ESRF	Experiment title: Stroboscopic diffraction imaging on KTP under electric field	Experiment number:
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Report:

Scientific Background

KTP ($KTiOPO_4$) is a one-dimensional ferroelectric ionic conductor widely used in nonlinear optics. It was reported that the X-Ray Bragg diffracted intensity is enhanced by a factor up to ten when an electric field is applied on a KTP crystal along the c polar axis [1]. X-ray projection topographs of KTP crystals under field show lines parallel to the c axis. To explain such lines, inhomogeneous one-dimensional conductivity was firstly invoked. But a low temperature experiment performed at the ESRF suggested that the origin of these lines is a strongly anisotropic and inhomogeneous polarization in narrow channels connecting the electrodes [2,3]. KTP crystalline structure present two local minima sites for potassium ions, which are usually unoccupied. When applying an electric field along the polar axis, potassium ions can move into these holes of potential. This creates additional individual dipoles in the sample. Due to electrostatic interactions, these dipoles built up chains of dipoles joining the electrodes. A gradient of distortion between regions of different polarizations produces the observed contrast appearing as lines on projection topographs.

Experimentalmethod:

When an electric field is applied, the time evolution of these polarized channels is too fast (<1s) to be observed by classical topography. For this reason, to be able to observe their formation, we developed a periodic shutter to realize stroboscopic imaging [4,5] in the 1-40 Hz range.

This experiment consists of observing the formation of the lines along c in KTP when applying a periodic rectangular electric field (140V/cm and DC=10%) and using stroboscopic diffraction imaging at low frequencies (2 Hz). The aim of this experiment is to confirm (or not) the previously proposed model of polarized channels, and to know more about this still puzzling phenomenon. The stroboscopic pulsed beam time width was 2.5% of the period (we thus integrate dynamic phenomena occuring during this fraction of the period). We recorded section topographs (20 µm width sections set perpendicularly to the c axis) on both SR films (resolution about 5µm) and nuclear plates ILFORD L4 (resolution ~2µm). We studied given moments of the period from -1% to 16% of the period, with a 1% step. This corresponds to the formation of the lines and the beginning of their vanishing.

Experimental results

We are mainly interested in 00ℓ reflections, where the lines interpretated as polarized channels appear as points on section topographs. Using stroboscopic imaging, we obtained information about the formation of these lines. Just after applying the electric field, some diffuse lines parallel to the main faces of the platelet shaped sample appear (pulsed beam at given moments from 1% to 4%). Their contrast is enhanced until points can be observed. The size of points goes increasing but their position remain the same during all the electric field application (5% to 11%). When the electric field is turned off, points tend to be homogeneously spot in all the section (12% et 13%), and the size of points decreases gradually up to their vanishment (relaxation).

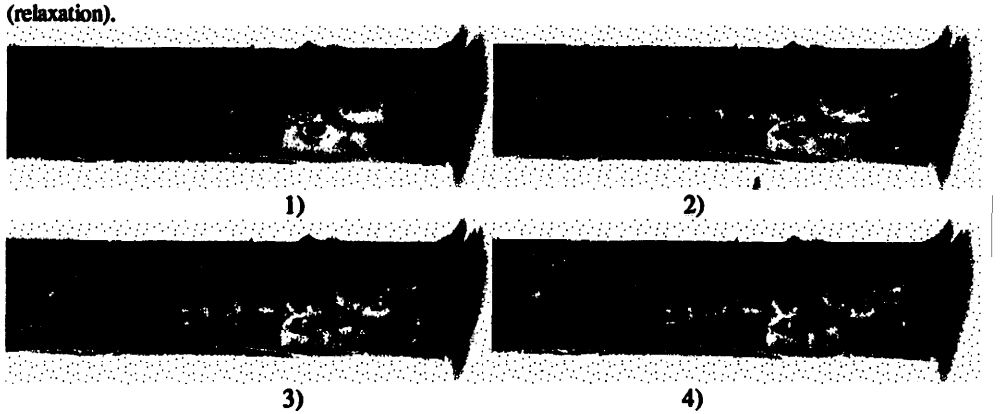

figure - 1), 2), 3) and 4) : section topographs of 00l reflexion, respectively of 1%, 3%, 5% and 7% of the period.

Present conclusions

We obtained new results both from an experimental or a scientific points of view:

-We have optimized the experimental parameters such as DC, amplitude and frequency of the periodic electric field to reach a complete relaxation. As a result, the dynamic phenomenon in KTP is actually periodic and can thus be studied using stroboscopic imaging.

-Topographs show that points do not appear gradually and then grow, but that diffuse lines parallel to the surface (on section topographs) appear and then turn into points. This is an unexpected result, which is under further investigation.

Let us emphasize on the fact that it is the first time such features have been observed and that the ESRF is a unique tool for this kind of experiments.

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