Impact of 3D/2D Composition Ratios on the Crystallinity, Optical Properties, and Stability of Hybrid Perovskite Films via GIWAXS and Spectroscopic Measurements.

Celline Awino [1,2], Miller Shatsala[1,2], Silas Abok[2] & M.A. Nalianya[2]

[1]*Lawrence Berkeley National Laboratory, Berkeley, California, USA*
[2]*Masinde Muliro University of Science and Technology, Kakamega, Kenya*

Hybrid perovskite materials offer exceptional promise for photovoltaic and optoelectronic applications, yet challenges remain regarding their stability and structural consistency under environmental conditions. In this work, we systematically explored the influence of dimensionality—specifically, the ratio of three-dimensional (3D) to two-dimensional (2D) organic spacer cations; Ethylenediammonium iodide (EDAI) and Butylammonium iodide (BAI) on crystallization dynamics, structural integrity, optical characteristics, and environmental stability of $Cs_{0.25}FA_{0.75}Pb(I_{0.77}Br_{0.23})_3$ perovskite films. Employing Grazing-Incidence Wide-Angle X-ray Scattering (GIWAXS), photoluminescence (PL), and UV-Vis spectroscopy, we demonstrate that mixed-dimensional perovskites (particularly with a 3D/2D ratio of 1:1) exhibit enhanced crystallinity, improved optical properties, and superior stability compared to pure 3D or other mixed-dimensional compositions. Morphological analyses via scanning electron microscopy (SEM) further correlate improved optical performance and stability to optimized grain structures and reduced defect densities. These insights provide critical guidelines for dimensional engineering aimed at advancing the performance and durability of hybrid perovskite-based optoelectronic devices.

Keywords [optional]: 3D/2D Perovskites, GIWAXS, crystallization, composition variations, crystal orientations

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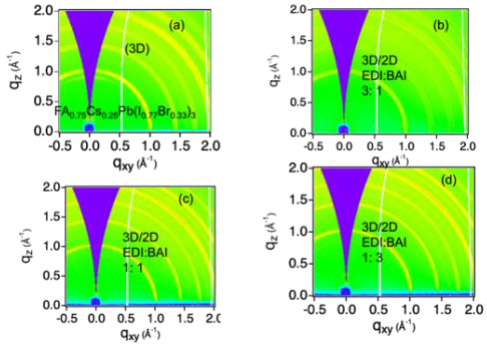

Figure 1. GIWAXS maps of (a) $Cs_{0.25}FA_{0.75}Pb(I_{0.77}Br_{0.23})_3$ 3D (b) 3D/2D with concentration of ethane, 1,2 diamoniem iodide (EDI) to Butylammonium iodide (BAI) 3:1 (c) 3D/2D with EDI to BAI 1:1 and (d) 3D/2D with EDI to BAI 1:3