ESRF	**Experiment title:** Simulating X-ray interstellar processing on dust grains analogues	**Experiment number**: HC-1709
Beamline: ID16B-NA	**Date of experiment**: from: 20/11/2014 to: 22/11/2014	**Date of report**: 05/09/2017
Shifts: 6	**Local contact(s)**: Damien Salomon	*Received at ESRF:*

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Report:

Following a successful experimental run in 2014, we reduced, modeled and published the data obtained at the ESRF in the following article published by **Astronomy & Astrophysics** :

L. Gavilan, C. Jäger, A. Simionovici, J. L. Lemaire, T. Sabri, E. Foy, S. Yagoubi, T. Henning, D. Salomon, and G. Martinez-Criado
Hard X-ray irradiation of cosmic silicate analogs: structural evolution and astrophysical implications
Astronomy & Astrophysics, 587, A144 (8pp), 2016
http://adsabs.harvard.edu/abs/2016arXiv160105464G

Abstract:
Context. Protoplanetary disks, interstellar clouds, and active galactic nuclei contain X-ray-dominated regions. X-rays interact with the dust and gas present in such environments. While a few laboratory X-ray irradiation experiments have been performed on ices, X-ray irradiation experiments on bare cosmic dust analogs have been scarce up to now.
Aims: Our goal is to study the effects of hard X-rays on cosmic dust analogs via in situ X-ray diffraction. By using a hard X-ray synchrotron nanobeam, we seek to simulate cumulative X-ray exposure on dust grains during their lifetime in these astrophysical environments and provide an upper limit on the effect of hard X-rays on dust grain structure.
Methods: We prepared enstatite ($MgSiO_3$) nanograins, which are analogs to cosmic silicates, via the melting-quenching technique. These amorphous grains were then annealed to obtain

polycrystalline grains. These were characterized via scanning electron microscopy (SEM) and high-resolution transmission electron microscopy (HRTEM) before irradiation. Powder samples were prepared in X-ray transparent substrates and were irradiated with hard X-rays nanobeams (29.4 keV) provided by beamline ID16B of the European Synchrotron Radiation Facility (Grenoble). X-ray diffraction images were recorded in transmission mode, and the ensuing diffractograms were analyzed as a function of the total X-ray exposure time. *Results:* We detected the amorphization of polycrystalline silicates embedded in an organic matrix after an accumulated X-ray exposure of 6.4×10^{27} eV cm^{-2}. Pure crystalline silicate grains (without resin) do not exhibit amorphization. None of the amorphous silicate samples (pure and embedded in resin) underwent crystallization. We analyze the evolution of the polycrystalline sample embedded in an organic matrix as a function of X-ray exposure. *Conclusions:* Loss of diffraction peak intensity, peak broadening, and the disappearance of discrete spots and arcs reveal the amorphization of the resin embedded (originally polycrystalline) silicate sample. We explore the astrophysical implications of this laboratory result as an upper limit to the effect of X-rays on the structure of cosmic silicates.

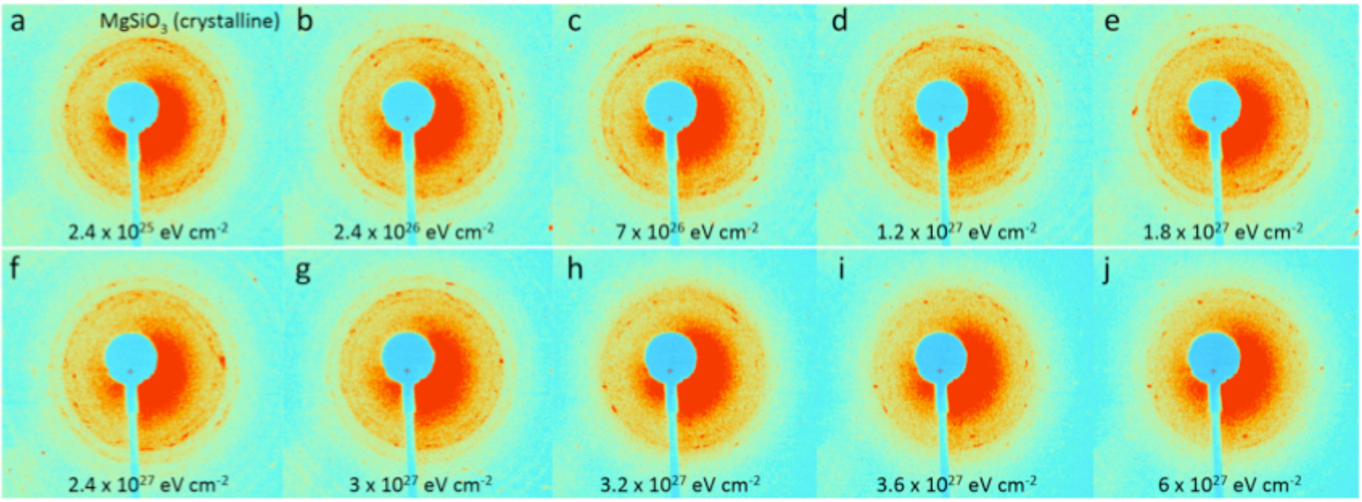

Fig. 3. Diffraction patterns for $MgSiO_3$ crystalline powder samples embedded in the Si_3N_4 substrate at increasing X-ray exposures. **a)** Crystalline $MgSiO_3$; **b)–e)** diffraction rings and visible arcs; **f), g)** less rings, few arcs, and spots; **h)–j)** no rings, a few spots.

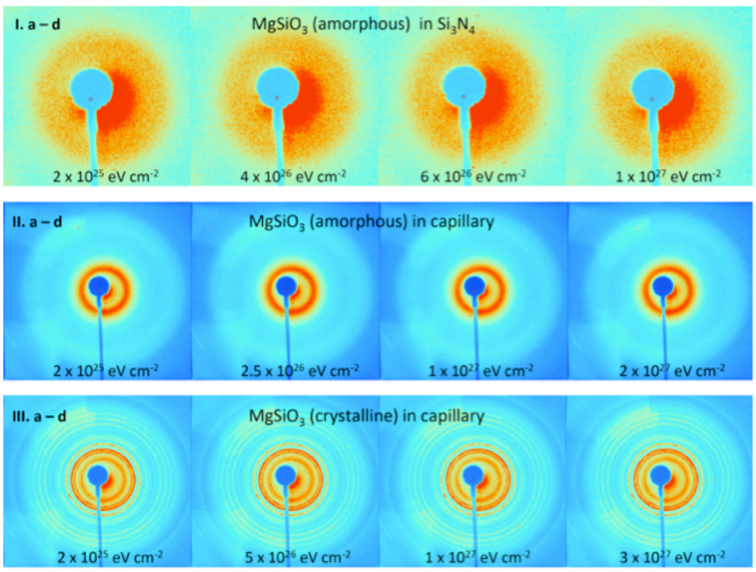

Fig. 4. Samples showing no evolution in their diffraction pattern with increasing X-ray exposure. **I)** $MgSiO_3$ amorphous grains in a resin embedded Si_3N_4 support. **II)** $MgSiO_3$ amorphous grains in a capillary. **III)** $MgSiO_3$ crystalline grains in a capillary.