Recent Progress in Transparent Perovskite Light-emitting Diodes

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Abstract— Light-emitting diodes based on perovskites (PeLEDs) show excellent optoelectronic properties, including high fluorescence quantum efficiency, high carrier mobility, high color purity and the compatibility with flexible substrates, showing great potential in lighting and display applications So far, the majority of research activities focus on non-transparent PeLEDs (e.g., Ref. [1]).

Transparency is required for PeLEDs applications in many areas, such as the integration of PeLEDs into the screens of electronic equipment or automobiles, and the fabrication of full color, see-through display devices, under-plane camera, wearable devices, and solid-state lighting. While other types of LEDs have achieved much on transparency [2], transparent-PeLEDs (T-PeLEDs) has received much less attention. The brightness and efficiency of these devices also need to be improved. Currently, PeLEDs show a number of limitations, including their incompatibility with high-temperature processes [3], the difficulty in producing smooth layers [4], and the high absorption coefficients of PeLEDs materials hindering the transmission of photons [5, 6].

While various methods show the feasibility of fabricating T-PeLEDs. These methods require specialized top electrodes (such as DMD [3, 4, 7, 8], TCO [7–9], alkali/inert metals [5] and silver nano-wire grids [10]), nano-imprinting of feedback gratings [11], thinner emissive layers and reflective layers [3, 7] and microcavities [12]. They show great transparency and top emission characteristics. Future work may involve the following directions. (i) Improving the performance of standard non-transparent PeLEDs, and optimize its electrodes. (ii) Controling the process of crystal formation for thinner and uniformly deposited transparent electrodes. (iii) Improving the design of transparent top electrodes while protecting the underlying layers. (iv) The top electrode should show high transmittance and low surface resistance, energy levels that match the active layers for efficient carrier injection. (v) Developing low-temperature deposition processes.

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