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RESEARCH HIGHLIGHTS

# Application of metal halide perovskite photodetectors

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In recent years, metal halide perovskite materials have attracted wide attention in the fields of photovoltaics (PVs), light-emitting diodes (LEDs) and photodetectors (PDs) due to their excellent light absorption[1–6], adjustable bandgaps and long carrier diffusion length. Compared with commercial Si and GaN photodetectors, perovskite photodetectors (PPDs) present wider light detection range, higher sensitivity and higher external quantum efficiency (EQE)[7–9].

PDs are divided into two types: wide-bandgap detectors and narrow-bandgap detectors, and their functions correspond to different wavelength ranges. The traditional detectors (Si, GaN, InAs PDs) need low-temperature environment for their operation[10, 11], and it is difficult to perform simultaneous detection to short-wavelength and long-wavelength light, thus limiting their development, while the adjustable bandgaps of perovskites enable them to sense photons of short-wavelength and long-wavelength at once efficiently[12]. Moreover, perovskites can be made *via* a facile solution-processing, making PPDs more favorable in fabrication of large-area and flexible devices[13–17]. The development and application of PPDs are worthy of discussing.

Visible light communication (VLC) is a wireless communication technology (Fig. 1), which uses visible light (300–900 nm) as the information carrier to transmit information within a certain distance[18–20]. It has the advantages of high response speed, security, low energy cost and electromagnetic interference resistance[21]. Gao *et al.*[22] reported that $CsPbI_xBr_{3-x}$ photodetector simultaneously possessed high sensitivity and fast response by engineering device and film quality (Fig. 2(a)). $CsPbIBr_2$ photodetector had a detectable limit of ~21.5 pW/cm$^2$ and a response time of 21 ns. Moreover, the photoresponse characteristics can keep for 2000 h. The photodetector was integrated into the VLC system (Fig. 1), and successfully realized the transmission of text and audio signals.

PPDs present specific responses to red, green and blue light, which is similar to the light-receiving vertebral body of human retina. Lin *et al.* [23] used a PPD with a microcavity structure to realize detection to different colors without using external filters, thus realizing full-color image restoration (Fig. 2(b)). The detection degree ($D^*$) of the device reached $10^{13}$ Jones, the linear dynamic range (LDR) was 154 dB, and the response time was 580 ns, which were better than those of human retina. Fan *et al.*[24] made hemispherical $FAPbI_3$ nanowire arrays by using a template method, which is almost impossible for traditional commercial semiconductors. And the bionic eye has been successfully assembled by using hemispherical nanowire detector arrays (Fig. 2(c)). The density of nanowire detectors on bionic eyes is much higher than that of photoreceptors in human retina, so higher image resolution can be achieved.

Self-driven flexible PDs have attracted interests because they can be applied to wearable and portable devices[25–28]. The traditional planar photodetector is not satisfactory in both photoelectric and mechanical properties, and its structure needs to be improved to make it more suitable for flexible devices. Li *et al.*[29] reported a $Cs_{0.05}(FA_{0.85}MA_{0.15})_{0.95}Pb(I_{0.85}Br_{0.15})_3$ PD with inverse opal structure, which can enhance light capture and improve carrier transport. The PD presented a high responsivity of 473 mA/W. What's more, the detector had good mechanical properties, and the photocurrent maintained after 500 bending tests. The flexible device can detect sunlight from 5am to 7pm (Fig. 2(d)).

At present, the infrared PD technology becomes mature. Owing to the limited detection range of Si and GaN PDs, the development and application of UV–visible light detection is required. Perovskite fabrication is simple, and perovskite has advantages in structure tuning. PPDs will present breakthroughs in the near future.

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Fig. 1. (Color online) Schematic for visible light communication system. At the sending port, LED lamps transfer electrical signals into optical signals; at the receiving port, PDs convert optical signals into electrical signals, which are then transcoded by digital-to-analog converters.

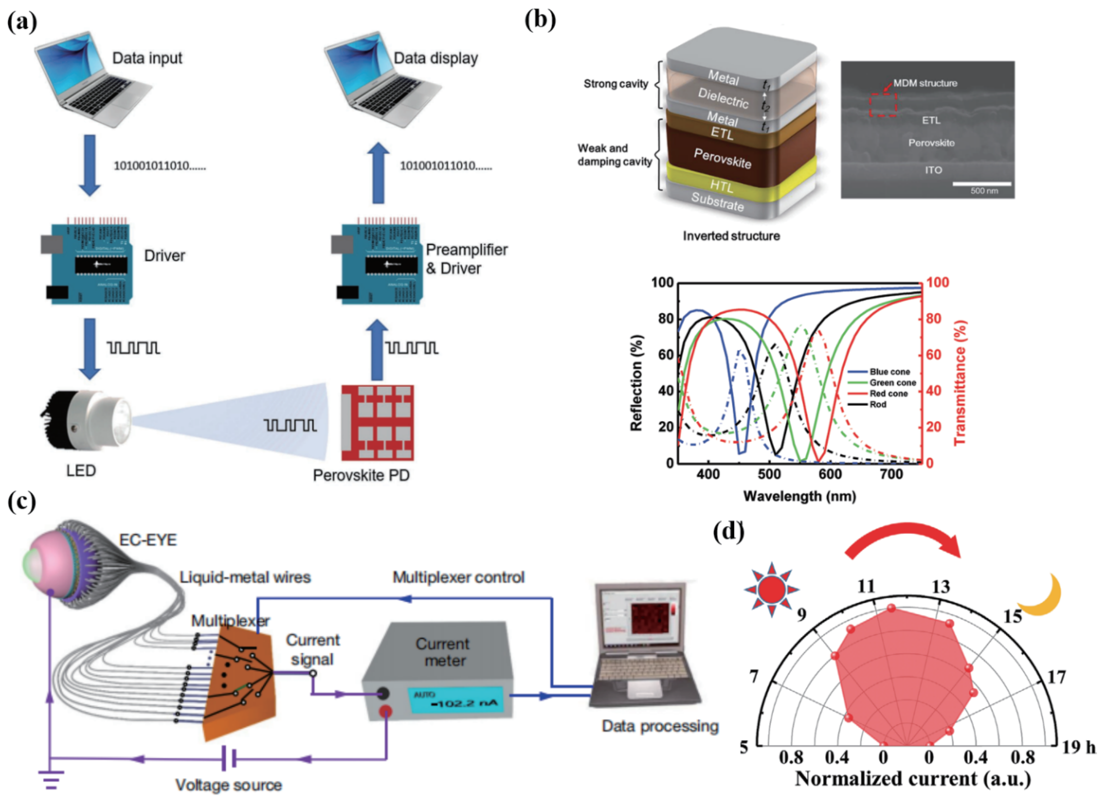


Fig. 2. (Color online) (a) $CsPbIBr_2$ photodetector applied to VLC system to transmit files and radio[22], Copyright 2019, Wiley. (b) Optical microcavity regulates the response of detector in different bands[23], Copyright 2019, Wiley. (c) Application of electronic bionic eye[24], Copyright 2020, Springer Nature. (d) Flexible devices in the solar detection system[29], Copyright 2020, Wiley.

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