Synthesis, micro-structural characterization and optical properties of $LiNbO_3$ thin films deposited by the aerosol assisted chemical vapour deposition method

J. Ocón, M. Miki-Yoshida, *J. G. Murillo, J. E. Ledezma, P. Amezaga, and W. Antúnez-Flores

Centro de Investigación en Materiales Avanzados S.C., Miguel de Cervantes 120, Complejo Industrial Chihuahua, C. P. 31109, Chihuahua, Chih., México.
**jose.murillo@cimav.edu.mx*

Abstract: We report the synthesis, micro-structural characterization and optical properties of $LiNbO_3$ thin films deposited by the Aerosol Assisted Chemical Vapour Deposition method. The films were polycrystalline, uniform and non-light scattering.

Introduction

Lithium niobate ($LiNbO_3$) single crystal has been found an excellent material for numerous applications in optics including electro-optic modulators, frequency doublers, multiplexors and guided wave optics. Structural, electric and optical properties have been widely studied in bulk crystals samples. However, recently thin films of this ferroelectric oxide have attracted a great deal of interest, mainly due to their attractive piezoelectric and ferroelectric properties with potential use in the telecommunications area. Several methods have been used for fabricating thin films of this material, including sol gel, sputtering and metalorganic vapour phase epitaxy [1-2].

Experimental procedure

In this work we report the synthesis, micro-structural characterization and optical properties of $LiNbO_3$ thin films deposited by the Aerosol Assisted Chemical Vapour Deposition method (AACVD) employing a (100) silicon plate as a substrate. The deposition setup was similar to that previously reported elsewhere [3]. The starting solutions were dilutions of niobium ethoxide and lithium acetylacetonate in methanol, employing a rate 2:1 with concentrations of 0.02 mol L^{-1} and 0.01 mol L^{-1} respectively. The films were prepared at different temperatures between 623 and 773 K. In the method of deposition an ultrasonic nebulizer working at 2.4 MHz generated the aerosol that was conveyed by the carrier gas and directed towards the substrate by a fixed nozzle. The speed of carrier gas, the distance from the nozzle to the substrate and the time of deposition were also varied in order to determine the optimum deposition conditions.

The microstructure of $LiNbO_3$ thin films obtained was characterized by Grazing Incidence X-ray Diffraction (GIXRD), and Scanning Electron Microscopy (SEM). From these studies the best thin films were obtained at 653 K using a deposition time around one hour. It was also observed that the best samples were obtained employing a thermal treatment around 1000 K during 5 hours after the deposition procedure to enhance their crystallinity.

The surface morphology and film's thickness were studied by field emission SEM. In fact, the films obtained have great uniformity as can be observed in Fig 1. To determine the thickness, cross sectional samples of the films were observed. GIXRD patterns were acquired to determine the crystalline phases present in the film. Grazing incidence angle was fixed at 0.5° and scanning angle 2θ was varied between 20° and 85°, at 0.02° step. As shown in Fig. 2 the films obtained were polycrystalline. In order to carry out the optical characterization of some relevant optical properties of every one of the deposited films, reflectance spectra were measured employing a UV-VIS-NIR spectrometer. The films obtained were also non-light scattering showing high optical quality.

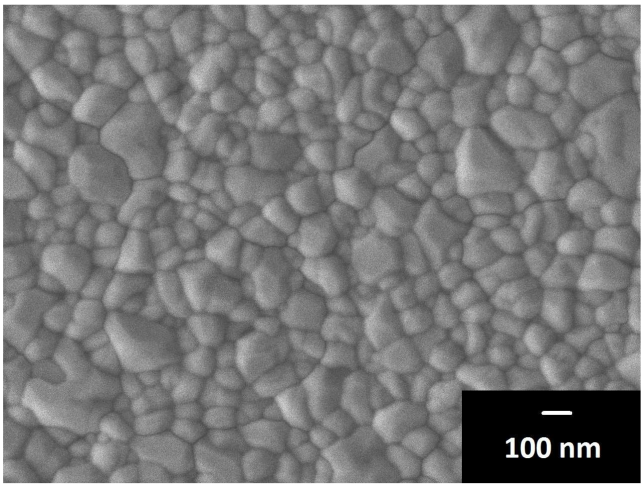

Fig. 1. Secondary electron SEM micrographs of $LiNbO_3$ based thin film deposited at 653 K with a deposition time of one hour.

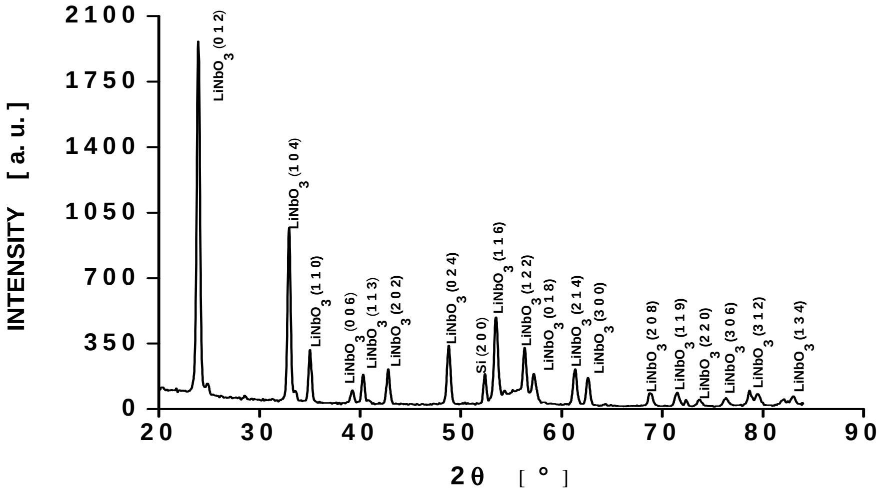

Fig. 2. GIXRD patterns of $LiNbO_3$ films annealed at 1000 K during 5 hours.

Conclusion

High optical quality, polycrystalline, uniform and non-light scattering $LiNbO_3$ thin films were deposited on silicon substrate by Aerosol Assisted Chemical Vapour Deposition Method. The films were polycrystalline, uniform with and non-light scattering.

References

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