ESRF	**Experiment title:** Visualising the impact of elastic constant on cooperative switching in a family of Fe-based transition materials	**Experiment number**: hc3747
Beamline: ID09	**Date of experiment**: from: 04/07/2018 to: 10/07/2018	**Date of report**:
Shifts: 18	**Local contact(s)**: Matteo Levantino (matteo.levantino@esrf.fr)	*Received at ESRF:*

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Report:

Our recent studies on photo-switching of spin-crossover materials revealed a number of fascinating perspectives arising in these systems. First and foremost, a laser pulse activates elastically driven cooperativity, which largely exceeds the sole action of the absorbed photons (at best a single molecule switching per photon). When the number of photo-switched high spin molecules reaches a certain threshold, the propagating lattice expansion, which re-establishes mechanical equilibrium, becomes sufficient to pull low-spin molecules to the high spin state. Reminiscent of a feedback mechanism, the more the lattice expands, the more molecules switch, the more the lattice expands, and so on. These crystal deformations occur on the acoustic timescale, determined by the speed of sound and the size of the studied system, so generally slower, but also ultrafast when nano-scale materials are dealt with.

We were allocated beamtime (HC3439) for investigating whether or not volume expansion is concomitant with the elastic switch of the molecules, and whether threshold values obtained in structural experiment will corroborate the results of all optical experiments. Herein we proposed taking the structural experiment a step further, by addressing a new type of material, where volume shrinks instead of expanding upon transition, to

investigate the influence on the amplitude and the onset of the elastic switch. The studied compound was the V_2O_3 Mott insulator, which undergoes a phase transition from paramagnetic monoclinic (low temperature, LT) to antiferromagnetic rhombohedral (high temperature, HT) around 160 K. Prior to the proposed time-resolved X-ray studies at ID09, co-workers conducted detailed infrared (IR) pump-probe studies on this material. Samples were thin films grown on sapphire substrate (fig.1, left). We benefited from the OPA capacity of the ID09 beamline, to tune laser wavelength to 0.8 eV (above gap yet sparing excess heat), excited the crystal from the top and probed with x-rays at grazing incidence (fig.1, center). Laser beam was focused in the sample plane and its aspect ratio was chosen with a pair of cylindrical lenses to match the x-ray footprint and achieve same fluences as were used on previous IR measurements.

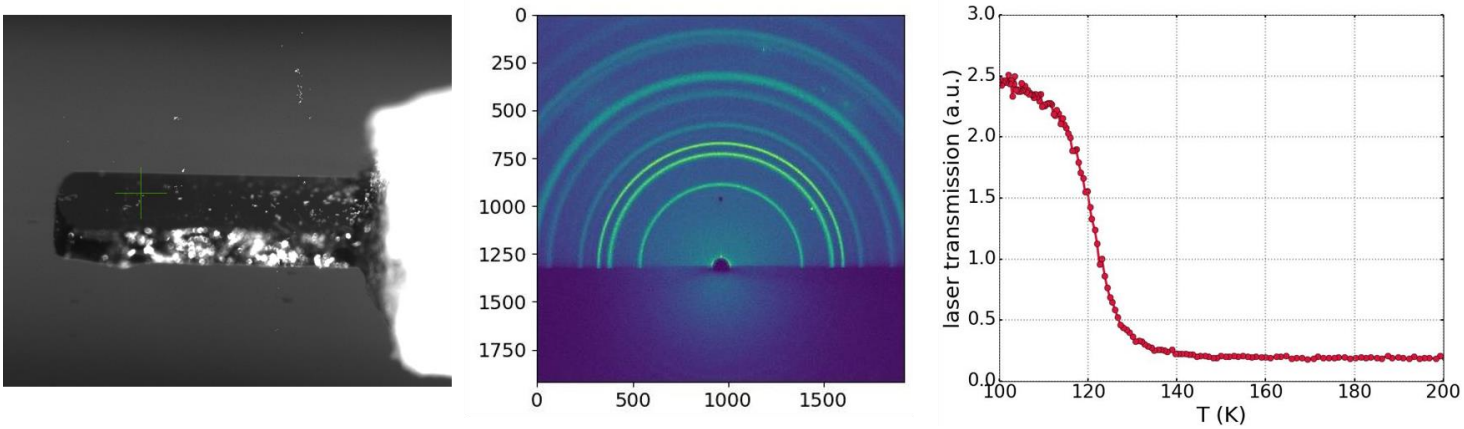

Fig. 1: Picture of the sample: V_2O_3 film on Al_2O_3 substrate (left), associated diffraction image (center) and laser transmission throug the sample with temperature (right)

To efficiently probe the sample surface, where laser x-ray wavelengths of 11.8 and 14.5 keV were used. Samples of different thicknesses were studied under controlled temperature, to investigate the effects on the elastic process.

Switching from LT to HT phase, one expects a merging and/or shift of Bragg peaks in the diffraction pattern. This is evidenced by looking at the difference between patterns at different time delays under laser excitation and a reference (fig.2), enlightening a photo-induced transition.

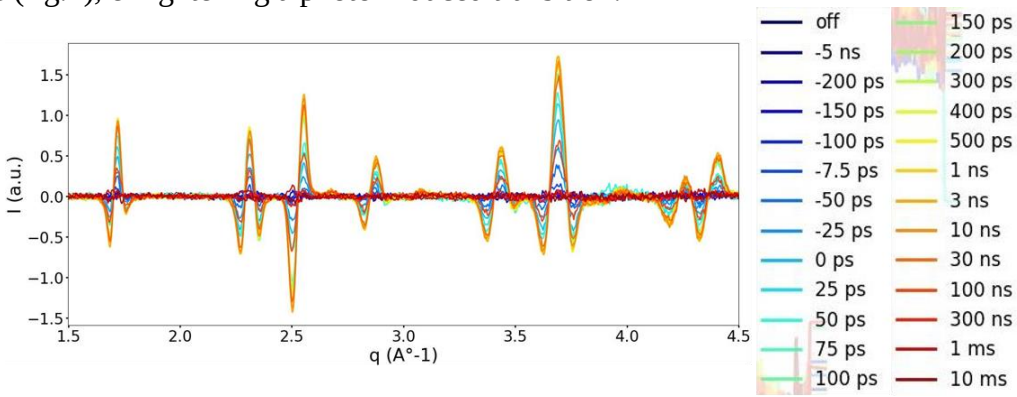

Fig. 2: Difference between patterns at different delays and a reference pattern (-5 ns). Experiment performed under laser excitation, at 95 K.

The full analysis of the diffraction pattern (fig.3) is in progress and will allow discriminating structural changes and excited phase fraction dynamics.

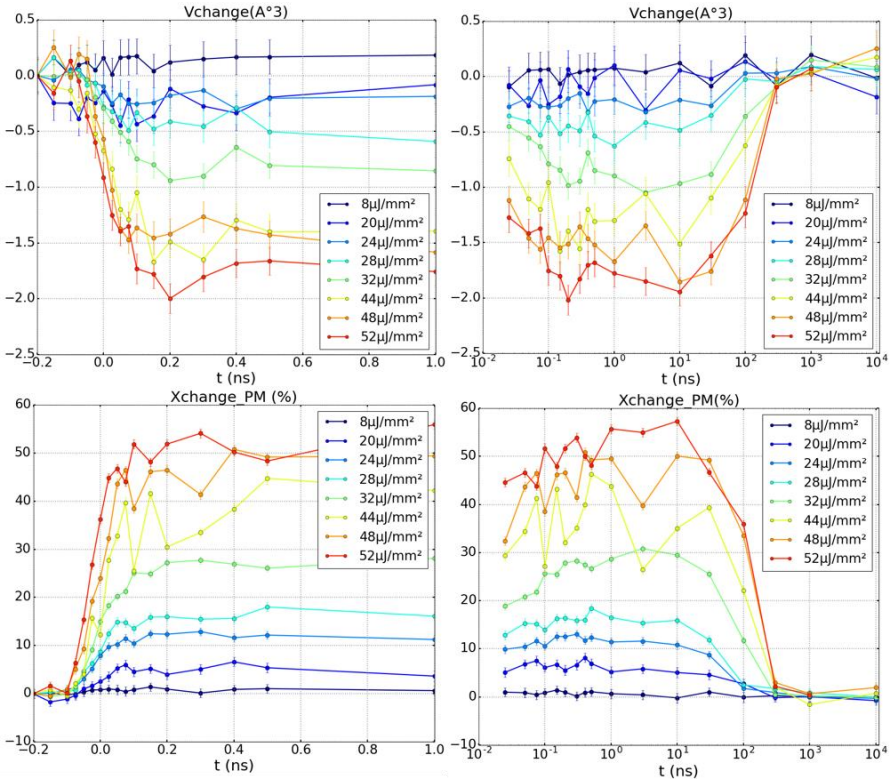

Fig. 3: Time-resolved mean unit cell volume (up) and paramagnetic (PM) phase fraction (down), extracted from diffraction patterns