Ultrafast Photoinduced transition of Cr:V_2O_3

M. Sander [1], J. C. Guzman-Brambila[2], D. Babic[1], S. Zerdane[1], R. Mankowsky[1], E. Janod[2], H. Lemke[1]

1 Paul Scherrer Institute - Switzerland, 2 Institut des Matériaux de Nantes Jean Rouxel - France

mathias.sander@psi.ch

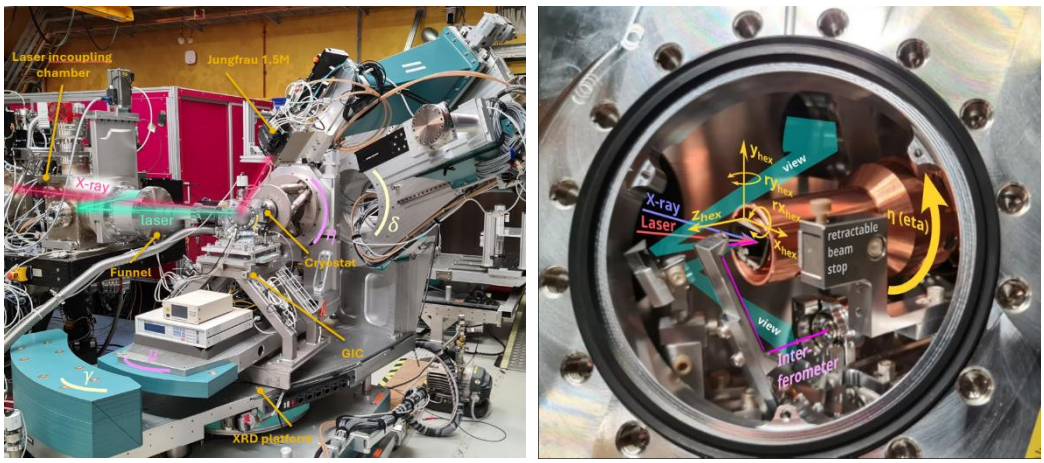
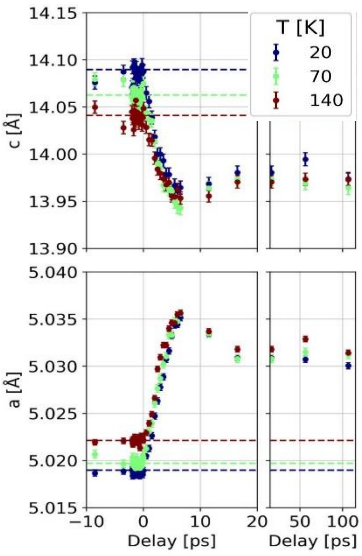


Figure 1. New Low-temperature surface diffraction instrument of the Bernina endstation at the Swiss Free Electron Laser [1] (left), and inside view of the low-temperature vacuum chamber (right).



Strongly correlated electron systems provide a rich platform for studying non-equilibrium phase transitions in which electronic and lattice degrees of freedom are strongly coupled. Among these materials, Vanadium(III) oxide (V_2O_3) is a prototypical Mott system exhibiting a first-order insulator–to–metal transition that can be triggered by temperature, pressure, or external perturbations such as optical excitation. Ultrafast pump–probe techniques have emerged as powerful tools for driving such transitions far from equilibrium and tracking the associated structural and electronic dynamics with femtosecond time resolution. We present a new grazing-incidence cryogenic vacuum chamber (GIC) optimized for high-stability diffraction experiments at sample temperatures between 4 K and 500 K using a helium flow cryostat. The chamber features a large diffraction angular range enabled by a beryllium dome exit window, allowing access to large scattering vectors necessary for resolving subtle lattice distortions in correlated materials. A compact sample survey and positioning system incorporates two non-collinear microscopic vies together with an interferometric position sensor, enabling stabilization of the sample surface <100 nm relative to the FEL beam. The chamber is optimized for the XRD base platform and incorporates a two-circle detector arm equipped with a variable-distance large-area detector. We present the first experimental results enabled by this new surface diffraction instrument, which allows structural changes associated with the insulator-to-metal transition to be measured with both high temporal and spatial resolution. This capability provides direct insight into the coupling between electronic correlations and lattice deformation. **Figure 2** shows the time-resolved lattice constant refinement of a Cr-doped V_2O_3 polycrystalline thin film (50 nm) following ultrafast laser excitation at different temperatures. The measurements confirms that the insulator-to-metal transition proceeds via the propagation of a strain-mediated structural transformation, in which a transient lattice distortion precedes the electronic response [2-4].

[1] https://www.psi.ch/en/swissfel/bernina [2] T. Amano, Nature Phys. Vol. 20, p.1778–1785 (2024) 2, 65-71. [3] D. Babic, Adv. Electron. Mater., 11 (2025) [4] J. Mohr, Phys. Status Solidi A 2024, 221, 2300405 (2024)