Electron Microscopy of Perovskite Phase Distribution on Light Emitting Edges

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Abstract

New and different properties are found at edges of two-dimensional halide perovskites. The source of such properties has been difficult to find. For example there has been a controversy about the optical properties of 2D $CsPb_2Br_5$ and its ion exchanged halides. Recently the root cause of such a behavior has been revealed by using a combination of techniques (Raman and Photolumi-nescence, PL), one static and the other dynamic with a variable hydrostatic pressure. It has been possible to correlate PL with the structure and distinguish different mechanisms of PL from point defect versus extended structures. In that case, it is shown that bright green emission is due to the presence of $CsPbBr_3$ nanocrystals overgrown on the surfaces and at the edges of $CsPb_2Br_5$ platelets, producing a bright edge emission. Electron microscopy with atomic resolution has been helpful in this case to show the structure of the involved phases. In the present electron microscopy investigation, the involved material is an exfoliated 2D halide perovskite containing a variety of thin crystals. It is of relevance to identify the phases as a function of position, starting from the edge of the material. The main objective is to determine the origin of the edge states in 2D perovskites so that their optical and electrical properties can be controlled. In this investigation the sample is synthesized to have the $BA_2MA_2Pb_3Br_{10}$ perovskite and it shows properties of edge emission. Then it is required to clarify such a property. Electron microscopy needs to be applied in conditions of low dose to avoid any beam sample interaction that can change the sample structure. The electron microscope work shows a phase distribution with two main components in the exfoliated sample. The edge of the sample is dominated by the MAPbBr3 perovskite while the interior is $BA_2MA_2Pb_3Br_{10}$. The former is produced by a process involving the lost of BA radicals. Low dose electron microscopy in transmission mode has been performed to preserve the genuine sample phase structure, especially in the presence of water, N, C and O. Focal series are used together with an exit wave reconstruction procedure to produce phase and amplitude images of nanoparticles and then conclude on the phase distribution of the material from the edge to the interior. The sample is particularly unstable and only 10-15 images can be taken at rather low dose (10 e-/A^2s) and 80 keV in the TEAM05 electron microscope of the NCEM-MF. These focal series are used to produce the reported phase images with atomic resolution. Simulations are also performed and it is seen that crystalline structure coincides with the expected projections of the MAPbBr3 perovskite (sg 221).

Biography

Hector A. Calderon received PhD from Northwestern University, USA and acquired research experience in several institutions in Europe (ETH-Zürich, EP Toulouse, France and FZ Jülich, Germany), the USA (MF-LBNL) and Mexico. He is currently a Professor in the Physics Department of the Technical University IPN in Mexico. His research experience includes synthesis and study of mechanical properties of Ni and Fe based super-alloys as well as intermetallic alloys and synthesis and characterization of nanomaterials for energy and food applications. He has published over 280 peer reviewed articles to date. Prof. Calderon has expertise also in the use of electron microscopy in low dose to avoid sample damage. His group's current research emphasis is on developing collaborations and designing new nanomaterials to recover sunlight and fabricate devices to produce solar fuels from sustainable sources.