Docket #: S13-410

Solution-state assembly of intrinsic broadband white-light emitters

Stanford researchers have patented a family of white light emitting perovskites with initial photoluminescence quantum efficiencies (PLQEs) of 9% and stable emission over at least three months of continuous irradiation, with third party validation studies achieving 32% PLQE. Upon near-ultraviolet excitation, two new Pb–Cl and Pb–Br perovskites emit broadband 'cold' and 'warm' white light, respectively, with high color rendition. Emission from large, single crystals indicates an origin from the bulk material and not surface defect sites. Advancing hybrid perovskite technology these white-light emitting phosphors demonstrate high color rendition, tunable chromaticity, and sustained emission stability over one week of continuous irradiation. Overcoming critical solid-state lighting (SSL) limitations, these materials offer room-temperature synthesis, binder-free solution-state film deposition over large-area panels, high color rendition, tunable chromaticity, and sustained long-term performance.

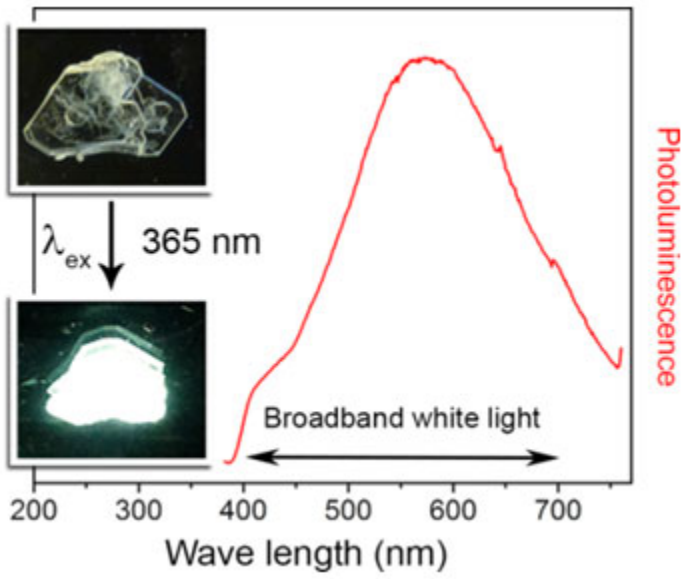

Figure 1 - Broadband white-light photoluminescence (PL) from a single crystal of (EDBE)[PbBr4] under near-UV irradiation.

(Image courtesy the Karunadasa Group)

Stage of Development – Proof of Concept

- Mechanistic studies determined the emission is a bulk property of the material opposed to surface defect sites or due to permanent material defects.
- Thermal losses are a major source of emission quenching.
- (EDBE)(PbBr4), shows an undiminished PLQE of 9% over 3 months of continuous 365-nm irradiation under vacuum, with no observable change in emission color or intensity. The absorption spectrum of this material remains largely unchanged during this period.
- Zhang et al. demonstrates these types of light emitters show a PLQE of 32%. Zhang, M., Zhao, L., Xie, J., Zhang, Q., Wang, X., Yaqoob, N., ... & Xing, J. (2021). Molecular engineering towards efficient white-light-emitting perovskite. Nature Communications, 12(1), 4890. https://doi.org/10.1038/s41467-021-25132-2

Applications

- **Solid state lighting** – Single-source broadband white-light emitters
- **Solar Energy** – UV to visible conversion absorbers for improved solar cell efficiency
- Electroluminescent materials for **light-emitting diodes (LEDs)**
- Solid state **lasers** and **optoelectronic devices**
- Large area **coatings**

Advantages

- First reported white-light emission from organic-inorganic hybrid perovskites
- Single-phase bulk white-light emitter — not dependent on surface sites, dopants, or particle size
- Continuous emission spectrum spanning 400-700nm with high CRI (>80)
- Tunable color temperature (warm to cool) through systematic synthetic design and halide substitution
- Large Stokes shift minimizes self-absorption and eliminates differential aging seen in multi-phosphor systems
- Improved photoluminescence quantum efficiencies (PLQEs)

- Low-cost, room-temperature synthesis using inexpensive, relatively low-toxicity precursors
- Scalable film processing with no binders required; solution-state deposition enables large-area substrate coatings
- More energy efficient – SSL adoption reduces global electricity consumption

Publications

- Dohner, E. R., Hoke, E. T., & Karunadasa, H. I. (2014). Self-assembly of broadband white-light emitters. *Journal of the American Chemical Society, 136* (5), 1718-1721. https://doi.org/10.1021/ja411045r
- Dohner, E. R., Jaffe, A., Bradshaw, L. R., & Karunadasa, H. I. (2014). Intrinsic white-light emission from layered hybrid perovskites. *Journal of the American Chemical Society, 136*(38), 13154-13157. DOI: 10.1021/ja507086b https://doi.org/10.1021/ja507086b

Patents

- Published Application: WO2015061555
- Published Application: 20160289554
- Published Application: 20190023983
- Issued: 10,087,366 (USA)
- Issued: 11,306,244 (USA)

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