Experimental report: Grazing Incidence Investigation of Photostriction (28-01 1022)

Dates: 10/7/2012 – 16/7/2012

Summary of Experiment

The aim of our experiment was to investigate photostriction in the archetypal photoferroelectric $BiFeO_3$ (BFO), using diffraction methods. Photostriction is the combined effect of the photoelectric effect and inverse piezoelectricity in crystals which exhibit both of these phenomena. We constructed a rig which could illuminate a small single crystal sample with blue/UV light and integrated this system with SPEC, so that the sample illumination state could be controlled by the diffractometer software. We aimed to measure the rocking curve peak shift of multiple Bragg reflections in order to describe fully the change in lattice parameters associated with the photostriction.

Summary of Results

In addition to collecting enough Bragg reflection shifts to describe the photostriction tensor for incoherent incident illumination, we also collected data pertaining to the time dependence of photostriction by collecting the same rocking curve as a function of illumination time (figure 1). In order to reduce the effect of thermal expansion from the photostriction, we also took full advantage of the fully programmable nature of the controlling software to develop timing routines which fully synchronised the sample illumination and data collection. We can also be satisfied that our results are truly photostriction and not thermal expansion since they show that the light induced deformation that is observed has a positive poisson ratio, unlike what would be expected for thermal expansion in this material.

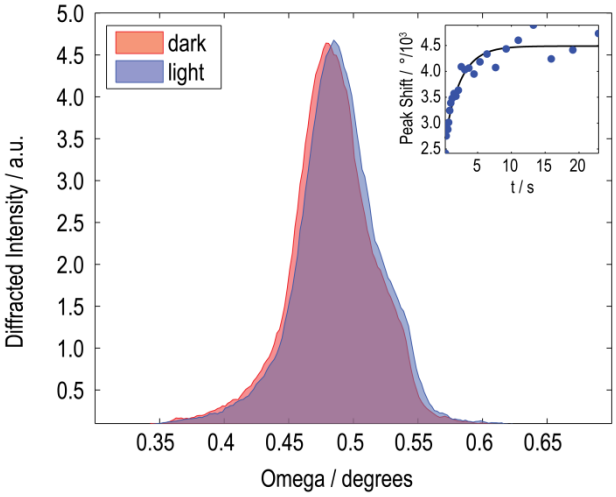

Figure 1 - comparison of dark and light rocking curves of the (5 2 5) Bragg reflection from a single crystal of BFO. A consistent and measureable peak shift is observed. inset: the time dependence of the peak shift, showing that longer exposures of UV light before x-ray data collection lead to a larger peak shift.

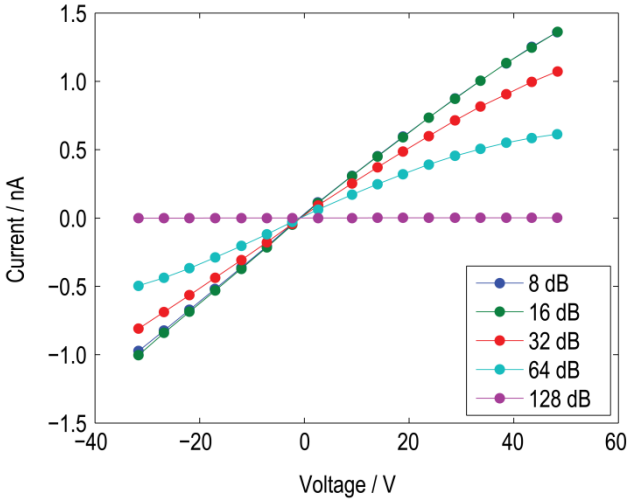

Figure 2 – the effect of x-ray beam intensity on the I-V curve measured from a 60 nm BFO thin film. Significantly higher current is observed under higher incident flux, demonstrating that there is a substantial photoconduction, photocurrent, and a non-zero open circuit voltage.

We also took advantage of the ancillary equipment on the beamline to collect the photoelectrical behaviour of a thin film device under x-ray illumination, something that was outside of the original scope of the proposal, but has nonetheless proven to be very worthwhile (figure 2). We observed significant photoconduction, photocurrent, and open circuit photovoltage, and this has led to a new tranche of experiments where we examine more closely the effect of x-ray illumination in photoferroelectrics. This includes experiments both on the electrical behaviour but also on the x-ray induced photostriction itself. More experiments at XMaS will be proposed which build on this principle and aim to quantify the x-ray photostriction in BFO and other materials.