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Photodetectors in Analytical Applications

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Photodetectors are among the most ubiquitous types of technology in use today. They range from simple devices that automatically open supermarket doors, to receivers on TV and VCR remote controls, to photodiodes in a fiberoptic connection, to the CCD in a video camera, to enormous arrays used by astronomers to detect radiation from the other side of the universe. Photodetectors are present in a huge variety of devices used in commerce, industry, entertainment and research. In fact, the field of photodetector design and use has grown to the point that few practitioners have a complete overview.

For our purposes, photodetectors include any device for registering photons with frequencies above that of radio waves—from far infrared on up to gamma rays. In this article we survey the main types of applications that use photodetectors. Broadly speaking, these applications fall into two general groupings—communications and remote sensing. In communications, the radiation is simply the carrier for an encoded signal, while in the various forms of remote sensing, the radiation is the signal, conveying information about an object or scene.

Perhaps the most ubiquitous communications market is fiberoptic communications systems, in which photodetectors, generally operating in the infrared (IR), pick up high-speed signals. These detectors do not need high sensitivity, since the laser drivers provide plenty of radiation to the fiber, but they must have extremely fast response, exhibit high reliability, and have a low cost.

Photodiodes, especially those based on indium gallium arsenide (InGaAs) are the workhorses of optical communications, currently achieving data communication rates as high as 2.5 Gbits/s, which is more than 200,000 times the capacity of a single copper telephone wire.

While the detectors used in fiberoptic communications are invisible to the telephone user, those used in common remote control devices are obvious and are found in nearly every American home. Again, photodiodes sensitive to IR wavelengths are the standard, but requirements are far laxer than for fiberoptic devices, since data transmission rates are low, and only a small amount of information is generally conveyed—simple commands to change channels, or switch a VCR or TV on or off. Even remote controls, however, are increasing in sophistication—cordless mouse devices for PCs, for example, use detectors that measure the relative strength of signals to determine mouse orientation and position.

Applications are:

Safety and security:

The simplest types of remote sensing applications involve just the detection of the presence or absence of an object or a condition for safety and security monitoring. Such applications typically use photoconductors, the cheapest and most rugged of detector technologies. The most common of such applications is IR-sensitive motion detectors for home security systems.

Process control:

The next step up in sophistication comes in process control applications, another large volume consumer application of photodetectors. In many cases, these devices may be as simple as position sensors to check that a work piece is in the proper place or to provide feedback for robotic systems. Process control applications in factories often require detector systems that can endure extreme environmental conditions In the food industry.

The cutting edge:

The most advanced detectors tend to be made for low- volume specialized fields, such as laboratory research, biomedicine, defense, environmental monitoring, and astronomy. Thermography, measuring the heat radiated by the human body, has long been a routine diagnostic test, requiring IR detectors. Recent developments have allowed research biologists to observe rapid biochemical reactions with ultrahigh-speed CCDs.

Environmental sensing:

Environmental monitoring today uses a broad range of photodetectors from the UV to the IR. Typically, signals are low intensity, so the primary detectors are PMTs and avalanche photodiodes (solid-state photomultipliers).

Pollution detection generally relies on UV spectroscopy, with detectors measuring the strength of absorption lines for such pollutants as sulfur dioxide, nitrous oxides, and ozone. Astronomy:

Challenging applications for photodetectors come in the field of astronomy, where the range of wavelengths studied extends from the far-IR at hundreds of microns to cosmic ray photons with 1020 eV of energy and wavelengths of 10- 20 μm, a range of 22 orders of magnitude. At the long wavelength end, the European Space agency is making plans for FIRST, the far-infrared and submillimeter space telescope, which will open up the one spectral band not yet surveyed—from 60 to 670 μm.

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