22nd International Conference on
Diffusion in Solids and Liquids
22 TO 26 JUNE 2026 | RHODES, GREECE

ABSTRACT:

Photo-Chemical Effects on Oxide Layers in the Hard X-Ray Regime

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Oxide surfaces belong to the most important and widespread inorganic materials in environement. Understanding the surface phenomena occurring at these surfaces is of prime importance in a large variety of fields and especially for ferroelectric materials involved in multiferroic structures. Because ferroelectrics are insulators with rather small band gaps, photons can efficiently interact with electrons leading to photoconduction or photovoltaic effects upon exposure to visible and ultra-violet light. However, these effects derive from the use of photon energies adapted to the insulator gap and only relatively little attention has been paid to the photon induced elasticity or surface reactivity changes occurring when using hard X-rays.

We will report significant changes occurring during reflectivity measurements upon the photon flux densities for hard X-rays (> 10 keV) using intense synchrotron radiation. These changes can be as important as shifting Kiessig fringes from maxima to minima positions, which serioulsy mingles the layer thickness analysis. For a variety of oxide hetero-structures we observed reversible periodicity changes in reflectivity with respect to the incident X-ray photon flux density. We found that the effect is absent for metal covered oxides or metal/semiconductor multilayers on the same experimental station and under identical photon energy and flux conditions pointing the necessary interaction of the surface with its environment as could be verified by monitoring the effect under different gas conditions. The phenomenon is ultimately understood as due to irradiation damages producing oxygen vacancies in large enough amounts to change the apparent layer thickness. This effect has strong implications and should be considered for specular reflectivity, conducted in air, as well as hard X-ray investigations routinely used to characterize thin oxide films.