Poster

SNOM study of periodically poled ferroelectric domains in $LiNbO_3$, $LiTaO_3$ and $Ba_2NaNb_5O_{15}$ crystals

Jorge Lamela[1], Eugenio Cantelar[1], Daniel Jaque[1], Ginés Lifante[1], Fernando Cusso[1], Francisco Jaque[1], Shi-Ning Zhu[2], Alexander Kaminskii[3]

[1]Departamento de Física de Materiales, C-IV, Universidad Autónoma de Madrid, 28049, Madrid, Spain

[2]National Laboratory of Solid State Microstructures, Nanjing University, China

[3]Institute of Crystallography, Russian Academy of Sciences, Moscow 119333, Russia

jorge.lamela@uam.es

The feasibility of forming periodic ferroelectric domain structures in ferroelectric crystals as: $LiNbO_3$, $LiTaO_3$ and $Ba_2NaNb_5O_{15}$, has extended the range of application of these materials in the photonic field. In fact, it has been demonstrated the ability, using these ferroelectric periodic structures, to manufacture different non-linear optical devices as: optical super-lattices (OSLs), second harmonic generation (SHG), and difference frequency generation (DFG), as well as in new fields like squeezed light generation for optical communication and information processing [1,2].

These periodic ferroelectric structures can be achieved using different procedures: during the crystal growth by the “off centre Czochraski technique” (OCCT), applying an external electric field (EF) or by electron beam injection method (EBI).

The aim of this work is to study, in periodically poled $LiNbO_3$ (CT), $LiTaO_3$ (EF) and $Ba_2NaNb_5O_{15}$ (CT) crystals, new phenomena arising from the interaction between laser propagating beams and refractive index singularities associated with the ferroelectric domains. For this purpose scanning near-field optical microscopy (SNOM) technique has been used [3]. The SNOM study has been combined with far field light diffraction experiments.

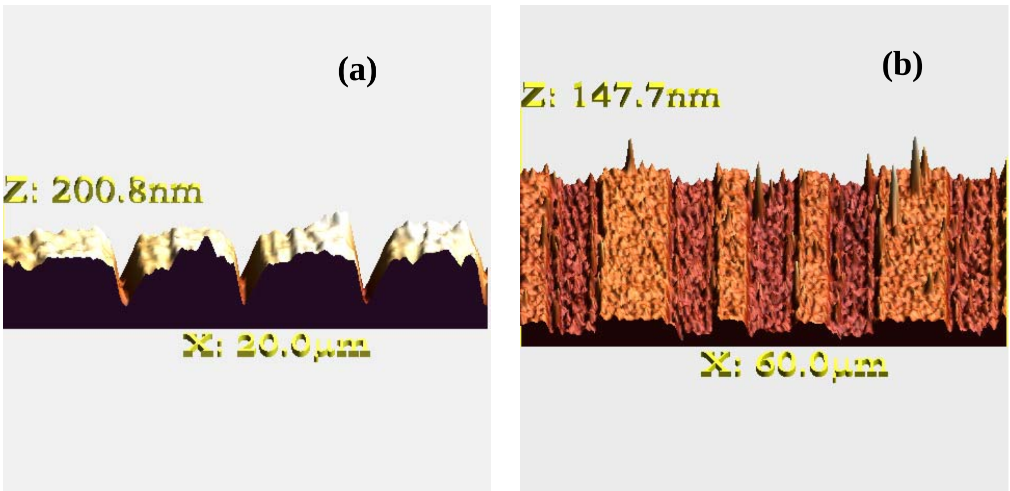

Figure 1. AFM images of (a) Er-Yb doped $LiNbO_3$ and (b) $LiTaO_3$ periodically poled crystals.

In order to know the structure of these domains, images using atomic force microscopy (AFM) in etched samples were obtained. As an example, Figure 1a shows the 3D topographic image obtained in periodically poled Er-Yb doped $LiNbO_3$ (OCCT) sample. As it can be observed, the etching gives place to a series of depressions or walls in the negative ferroelectric domains faces with a periodicity of ~ 6 µm. Figure 1b shows the 3D AFM image of an etched $LiTaO_3$ (EF) sample. In this case the etching reveals the ferroelectric domain structure produced by applying an external electric field pulse using a specific electrode configuration typical for SHG applications. [4]

Figure 2a shows the SNOM image observed using the reflection mode in Er-Yb doped $LiNbO_3$ crystals grown by OCCT. The SNOM image presents an unexpected high optical contrast with a periodicity of ~6 µm, according with Figure 1a. Figure 2b shows the SNOM image obtained using the reflection mode in $Ba_2NaNb_5O_{15}$ (OCCT) crystal. The back scattering light intensity shows a very high optical contrast with a periodicity of ~4.5 µm which corresponds to the ferroelectric domains structure created during growth.

High optical contrast with periodicities consistent with the ferroelectric domain structures using the SNOM transmission and collection modes were also observed. The largest optical contrast values, close to 80%, were obtained by the collection method in $Ba_2NaNb_5O_{15}$ [5,6].

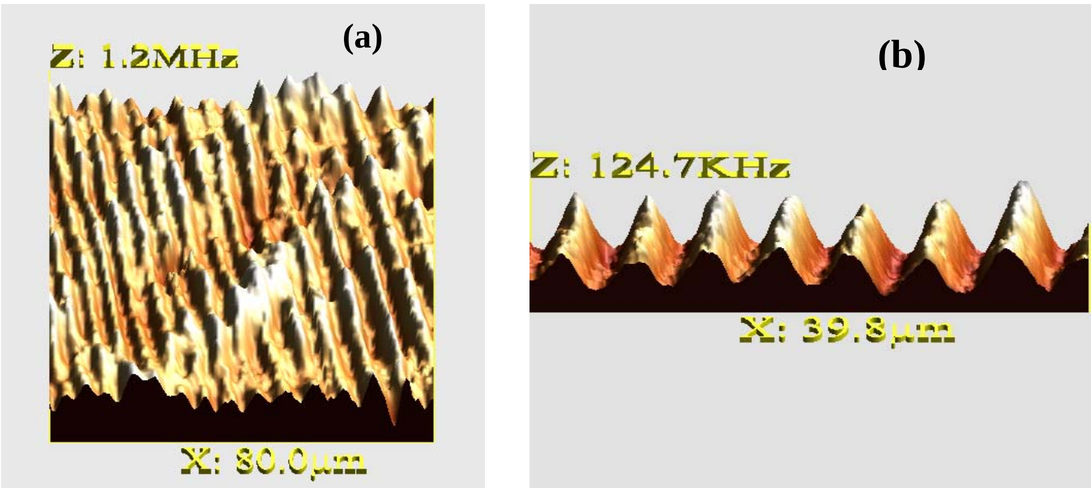

Figure2. SNOM images of (a) Er-Yb doped $LiNbO_3$ and (b)$Ba_2NaNb_5O_{15}$.

The unexpected large optical contrast observed in the three systems is explained, by means of a beam simulation method, considering that the ferroelectric domains operate as a periodic array of planar waveguides or optical superlattice.

References

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