types** | | | | | | | | | |
| S3590-03 | 10 × 10mm active area, Modified type of S1790 with new package | ❶ | Epoxy resin | 10 × 10mm | 320 to 1100 | 960 | 0.59 | 0.26 | 0.31 |
| S2662-03 | 7.5 × 20mm active area | ❷ | Epoxy resin | 7.5 × 20mm | 320 to 1100 | 960 | 0.59 | 0.26 | 0.31 |
| S2744-03 | 10 × 20mm active area | ❸ | Epoxy resin | 10 × 20mm | 320 to 1100 | 960 | 0.59 | 0.26 | 0.31 |
| S3204-03 | 18 × 18mm active area | ❹ | Epoxy resin | 18 × 18mm | 320 to 1100 | 960 | 0.59 | 0.26 | 0.31 |
| S3584-03 | 28 × 28mm active area | ❺ | Epoxy resin | 28 × 28mm | 320 to 1100 | 960 | 0.59 | 0.26 | 0.31 |
| S3588-03 | 3.4 × 30mm active area | ❻ | Epoxy resin | 3.4 × 30mm | 320 to 1100 | 960 | 0.59 | 0.26 | 0.31 |

*1 See pages 10 and 11 for outlines.

*2 Windowless types (suffix "-04" series) are also availables.

*3 This is the useful area for detecting light from the UV to near IR. For direct detection of radiation particles, the active area is expanded to a size equivalent to the depth of the depletion layer.

*4 NEP (noise equivalent power) is given by

$$NEP = \frac{\text{Noise Current } (A/Hz^{1/2})}{\text{Sensitivity at } \lambda p \text{ (A/W)}}$$

| Characteristics ($V_R$=70V, Ta=25℃) | | | | | Absolute Maximum Ratings | | | Type No. |
|---|---|---|---|---|---|---|---|---|
| Dark Current $I_D$ | | Cut-off Frequency fc | Terminal Capacitance Ct f=1MHz | NEP*4 | Reverse Voltage $V_R$ Max. | Operating Temperture Topr | Storage Temperture Tstg | |
| Typ. (nA) | Max. (nA) | Typ. (MHz) | Typ. (pF) | Typ. (W/Hz$^{1/2}$) | (V) | (℃) | (℃) | |
| 3 | 10 | 40 | 55 | $5 \times 10^{-14}$ | 100 | −20 to +60 | −20 to +80 | S3590-03 |
| 3 | 10 | 35 | 75 | $5 \times 10^{-14}$ | 100 | −20 to +60 | −20 to +80 | S2662-03 |
| 4 | 15 | 25 | 95 | $6 \times 10^{-14}$ | 100 | −20 to +60 | −20 to +80 | S2744-03 |
| 6 | 20 | 20 | 140 | $7 \times 10^{-14}$ | 100 | −20 to +60 | −20 to +80 | S3204-03 |
| 10 | 30 | 10 | 330 | $1 \times 10^{-13}$ | 100 | −20 to +60 | −20 to +80 | S3584-03 |
| 4 | 15 | 40 | 50 | $6 \times 10^{-14}$ | 100 | −20 to +60 | −20 to +80 | S3588-03 |

Figure 1: Spectral Response

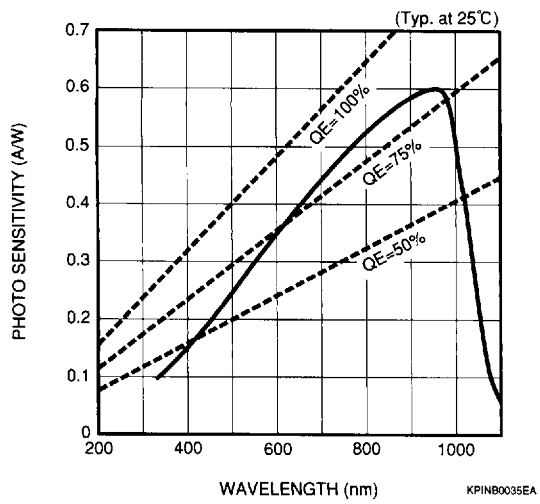



Figure 2: Terminal Capacitance vs. Reverse Voltage

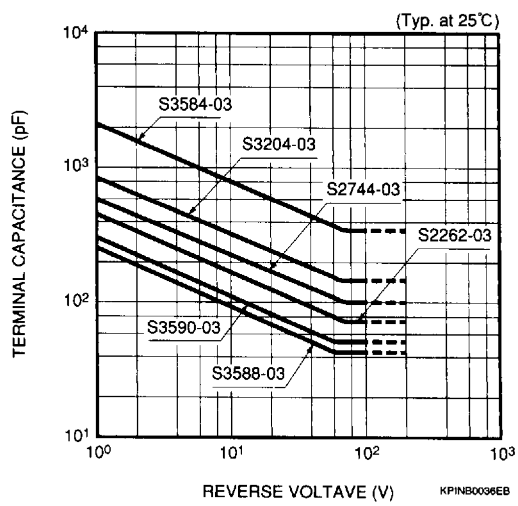



Figure 3: Dark Current vs. Reverse Voltage

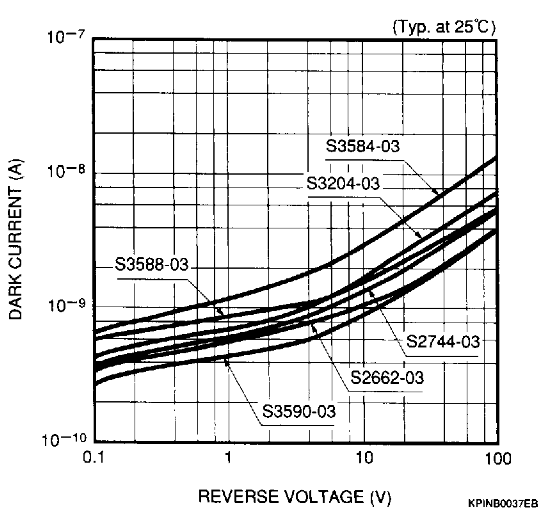
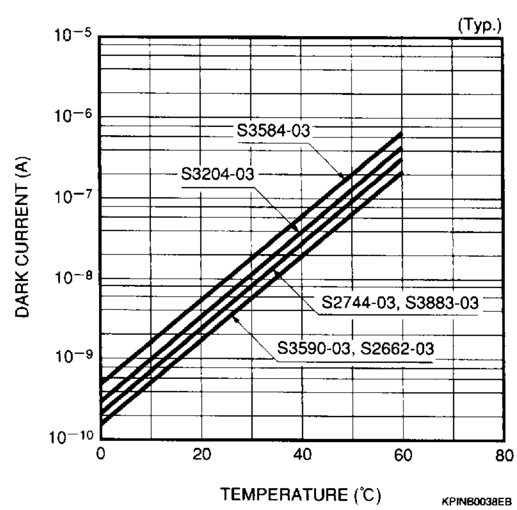



Figure 4: Dark Current vs. Temperature



# Large-Area PIN Silicon Photodiodes

| Type No. | Remarks | Out[*1] line | Window[*2] Material | Active[*3] Area (mm) | Spectral Response Range $\lambda$ (nm) | Peak Sensitivity Wavelength $\lambda p$ (nm) | Characteristics (Ta=25℃) Photo Sensitivity S Typ. Peak (A/W) | BGO 480nm (A/W) | CsI (Tl) 540nm (A/W) |
|---|---|---|---|---|---|---|---|---|---|
| **200 $\mu$ m Wafer Thickness Types** | | | | | | | | | |
| S3590-01 | 10 × 10mm active area | ❶ | Epoxy resin | 10 × 10 | 320 to 1060 | 920 | 0.56 | 0.26 | 0.31 |
| S2662-01 | 7.5 × 20mm active area | ❷ | Epoxy resin | 7.5 × 20 | 320 to 1060 | 920 | 0.56 | 0.26 | 0.31 |
| S3588-01 | 3.4 × 30mm active area | ❻ | Epoxy resin | 3.4 × 30 | 320 to 1060 | 920 | 0.56 | 0.26 | 0.31 |
| **500 $\mu$ m Wafer Thickness Types** | | | | | | | | | |
| S3590-05 | 9 × 9mm active area | ❶ | Epoxy resin | 9 × 9 | 320 to 1120 | 980 | 0.6 | 0.25 | 0.3 |
| S3204-05 | 18 × 18mm active area | ❹ | Epoxy resin | 18 × 18 | 320 to 1120 | 980 | 0.6 | 0.25 | 0.3 |
| S3584-05 | 28 × 28mm active area | ❺ | Epoxy resin | 28 × 28 | 320 to 1120 | 980 | 0.6 | 0.25 | 0.3 |

*1 See pages 10 and 11 for outlines.

*2 Windowless types (suffix "-02" series for 200 $\mu$m wafer thickness types and "-06" series for 500 $\mu$m wafer thickness types) are also available.

*3 This is the useful area for detecting light from the UV to near IR. For direct detection of radiation particles, the active area is expanded to a size equivalent to the depth of the depletion layer.

*4 Measured at following Reverse Voltage

S3590-01, S3588-01 : 30V

S2662-01 : 12V

S3590-05, S3204-05, S3584-05 : 100V

*5 NEP (noise equivalent power) is given by

$$NEP = \frac{\text{Noise Current } (A/Hz^{1/2})}{\text{Sensitivity at } \lambda p \text{ (A/W)}}$$

| Dark Current ID Typ. (nA) | Dark Current ID Max. (nA) | Cut-off Frequency fc Typ. (MHz) | Terminal Capacitance Ct f=1MHz Typ. (pF) | NEP*5 Typ. ($W/Hz^{1/2}$) | Reverse Voltage $V_R$ Max. (V) | Operating Temperture Topr (℃) | Storage Temperture Tstg (℃) | Type No. |
|---|---|---|---|---|---|---|---|---|
| Characteristic(*4Ta=25℃) | | | | | Absolute Maximum Ratings | | | |
| 1.5 | 5 | 35 | 75 | $4 \times 10^{-14}$ | 50 | −20 to +60 | −20 to +80 | S3590-01 |
| 2.5 | 10 | 20 | 120 | $5 \times 10^{-14}$ | 50 | −20 to +60 | −20 to +80 | S2662-01 |
| 2.0 | 5 | 35 | 80 | $5 \times 10^{-14}$ | 50 | −20 to +60 | −20 to +80 | S3588-01 |
| 8 | 30 | 20 | 25 | $8 \times 10^{-14}$ | 150 | −20 to +60 | −20 to +80 | S3590-05 |
| 15 | 50 | 20 | 80 | $1 \times 10^{-13}$ | 150 | −20 to +60 | −20 to +80 | S3204-05 |
| 20 | 100 | 10 | 200 | $2 \times 10^{-13}$ | 150 | −20 to +60 | −20 to +80 | S3584-05 |

Figure 5: Spectral Response

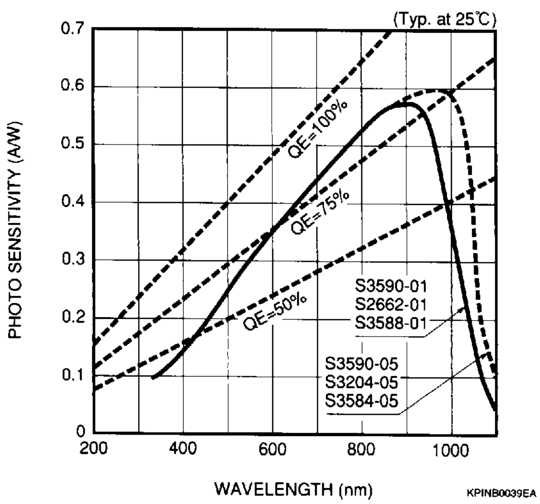



Figure 6: Terminal Capacitance vs. Reverse Voltage

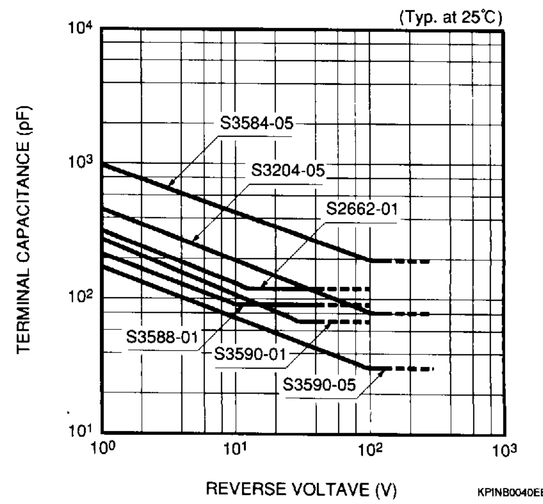



Figure 7: Dark Current vs. Reverse Voltage

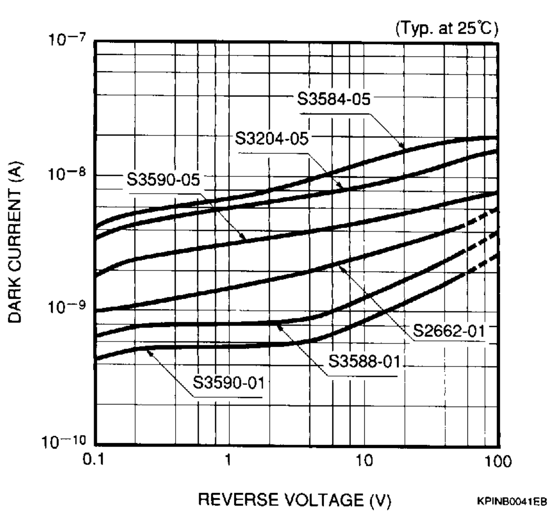
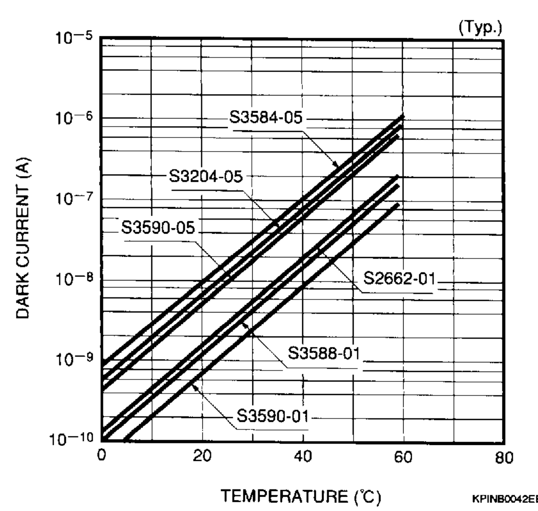
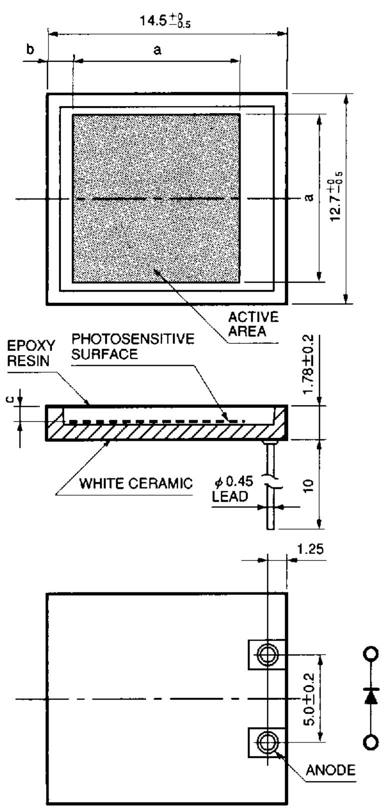



Figure 8: Dark Current vs. Temperature



# Large-Area PIN Silicon Photodiodes

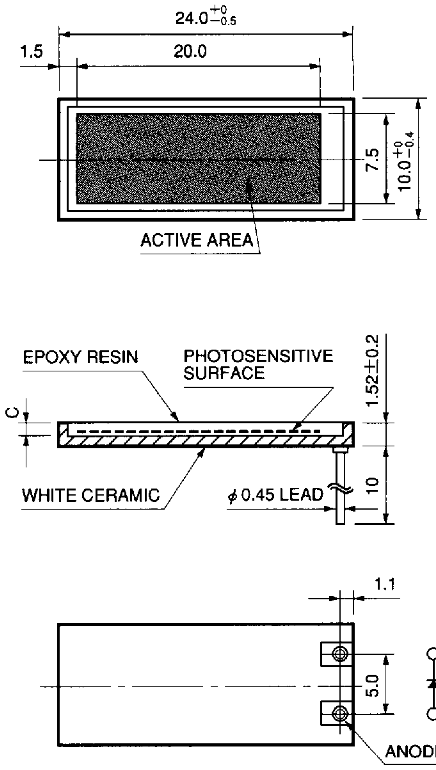
## ❶ S3590 Series




| | -01 | -03 | -05 |
|---|---|---|---|
| a | 10.0 | 10.0 | 9.0 |
| b | 1.4 | 1.4 | 1.9 |
| c | 0.8 | 0.7 | 0.5 |

KPINA0014EB

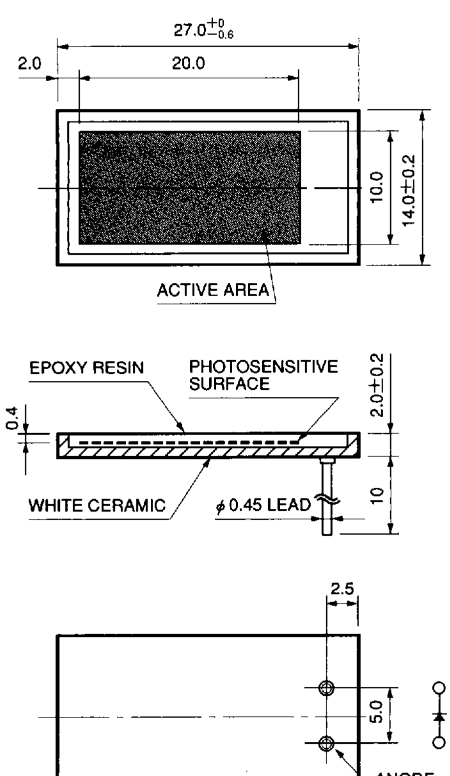
## ❷ S2662 Series




| | -01 | -03 |
|---|---|---|
| c | 0.5 | 0.4 |

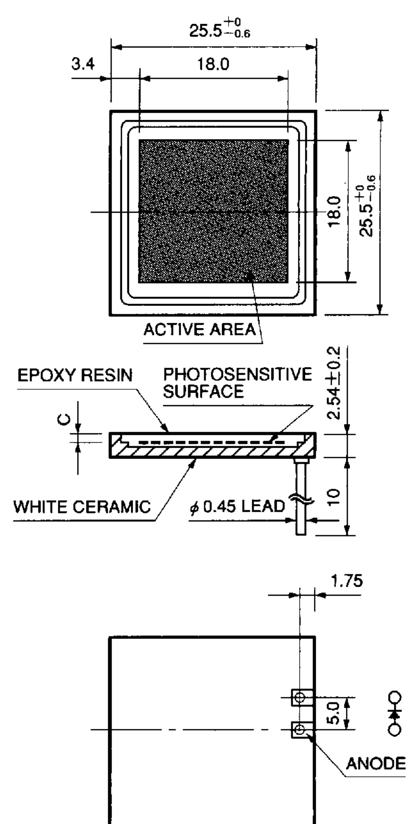
KPINA0015EB

## ❸ S2744-03




KPINA0016EB

## ❹ S3204 Series

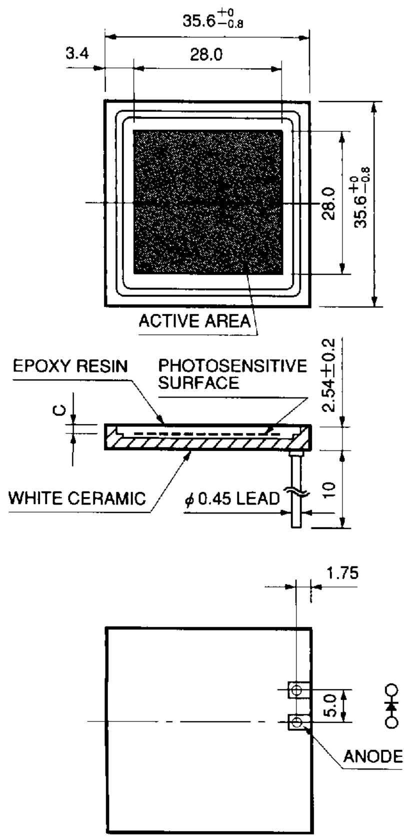



| | -03 | -05 |
|---|---|---|
| c | 0.4 | 0.2 |

KPINA0017EB

(Unit: mm)

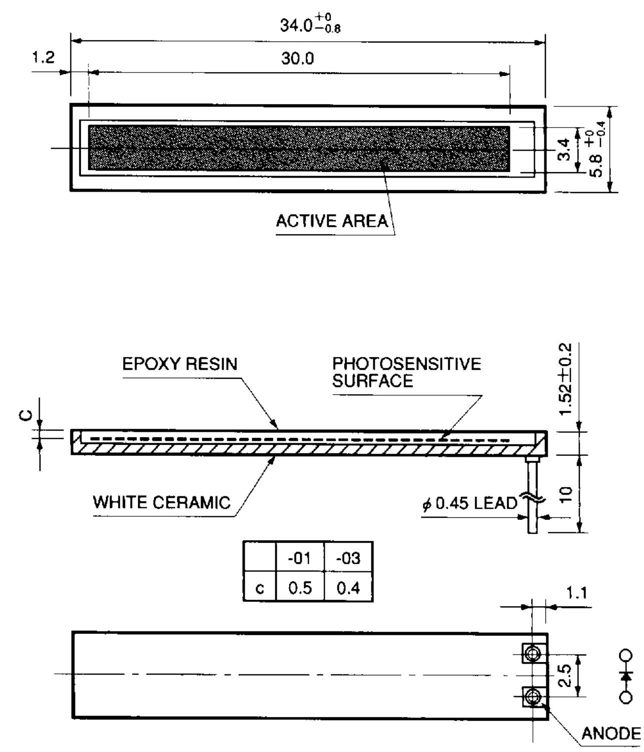
## ❺ S3584 Series




| | -03 | -05 |
|---|---|---|
| c | 0.4 | 0.2 |

KPINA0018EB

## ❻ S3588 Series




| | -01 | -03 |
|---|---|---|
| c | 0.5 | 0.4 |

KPINA0019EB

### Windowless Types Available

Our standard types have clear epoxy resin windows. However, windowless types are also available. (Bonding wires are protected at one point by resin coating.)

### Quick reference for Type No. suffix is as follows.

| Suffix No. | Wafer Thickness | Window |
|---|---|---|
| -01 | 200 μm | Epoxy resin |
| -02 | | Non |
| -03 | 300 μm | Epoxy resin |
| -04 | | Non |
| -05 | 500 μm | Epoxy resin |
| -06 | | Non |

## REFERENCE

Information on applications and performance data for our PIN silicon photodiodes can be referred to the following papers.


- K. Yamamoto, et al., "Highly Stable Silicon PIN Photodiode", Nucl. Instr. Meth., A253(1987), 542-547.
- Hamamatsu Photonics Technical Information SD-08/NOV. 87 "Solid State Photodiodes for Scintillation Detectors".
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- W. G. Gong, et al., "Resolution Tests of CsI(Tl) Scintillators Readout by PIN Diodes," MSUCL-627, 1987.
- R. J. Meijer, et al., "Light-Particle Detection with a CsI(Tl) Scintillator Coupled to a Double Photodiode Readout System, " Nucl. Instr. Meth. A256 (1987), 521-524.
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- R. Sumner, "The L3 BGO Electromagnetic Calorimeter," Nucl. Instr. Meth., A265(1988), 252-257.
- C. Bebek, "A Cesium Iodide Calorimeter with Photodiode Readout for CLEO II," Nucl. Instr. Meth., A265(1988), 258-265.


## PRECAUTIONS FOR HANDLING DETECTORS

### Photodiodes for Scintillation Detection

- Take care not to allow any sharp or hard objects to touch or rub the window surface as it may be scratched.
- Avoid touching the window with bare hands. If the window is contaminated, use a cotton pad moistened with alcohol to gently wipe it off.
  (Do not use any organic solvents other than alcohol as they may damage the epoxy-resin windows.)
- Because photodiodes are susceptible to damage from excessive heat, be careful with temperature and dwell times when soldering the leads. As a rule, the leads should be soldered 5 mm minimum away from the package surface, at 260℃ or below within 5 seconds.
- Avoid bending or twisting the leads as much as possible. If bending the leads, do not bend at the same position more than a few times.