ESRF	**Experiment title:** Study of piezoelectric devices by conventional and stroboscopic topography	**Experiment number**: HS-705
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Report:

X-ray topography is one of the most powerful techniques to assess the vibration modes of piezoelectric devices, widely used for frequency generation and filtering. We have previously demonstrated that stroboscopic topographies of vibrating thickness shear resonators made using the time structure of the synchrotron radiation contain contrasts which can be used to determine very accurately the vibration mode when the amplitude of the vibration is sufficiently small. For larger amplitudes, we have more recently shown that the actual mode shape can be determined using either conventional or stroboscopic topographies and numerical simulation [1] of the diffraction images. In the present experiment, we have been able to observe directly the mode shape of devices having a vibrating amplitude in the range actually used in most of their applications ranging from some µW up to several mW.

This method is based upon the use of a polychromatic beam with an extremely small divergence available at ESRF only. The distortion of the lattice planes due to the vibration is by several order of magnitude larger than the width of the intrinsic rocking curve so that each region with a different deformation diffracts a radiation with a different wave length. It means that the diffracted rays are deflected with different angles according to the local Bragg angle. In the experimental setting, the incident beam is collimated using a very thin slit (of the order of 20 µm, much thinner than the acoustic wave length) in the symmetric arrangement.

It can been shown very easily that the width of the diffraction image obtained on a film is a function of the local rotation of the lattice plane along the path of the beam inside the crystal. Since the divergence of the source is very small, this phenomenon can be amplified setting the film at a large distance from the crystal (of the order of 2 m). So, we obtain a direct recording of the vibration amplitude along the section of the crystal by the beam collimated by the slit. When the crystal does not vibrate one obtains a conventional section topograph of the device. When vibrating one sees an envelope corresponding to the maximum of the vibration (fig. 1).

To obtain further details on the vibration modes, the stroboscopic technique was employed (fig. 2). For resonator vibrating in overtone modes the deformation pattern is periodically repeated across the thickness so that reflected beams arising from the regions of maximum deformation propagate. The image is the superposition of all the patterns created by these beams and give information about the amplitude of the deformation through all the thickness of the resonator. The mode shape obtained in the case of a resonator having two curvatures displays oscillations which are not present in usual plano-convexe resonators which have very nearly the expected hermitto-gaussian modes. No other technique could show that before. These results will be published soon [2-4]

On the whole, this new method which makes use of the very improved characteristics of the beam delivered by the third generation synchrotron at ESRF, allows to directly determine the mode shapes of the piezoelectric devices with a very high precision.

[1] J. Appl. Cryst. (1998), 31, 574-582
[2] accepted for oral presentation at "Joint Meeting of the 13th European Frequency and Time Forum and 1999 IEEE International Frequency Control Symposium", Besançon, France, 13-16 April 1999
[3] submitted to XVIIIth IUCr Congress, Glasgow, UK, 4-13th August 1999
[4] to be submitted to J. Appl. Cryst.

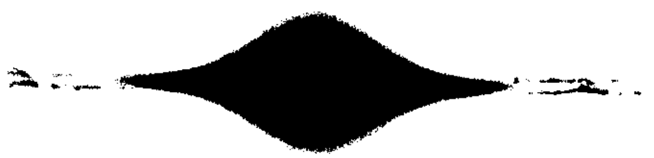

Figure 1
Section topograph of vibrating crystal

Figure 2
Stroboscopic topograph of vibrating crystal. The fringes allow to measure the amplitude of vibration