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Title: Photovoltaic and nonlinear optical effects of thin films based on perovskites

Keywords: hybrid perovskites, perovskite solar cells, nonlinear optics, phase transition, perovskite stability, thin films

Abstract: Perovskites are a group of materials discovered in the 19th century, whose optoelectronic potential has yet to be fully realized. Over the past two decades, their structural properties, linear and nonlinear optical properties, and photovoltaic characteristics have been intensively studied. The results indicate that these materials, due to their unique photovoltaic and nonlinear properties, represent a promising class of compounds for optoelectronic applications.

This dissertation studies selected thin film hybrid perovskites with the $MABX_3$ structure, where B = Pb, Cd, Ge, Sn, Zn, and X = I, Cl, Br. The materials were synthesized by physical vapor co-deposition (PVco-D) and then characterized using a variety of techniques, including atomic force microscopy (AFM), UV-VIS-NIR spectrophotometry, photoluminescence (PL) spectroscopy, second- and third-harmonic generation (SHG, THG), Z-scan, and electrical and photovoltaic measurements. These studies provided detailed information on the effect of chemical composition and composition percentage on the surface topography, structural stability, linear and nonlinear optical properties, and electrical parameters of perovskite solar cells. The studies demonstrated that the stability of perovskites strongly depends on their chemical composition, with materials containing I and Br atoms proving to be the most stable. Spectroscopic measurements over a wide temperature range confirmed the occurrence of phase transitions – from orthorhombic to tetragonal and from tetragonal to cubic. The strongest second-order nonlinear properties were observed for the perovskite containing the Br halogen. Third-order nonlinear effects were observed for all tested materials. Thin film photovoltaic cells with perovskites containing I, Cl, and Br halogens responded to illumination by generating an electrical voltage and achieving efficiencies of 3.43%, 2.80%, and 3.55%, respectively. These research results emphasize the crucial role of optimizing perovskites' chemical and structural composition in developing new materials for future optoelectronic and photovoltaic applications.