Experiment Report Form

The double page inside this form is to be filled in by all users or groups of users who have had access to beam time for measurements at the ESRF.

Once completed, the report should be submitted electronically to the User Office using the **Electronic Report Submission Application:**

http://193.49.43.2:8080/smis/servlet/UserUtils?start

Reports supporting requests for additional beam time

Reports can now be submitted independently of new proposals – it is necessary simply to indicate the number of the report(s) supporting a new proposal on the proposal form.

The Review Committees reserve the right to reject new proposals from groups who have not reported on the use of beam time allocated previously.

Reports on experiments relating to long term projects

Proposers awarded beam time for a long term project are required to submit an interim report at the end of each year, irrespective of the number of shifts of beam time they have used.

Published papers

All users must give proper credit to ESRF staff members and proper mention to ESRF facilities which were essential for the results described in any ensuing publication. Further, they are obliged to send to the Joint ESRF/ ILL library the complete reference and the abstract of all papers appearing in print, and resulting from the use of the ESRF.

Should you wish to make more general comments on the experiment, please note them on the User Evaluation Form, and send both the Report and the Evaluation Form to the User Office.

Deadlines for submission of Experimental Reports

- 1st March for experiments carried out up until June of the previous year;
- 1st September for experiments carried out up until January of the same year.

Instructions for preparing your Report

- fill in a separate form for each project or series of measurements.
- type your report, in English.
- include the reference number of the proposal to which the report refers.
- make sure that the text, tables and figures fit into the space available.
- if your work is published or is in press, you may prefer to paste in the abstract, and add full reference details. If the abstract is in a language other than English, please include an English translation.

LURE	**Experiment title: X-** X-ray assisted poling in silica glasses	**Experiment number**: CS 424-03
Beamline: D21	**Date of experiment**: from: to:	**Date of report**:
Shifts:	**Local contact(s)**: Robert CORTES	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Bertrand Poumellec*, LPCES UMR 8648, Université Paris SUD.

Raphael BLUM*, LPCES UMR 8648, Université Paris SUD.

Robert CORTES*, PMC UMR 7643, Ecole polytechnique

Report: The present report relates previous work achieved at LURE synchrotron, NOT at ESRF

The motivation for studying X-ray poling of glass waveguides in european contract GLAMOROUS of the Information Society Technologies (IST-2000-28366) is the potential of the technique to ultimately lead to high poling efficiencies. The poling efficiency is defined by two quantities :
- The amplitude of the electric field recorded in the material, which has to be strong and stable at the place of the optical waveguide.
- The third order nonlinear coefficient of the optical waveguide, which hopefully can be increased from the present value.
In contrast to thermal poling, when using photons (UV, X-ray or others electromagnetic field), electrons are excited from defects or from the glass network and become mobile. They are then moving to the positive electrode and leave behind positive centres. The photocurrent stops very rapidly, due to the screening field, assuming that on the way to the positive electrode, it exists an electron blocking.

We used LURE EXAFS beamline DCI D 21 from 17 to 20th september 2003 to perform our experiments.
Two kinds of experiments were then conducted : 1) evolution of the leakage current on a germanosilicate sample submitted to successive irradiations with tunable energies selected to match the excitation edge of Ge, 2) study of the leakage current on a pure silica sample for X-rays at fixed energy.

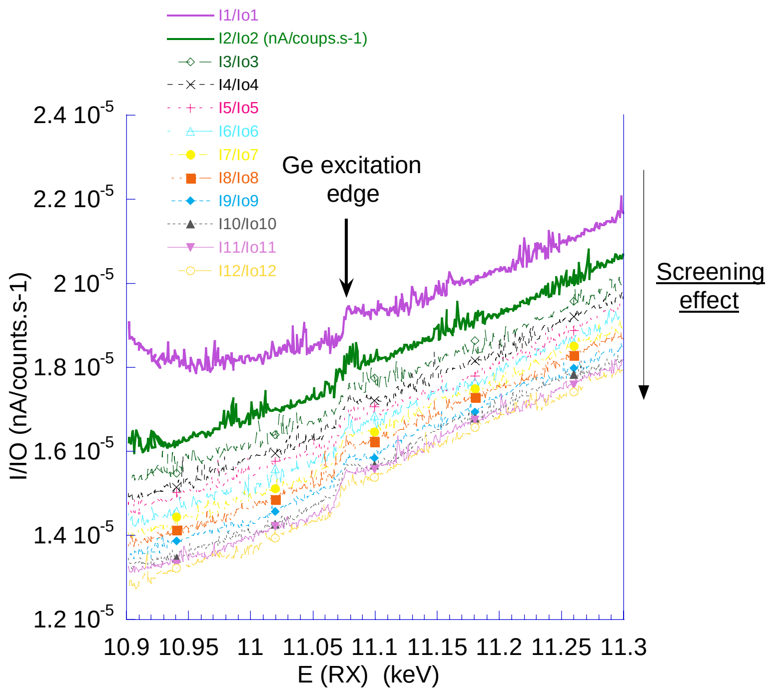

Figure 1. normalized current measurement vs x-ray energy under applied voltage of 1 kV on a pure silica substrate coated with a 5 µm thick Ge-doped silica layer

The current in the sample was recorded when the X-ray energy is increasing from 10.9 keV i.e. before the Ge K edge, until 11.1 keV i.e. after the edge. The external polarisation was applied permanently. One experiment last 1 hour. and the experiment was repeated 12 times. The first remark is that the current increases with the X-ray energy, probably due to increase of X-ray the penetration depth. This is just an increase of photoconductivity. More interesting is the Ge K edge appearing on the curve. It means that even if the layer thickness is small compared to the sample one (5 against 1000), it is detectable. This is the proof that the layer is active in the polarisation process. The second remarkable thing is that the current is decreasing along the time for a given energy, this is the trace of a screening effect. Unfortunately we were unable to measure non-linear coefficient on this sample. Real effect of the presence of Ge and its excitation on improved non-linearity has thus still to be proven.

We also used a fixed low energy photon at 4.2 keV for treatment of a pure silica sample. We do not want to describe more this procedure and the sample structure as we are filling a patent on that.

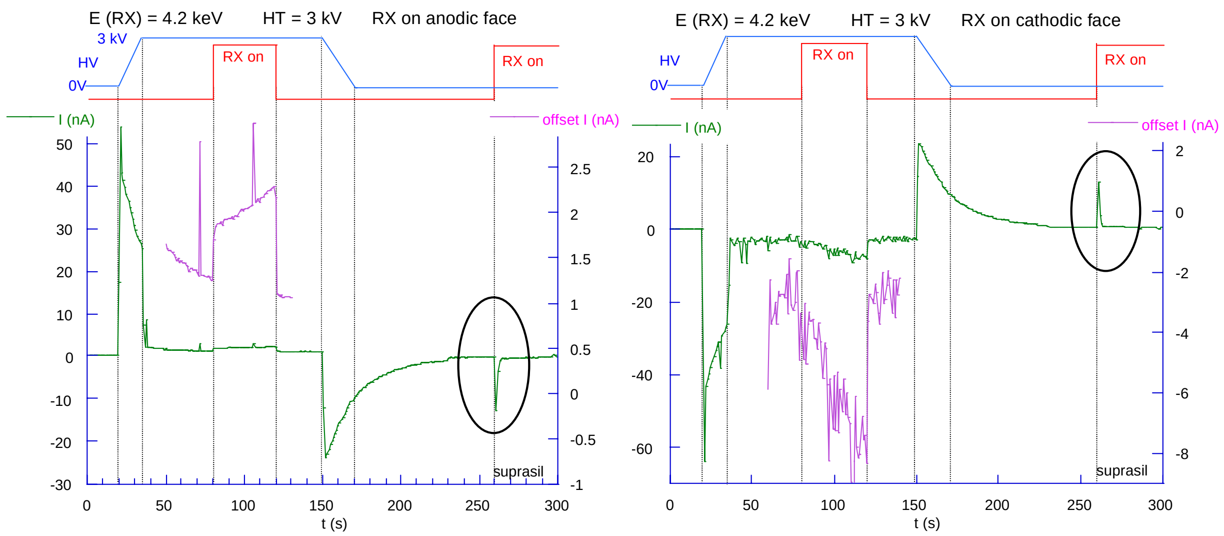

Figure 2. test cycle of suprasil sample with anodic (left), and cathodic (right) side facing X-Ray beam. The circles indicate the discharge current, proof of a space charge formation.

The experiment begins with the application of the external field. For anode facing the X-ray beam, the current increases due to leakage resistance and capacitance. Then, when X-ray are opened, the current increases abruptly in first, due to decrease of circuit resistance, this is normal. But after that, it increases slowly, this is abnormal. The resistance decreases due probably to creation of defects during the irradiation. The experiment goes on in stopping the irradiation, the current decreases. Then, the polarisation is stopped, the current arises from capacitance discharge. Now, when X-ray are opened again, we can see a current peak in negative sense. This is the proof that we achieve a space charge that is released under X-ray. As we can see in the figure below, the stored charge is larger when X-ray are on the anodic side than the reverse.

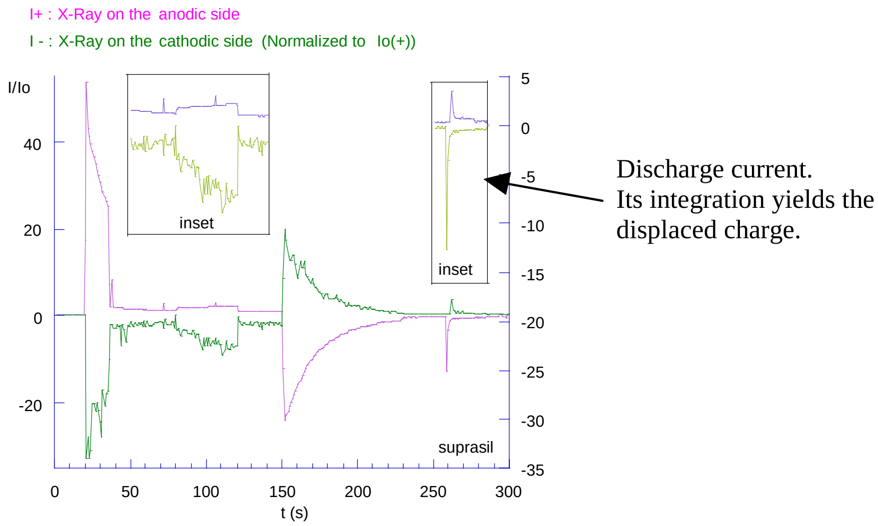

Figure 3. comparison of test cycle current measurements for both configuration (normalize to X-ray incident intensity)

Lastly, two samples were poled during 50 min with X-ray on the anodic face and 35 min with X-ray on the cathodic face, respectively. Maker fringe measurements (see figure below) achieved by PhLAM-USTL in WP1.2 yields the following conclusion:

- anodic side poled sample show a light overmodulation with a maximum harmonic power of about 1.10^{-3} µW ($9.\ 10^{-4}$ µW) that is only ten times weaker than the harmonic power measured on a standard thermally poled Suprasil sample.

- cathodic side poled sample shows a very weak harmonic power of about $2.5\ 10^{-5}$ µW with a strong overmodulation attributed to a thick non-linear layer of low amplitude.

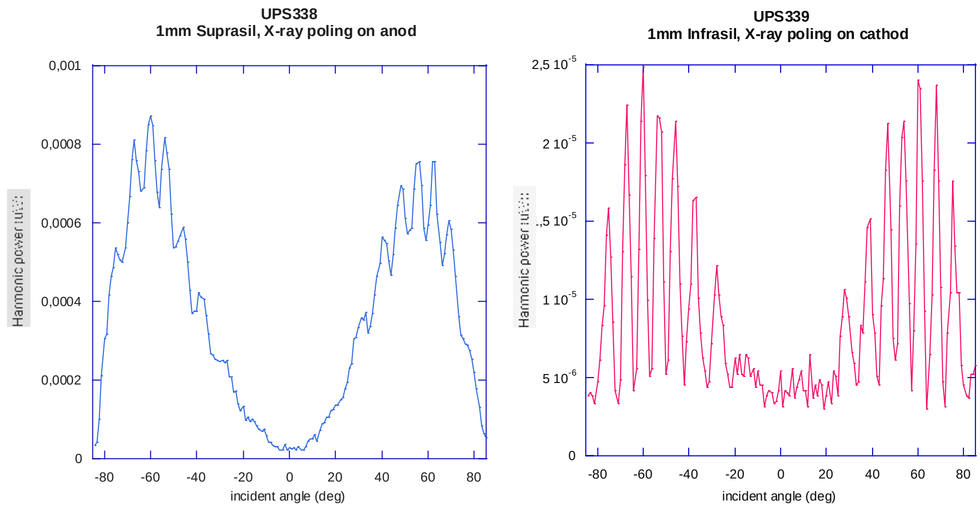

Figure 4. Maker fringe measurement for Suprasil X-ray poled on a) anodic face, b) cathodic face.

This values of Non-linearity are still very weak but due to insufficient beamtime access we were unable to fully understand which poling parameters play a keyrole in the enhancement of poling efficiency. The process needs to be pursued.