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Ho-doped Lithium Niobate Thin Films: Raman Spectroscopy, Structure and Luminescence

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Abstract : Lithium niobate (LN) crystals, renowned for their exceptional nonlinear optical, electro-optical, piezoelectric, and photorefractive properties, stand as foundational materials in diverse fields of study and application. While they have long been utilized in frequency converters of laser radiation, electro-optical modulators, and holographic information recording media, LN crystals doped with rare earth ions represent a compelling frontier for modern compact devices. These materials exhibit immense potential as key components in infrared lasers, optical sensors, self-cooling systems, and radiation-balanced laser setups. In this study, we present the successful synthesis of Ho-doped lithium niobate (LN:Ho) thin films on sapphire substrates employing the Sol-Gel technique. The films exhibit a strong crystallographic orientation along the perpendicular direction to the substrate surface, with X-ray diffraction analysis confirming the predominant alignment of the film's "c" axis, notably evidenced by the intense (006) reflection peak. Further characterization through Raman spectroscopy, employing a confocal Raman microscope (LabRAM HR Evolution) with exciting wavelengths of 532 nm and 785 nm, unraveled intriguing insights. Under excitation with a 785 nm laser, Raman scattering obeyed selection rules, while employing a 532 nm laser unveiled additional forbidden lines, reminiscent of behaviors observed in bulk LN:Ho crystals. These supplementary lines were attributed to luminescence induced by excitation at 532 nm. Leveraging data from anti-Stokes Raman lines facilitated the disentanglement of luminescence spectra from the investigated samples. Surface scanning affirmed the uniformity of both structure and luminescence across the thin films. Notably, despite the robust orientation of the "c" axis perpendicular to the substrate surface, Raman signals indicated a stochastic distribution of "a" and "b" axes, validating the mosaic structure of the films along the mentioned axis. This study offers valuable insights into the structural properties of Ho-doped lithium niobate thin films, with the observed luminescence behavior holding significant promise for potential applications in optoelectronic devices.

Keywords : lithium niobate, Sol-Gel, luminescence, Raman spectroscopy.
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