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Review

# Recent advances in ultraviolet photodetectors

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ABSTRACT

In recent years, ultraviolet (UV) photodetectors (PDs) have received much attention in the various field of research due to wide range of industrial, military, biological and environmental applications. In this paper, a special focus is given to the unique advantages of different UV PDs, current device schemes and demonstrations, novel structures and new material compounds which are used to fabrication of PDs. Additionally, we investigate numerous technical design challenges and compare characteristics of the various PD structures developed to date. Finally, we conclude this review paper with some future research directions in this field.



**Contents**



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## 1. Introduction

Recent development in technology of wide band gap semiconductors have stimulated up major interest in UV potential application. UV PDs have many applications in various areas such as engine control, solar UV monitoring, astronomy, lithography aligners, secure space-to-space communications, or detection of missiles [1]. In particular UV PDs have attracted significant attention in the recent years, due to the rise of new requirements of civil and military industries to improve UV instrumentation that is capable of operating at high temperature and in harsh environments. Therefore, many attempts have been made to fabricate PD devices with these features for operation in the UV region of the spectrum whilst remaining blind to visible wavelengths. Some PDs are commercially available such as PDs that are used in photodetection system of ultrafast imaging, measuring speckle motion to monitor ultrasonic vibrations, remote optical diagnostics of non-stationary aerosol media in a wide range of particle sizes, atmospheric clock transfer based on femtosecond frequency combs, measurement of the polarization state of a weak signal field by homodyne detection and so on. The UV region of the electromagnetic spectrum covers the wavelength range between $\lambda \sim 10$ nm and $\lambda \sim 400$ nm. It is often divided into the three spectral bands: UVA for $\lambda = 400$–$320$ nm; UVB for $\lambda = 320$–$280$ nm; and UVC for $\lambda < 280$ nm.

The fundamental operating principle of all solid-state photosensitive devices is the same. A photon with sufficient energy interacts with a semiconductor crystal, temporarily changing the distribution of electron energies within the crystal (Fig. 1). One electron gains enough energy to attain an energetic conductive state, where it is free to move about within the crystal. The promoted electron leaves behind a vacancy, called a hole, which can also move about within the crystal. Together, these are referred to as an electron–hole pair, and in an ideal PD, one such pair is created for every absorbed photon. Eventually, if left in the crystal long enough, the electron–hole pair will recombine, giving up the extra energy in the form of heat. This happens on a characteristic time scale called the recombination lifetime, $\tau_r$. While excited, the electron and hole will drift in the presence of an electric field, creating an electric current. This current can be detected by connecting the active area of the semiconductor into an electronic circuit. How the electric field is applied and the nature of the electrical contacts defines the class of detector [2].

For photodetection, there are many characteristics that describe the performance of the PD. These parameters indicate how a detector responds and they are as follows:

Quantum efficiency ($\eta$) is defined as the ratio of countable events produced per number of incident photons. It is also equal to the current responsivity times

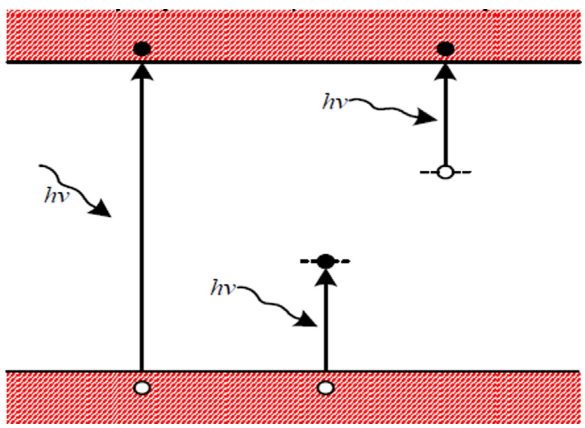


**Fig. 1.** Operating physics principle of PDs.