Experiment Brief

MonoCL4 Cathodoluminescence Detector

Title
Revealing the spatial distribution of phases in perovskite solar cells for the development of high efficiency and stable devices

Gatan instrument used
The MonoCL4™ detector is the leading spectroscopic cathodoluminescence (CL) system for scanning electron microscopes (SEMs) and focused ion beam (FIB) SEMs that offers unrivaled sensitivity with the fastest imaging speeds to analyze beam-sensitive materials.

Background
Since the first report of efficient solar cells being fabricated in 2009, perovskite materials have attracted widespread attention for photovoltaic applications due to the simple and cheap manufacturing methods available. However, widespread commercialization of perovskite-based devices is being held back by their instability under operational conditions. Current research includes a focus on the development of more stable compositions. The key to this, are experimental techniques able to map phase segregation with a spatial resolution suitable for analyzing individual grains as small as 30 nm; CL has recently been demonstrated as such a technique[1]. Although, to prevent degradation of the sample under exposure to high-energy electrons, extremely low probe currents are required, necessitating the use of the highest sensitivity CL detection system.

Materials and Methods
Perovskite solar cells incorporating rubidium (Rb) demonstrating enhanced thermal- and photo-stability were investigated. Spectrally resolved CL imaging was used to reveal the interplay of rubidium iodide (Rbl) with excess lead iodide (Pbl) in the phase formation of mixed-cation, mixed-halide perovskites. The distribution of Pbl, perovskite, and Rb-rich phases were revealed by wavelength filtered imaging; damage to the sample was minimized through the use of extremely low electron beam currents of just 13 pA. Improved device performance was ascribed to Rb-doping suppressing the yellow non-perovskite phase and re-distribute the Pbl phases.

Summary
The distribution of Pbl, perovskite, and Rb-rich phases were revealed by wavelength filtered imaging using electron beam currents of just 13 pA. Despite these weak excitation conditions, the supreme sensitivity of the MonoCL4 detector empowered by its’ unique design concept enabled high-quality phase distribution maps to be captured with excellent signal-to-noise ratio while minimizing degradation of the sample under investigation. Improved device performance and stability could be ascribed to Rb-doping suppressing the yellow non-perovskite phase and re-distribute the Pbl phases.

Credit(s)

Gatan, Inc. is the world’s leading manufacturer of instrumentation and software used to enhance and extend electron microscopes—from specimen preparation and manipulation to imaging and analysis.

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