Theory, glossary of the Photo Detector

This document comment on the theory of the Photo Detector device and a general term.

Kind of the Photo Detector

Photodiode

A photodiode is a semiconductor device which converts the light to electric energy when exposed to light. It comes in a package for use as an electronic component.

Characteristics of the photodiode

1. Excellent linearity of the output current with respect to incident light
2. Quick response
3. Wide spectral response
4. Long life
5. Small output change with respect to temperature changes
6. Small output current

Phototransistor

A phototransistor is designed to amplify the output from a photodiode using a transistor. Compared to the photodiode, it provides higher output signal levels.

Characteristics of the Phototransistor

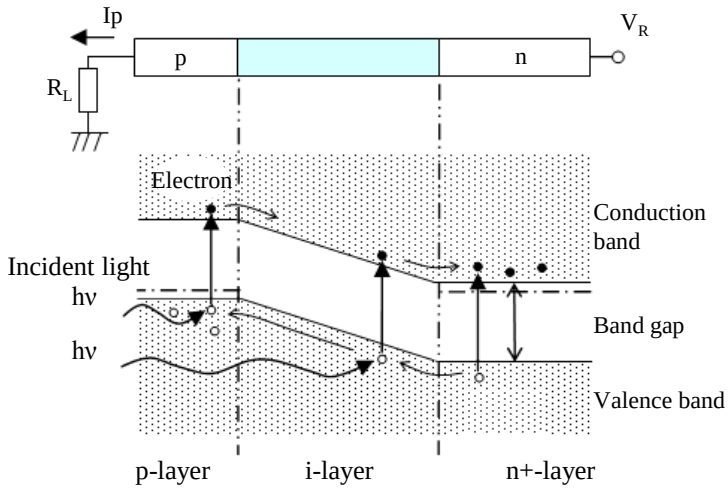
1. Large photo currents
2. Slow response
3. Long life
4. Poor output current linearity with respect to incident light
5. Large output changes with respect to temperature changes

Principle of Operation

Photodiode

The photodiode has a PN junction consisting of a P-type semiconductor region on the light receiving side and an N-type semiconductor region on the substrate side Fig.1. Applying a reverse bias to the PN junction creates a depletion layer between the P-layer and N-layer, so-called because it has no mobile carriers. When light that has greater energy than the semiconductor band gap energy strikes the region near the junction of the photodiode (the depletion layer and the area surrounding it), the electrons in the valance band absorb the light and rise up to the conduction band, thus leaving holes in the valance band and generating carriers. The carriers thus generated in the depletion layer separate due to electrical field conductivity, so that the electrons move to the N region, and the holes move to the P region. At this time, the number of carriers generated is basically in proportion to the luminance of the light, and a photo current flows through the photodiode. The size of the photo current is roughly proportional to the intensity of the light.

A PIN photodiode is a device that has a significantly thick I-layer between the PN junction. This widens the depletion layer when a reverse bias is applied, and allows the diode to be used at a high reverse bias voltage. The high electrical field conductivity in the wide depletion layer prompts the carriers to move, and has the effect of increasing response.



h : Planck's constant ν : Frequency of light
Eg : Energy gap

Fig.1 Theory of the PIN photodiode

Phototransistor

The phototransistor amplifies a photo current using the amplification function of a transistor, to compensate for the low sensitivity of photodiodes and PIN photodiodes. It has a structure that basically combines a photodiode and a transistor Fig.2.

When light strikes the depletion layer between the base and collector and its surrounding area, the photo current that is generated becomes the base current for the transistor and is amplified by the transistor's amplification factor ß. However, the photo current between the base and collector flows slowly, because it flows with the diffusion of the carriers. It also has a slower response than a photodiode or PIN photodiode, because the large diffusion of the carriers causes the high frequency component inside the photo current to short-circuit.

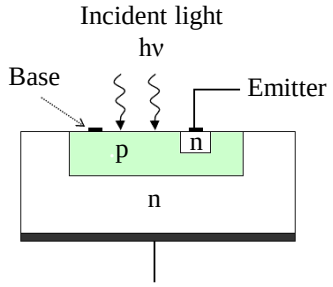
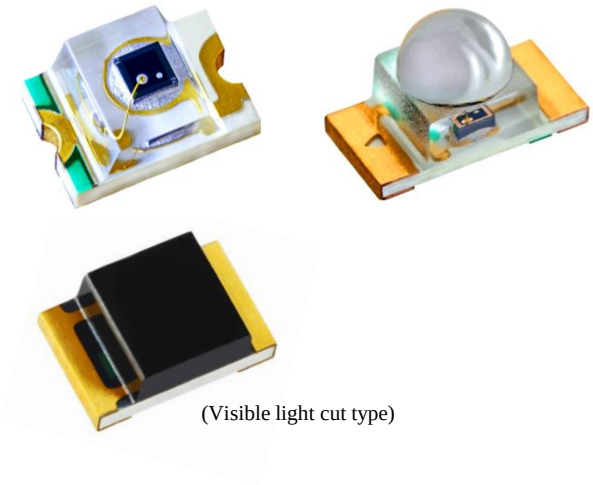


Fig.2: Structure of a phototransistor

Glossary of Terms

Surface mount Photo Detector Device(Chip Type)
The device which I put an Photo Detector die on a printed substrate with Photo Detector for surface mounting it and resin sealed.
The type that kept a filter function to cut visible light in sealing resin exists.



(Visible light cut type)

Photo Detector device is common

Radiation luminance [Ee]
The radiant flux that is applied per unit area. [W/cm^2]

Peak Sensitivity Wavelength [λp]
Wavelength at which the photo sensitivity is the greatest. [nm]

Response Time [tr/tf]
The rise (10% to 90%) and the fall (90% to 10%) time for peak photo current from a pulsed light source. [ns or μs]

Half Intensity Angle [$2\theta_{1/2}$]
Detection sensitivity distribution in the optical axis. Represented at an angle 50% of its peak value. [deg.]

Photodiode

Power Dissipation [Pd]
Power dissipated by photodiode (photo current and reverse voltage. [mW]

Reverse Voltage [V_R]
Reverse voltage applied from pin photodiode cathode to the anode. [V]

Dark Current [I_D]
Current that flows to photodiode when the reverse voltage is applied to the diode in the dark. [nA]

Photo current [I_P]
Current that flows from photodiode cathode to the anode by incoming light under specified conditions. [μA]

Inter-terminal capacity [C_T]
The capacitance between the cathode and anode terminals of a photodiode. [pF]

Sensitivity [S]
The amount of current that flows per energy of radiation from a single wavelength of light. [A/W]

Phototransistor

Collector-emitter Voltage [V_{CEO}]
Voltage applied from the phototransistor collector to the emitter. [V]

Emitter-collector Voltage [V_{ECO}]
Reverse voltage applied from the phototransistor emitter to the collector. [V]

Collector-Emitter Saturation Voltage [$V_{CE(sat)}$]
Phototransistor voltage between the collector and the emitter under specified saturation conditions. [V]

Collector Current [I_C]
Maximum value of the current that flows from the collector to the emitter of a Phototransistor. [mA]

Collector Dissipation [P_C]
Power dissipated by phototransistor . [mW]

Dark Current [I_C]
Collector current that flows to phototransistor when forward voltage is applied to the transistor in the dark. [μA]

Photo Current [I_C]
Phototransistor collector current that flows by incoming light under specified conditions. [mA]