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NEWS AND VIEWS

Perspective on the imaging device based on perovskite materials

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Large light absorption coefficients, tunable bandgaps, high tolerance to defects, long carrier lifetimes as well as diffusion lengths render lead halide perovskite materials ideal candidates for optoelectronic devices. Except application in solar cell, photodetectors based on perovskite materials have been recognized as another game changer due to the achievements such as high responsivity of 1.9 × 10^4 A/W[1], gain factor larger than 5.0 × 10^4[1], large detectivity of 10^{14} J[2], high on/off ratio of 10^5[3], fastest response time down to 1 ns[4], large linear dynamic range exceeding 170[5] and low detachable light intensity as small as 1 pW/cm^2[6], which demonstrate the potential applications of perovskite based photodetector in the areas of weak light detection, fast detection. Expect those properties, perovskite material has shown filter-less narrowband detection[7, 8] as well as promising photodetection ability in flexible device[9]. Recently, lead halide perovskites have also shown promising detection ability for high energy ionized radiation like X-ray and γ ray. The perovskite-based detector shows much lower detection limit around 5 nGy$_{air}$/s[10] and larger sensitivity around 10^5 μC/(Gy$_{air}$·cm^2)[11, 12], which are even better than that of currently commercialized devices.

Those advantages have extended to imaging devices, which were achieved by assembling pixel array on perovskite materials (Fig. 1)[13, 14] or incorporating perovskite materials with TFT array[15]. The former strategy is easy to be accomplished and demonstrate the image ability of perovskite photodetector. However, the lager distance between pixel make it hard to achieve high-resolution images and compete with CMOS chip used in cell phone, which has pixel distance around 2 μm. While TFT could facilitate to obtain a high-resolution image, the electric connections between perovskite mat-

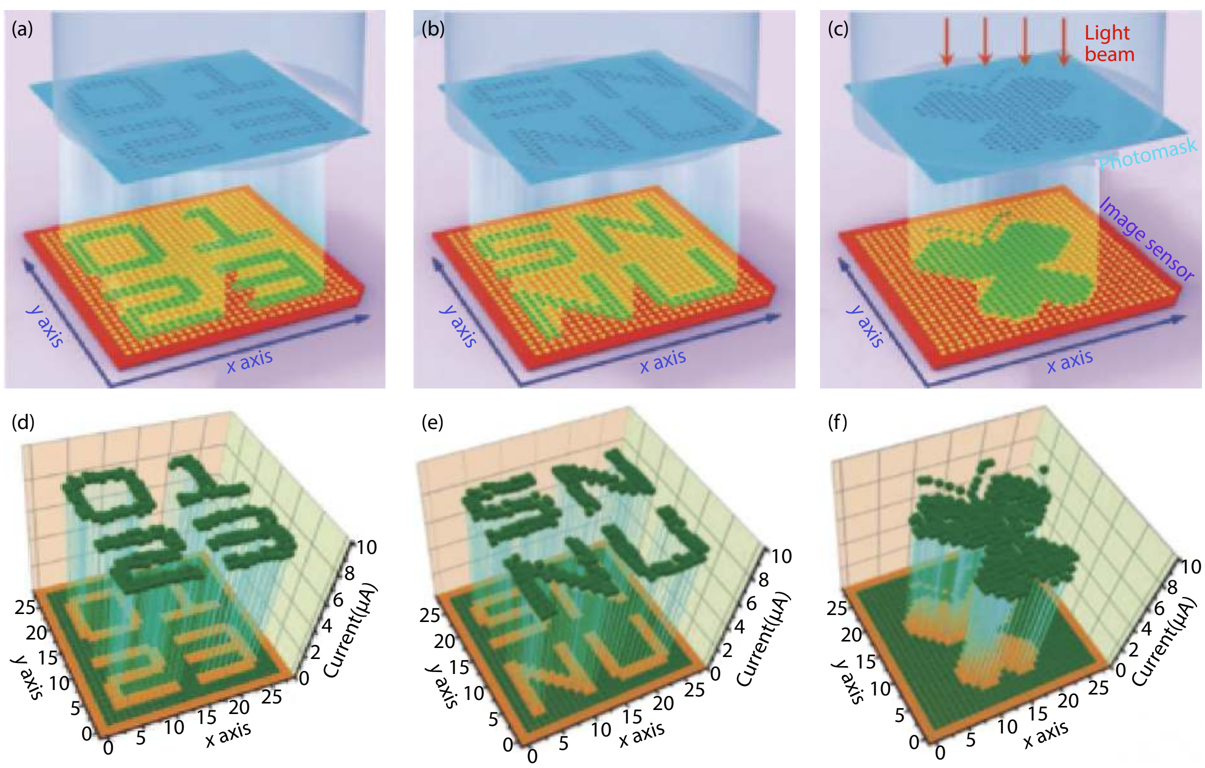

Fig. 1. (Color online) (a)–(c) Schematic illustration for the projection imaging mechanism. A prepatterned photomask was used directly above the imaging assembly. Under light illumination, the optical pattern is projected through the mask with bright and dark contrast to form the image of the mask on the sensor unit. (d)–(f) The corresponding photocurrent outputs from each pixel measured under 2 V bias with different optical patterns of “0123”, “SNNU”, and an image of a butterfly. Reproduced with permission[13]. Copyright 2018, Wiley-VCH.

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erial and TFT pixels was not that good to show the full potential of perovskite detectors.

The further efforts should be paid on: (1) the design and building of integrating circuit on large size single-crystalline perovskites. Single-crystalline perovskite shows better optoelectronic properties and detection performance than those of poly-crystalline thin films. However, the large-size single-crystalline perovskite is till limited. At the same time, ionic nature of perovskite makes it not compatible with currently used photolithography technology, which is urgent for developing high-resolution imaging sensor. (2) working mechanism of perovskite detector. Perovskite is an ionic and electronic transport. The electrical as well as optical stimulations will affect the transportation as well as distribution of these two kinds of carriers. The better understanding of the complex transportation phenomenon will easy the design and fabrication of high-performance devices. (3) device stability. As well known, perovskite will decompose under the stresses of light, heat, humidity. For detector, the heat and humidity are most important factors affecting its stability and should be concerned during device design and material selection. (4) toxic problem. That is a dilemma accompanying with the development of lead halide perovskite devices. As lead provides very good optoelectronic properties for perovskites, the toxic problem is much concerning during the large-scale application of perovskite materials. Less toxic materials with similar optoelectronic properties are desired.

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