Probing photo-induced solid-solid phase transition by fast X-ray diffraction.

M. Buron[a], *E. Collet*[a], *L. Guerin*[a], *M-H. Lemée-Cailleau*[a], *H. Cailleau*[a], *M. Wulff*[b], *S. Koshihara*[c], *S. Adachi*[d], *R. Tazaki*[d] *and J. Takahashi*[d]

e-mail: marylise.buron@univ-rennes1.fr

[a] Groupe Matière Condensée et Matériaux, CNRS, Université Rennes I, 35042 Rennes France

[b] ESRF, Grenoble, France.

[c] ERATO JST, Department of Materials Science, Tokyo Institute of Technology, Tokyo Japan.

[d] Institute of Materials Structure Science, High Energy Accelerator Research Organization, Tsukuba Japan.

Laser driven solid-solid phase transition is a new kind of manipulation of matter by light which offers fascinating possibilities for controlling ultra-fast macroscopic switching of materials. In some photo-active materials, the structural relaxation of the electronic excited states following the absorption of photons are not independent processes, as in conventional excitonic or photo-chemical ones, but entail a photoinduced phase transformation towards a new lattice structure and electronic order. This opens a way for light to trigger the physical properties of a material but also to induce symmetry breaking from a stable high temperature phase, and to establish a self-organized long-range order (structural, magnetic, ferroelectric,…). This new type of photo-induced effects is exemplified by molecular charge-transfer materials such as TTF-CA. The photo-induced phase transformation in this material takes place on a 100 ps time-scale. The present birth of ultra-fast X-ray diffraction gives a golden opportunity to observe structural changes at the atomic level and the inter-molecular reorganization. We will present our results on the direct evidence of the laser-induced ferroelectric order obtained by 100 ps X-ray diffraction experiment performed at the ESRF [1], and on the opposite photo-induced transition [2]. The reviewed results presented give an illustration of what can be done and open exciting perspectives [3]. Some present scientific challenges exist as the use of 100 fs sources in other complex materials. A deep understanding of cooperative and coherent phenomena at different scales requires the combined use of X-ray diffraction over different time scales.

[1] E. Collet, M. H. Lemée-Cailleau, M. Buron-Le Cointe, H. Cailleau, M. Wulff, T. Luty, S. Koshihara, M. Meyer, L. Toupet, P. Rabiller and S. Techert, Science **2003**, 300**,** 612.

[2] L. Guérin, E. Collet, M. H. Lemée-Cailleau, M. Buron-Le Cointe, H. Cailleau, A. Plech, M. Wulff, S. Koshihara and T. Luty, Chem. Phys. **2004**, 299/2-3, 163-170.

[3] H. Cailleau, E. Collet, M. Buron-Le Cointe, M.H. Lemée-Cailleau, *'Probing photo-induced structural phase transition by fast or ultra-fast time-resolved X-ray diffraction'*, chapter of 'Photoinduced Phase Transitions', Ed K. Nasu, World Scientific **2004**, 309-342.