Docket #: S13-410

Solution-state assembly of intrinsic broadband white-light emitters

Stanford researchers have disclosed a new family of white light emitting perovskites with photoluminescence quantum efficiencies (PLQEs) of up to 9%, which show stable emission over at least three months of continuous irradiation. 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. This work builds upon earlier research describing white-light emitting layered hybrid perovskites. Broadband emission from these materials displayed high color rendition, tunable chromaticity coordinates, and undiminished activity under continuous irradiation for a week. These materials have many promising attributes as phosphors including room-temperature synthesis, solution-state film deposition methods that do not require binding agents, high color rendition, tunable chromaticity, and sustained long-term performance.

Figure

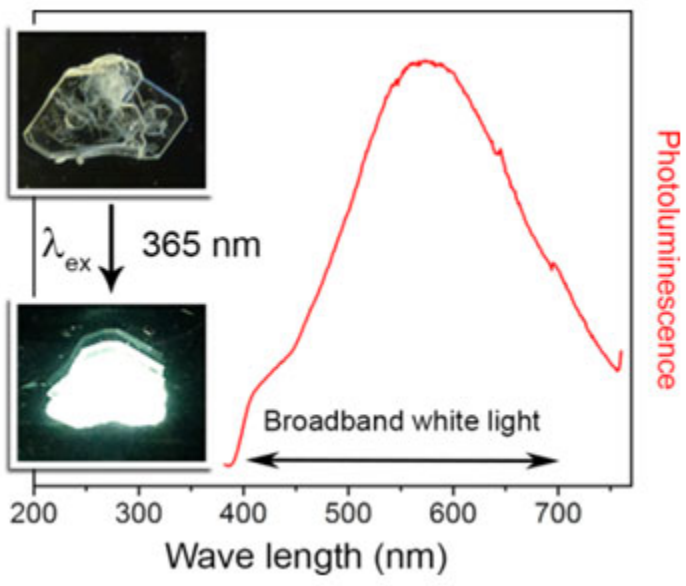

Figure description - Broadband white-light photoluminescence (PL) from a single crystal of (EDBE)[$PbBr_4$] under near-UV irradiation.

Stage of Research

- Mechanistic studies indicate that the emission is a bulk property of the material and is not due to surface defect sites or due to permanent material defects.
- Also determined that thermal losses are a major source of emission quenching.
- Highest-efficiency material (published), (EDBE)($PbBr_4$), 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.
- Highest efficiency (unpublished, work in progress) perovskite white-light emitter has a PLQE of 15%.

Applications

- Single-source broadband white-light emitters to use as phosphors in solid-state lighting devices
- Electroluminescent materials for light-emitting diodes (LEDs)
- Absorbers in multi-junction solar cells
- Solid state lasers
- Optoelectronic devices

Advantages

- First report of white-light emission from organic-inorganic hybrid perovskites
- Advantages of hybrid perovskite-based phosphors
    - Single-phase bulk white-light emitter
    - High CRI with easily tunable emission chromaticity
    - Low-temperature, scalable syntheses. Film processing does not require binders. Films can be deposited on substrates from solution enabling large-area coatings.
    - Inexpensive, relatively less toxic precursors
- Improved photo-luminescence quantum efficiencies (PLQEs)
- One of very few materials where white-light emission is a property of a single-phase bulk material (and not due to surface sites or dopants).The emission can

be systematically tuned through synthetic design
- Use of SSL device can reduce global electricity used for lighting by 50% by the year 2025

Publications

- Dohner, E. R.; Hoke, E. T.; Karunadasa, H. I. "Self-Assembly of Broadband White-Light Emitters." J. Am. Chem. Soc. 2014, 136, 1718.
- Dohner, E. R., Jaffe, A., Bradshaw, L. R., & Karunadasa, H. I. (2014). Intrinsic White-Light Emission from Layered Hybrid Perovskites." J. Am. Chem. Soc. 2014, 136, 13154

Patents

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

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