Two-Dimensional Lattice Confined Single-Molecule-Like Aggregates

A hybrid perovskite superlattice that delivers both single-molecule efficiency and aggregate stability for brighter LEDs, lasers, and quantum devices.

Organic molecules can play an important role in optoelectronic material design via their usage as organic emitters. Intermolecular distance between organic emitters has the largest impact on their optoelectronic properties, and much research has focused on creating either single molecule (diluted with foreign molecules) or aggregated materials at far or close distances, respectively. Single molecule materials are used widely for their high photoluminescence quantum yield, making these great for applications like lasers or LEDs. In contrast, aggregated materials inherently form very stable structures, which allow for properties like directional emission and radiative recombination. How organic emitters behave in-between single molecule and aggregated states is not well understood. Researchers at Purdue University have designed a novel 2D layered hybrid perovskite superlattice with alternating layers of organic and inorganic molecules. This allows for the organic molecules to be at the ideal intermolecular distance to retain both single molecule and aggregate state properties such as high photoluminescence quantum yields, directional emission, enhanced radiative recombination rate, and low-threshold lasing. This technology can be utilized to design other inorganic motifs like layered metal halide-organic heterostructures, molecule-intercalated layered 2D atomic crystals SLs, and 1D or 0D organic-inorganic hybrid clusters.

Technology Validation:

- Molecular Dynamics (MD) simulations and X-Ray Diffraction (XRD) to examine molecular configuration and packing behaviors of single molecules

- Temperature-dependent streak camera characterization of photoluminescence quantum yields for organic emitter films

Advantages:

- More stable than other 2D perovskites

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Category
Chemicals & Advanced Materials/Specialty & Performance Chemicals
Materials Science & Nanotechnology/Composites & Hybrid Materials
Computing/Photonic & Optical Computing Technologies

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- Enhanced radiative recombination rate

- 50-fold enhancement in external quantum efficiency

- Low cost

Applications:

- Advanced photonic applications like LEDs, lasers, quantum technologies

- Semiconductor materials

Related Publications (if none, delete this section):

Wang, K., Lin, ZY., De, A.â€¯et al.â€¯Two-dimensional-lattice-confined single-molecule-like aggregates.â€¯Natureâ€¯633, 567â€“574 (2024). https://doi.org/10.1038/s41586-024-07925-9

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