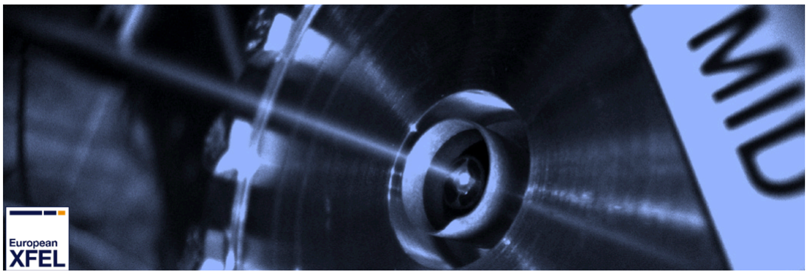

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Ultrafast probing of non-equilibrium melting and solidification of metals

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Due to a lack of relevant experimental data, the physical mechanisms of non-equilibrium melting and solidification (crystallization or vitrification) of metals are not fully understood. Conventional structural probes remain useless for direct observations of those transitions as they occur on an ultrashort time scale, usually from pico- to nanoseconds. As a result, their current understanding is incomplete and based mainly on theoretical modeling. Optical-pump X-ray free-electron laser probe technique is a unique method that allows tracing the structural pathway of the system through its metastable, transient states. In this approach, a thin metallic film is heated at 10^{14} K/s by an ultrashort laser pulse and cools down extremely rapidly (up to 10^{12} K/s) by dissipation of heat into a substrate. The state of the sample is probed during the heating and cooling ramps by an X-ray pulse, for which the X-ray diffraction (XRD) pattern is recorded at delay times ranging from sub-picosecond after the optical excitation. In the XRD pattern, the amount of structural information about the system is determined by the available range of the momentum transfer q, which scales with the energy of the incident photons. The availability of very hard X-ray pulses opens new opportunities both in terms of accessibility of high-q Bragg diffraction peaks (required to determine the temperature and the strain of the crystalline lattice) and for total scattering and X-ray Pair Distribution Function (PDF) analysis of the liquid/glassy state. This talk presents selected experimental results on non-equilibrium melting and solidification of metals, illustrating the advance in knowledge provided by very hard X-rays and a possible scientific impact in the field.

Primary author: ANTONOWICZ, Jerzy (Warsaw University of Technology)

Co-authors: Prof. SOKOLOWSKI-TINTEN, Klaus (Fakultät für Physik, Universität Duisburg-Essen); ZALDEN, Peter (Eur.XFEL (European XFEL)); SOBIERAJSKI, Ryszard (Institute of Physics Polish Academy of Sciences)

Presenter: ANTONOWICZ, Jerzy (Warsaw University of Technology)

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