Relaxation processes and aging in metallic glasses

B. Ruta[1]

[1] *ESRF - The European Synchrotron, 71 Avenue des Martyrs, 38043, Grenoble, France*

The unique structural features and outstanding mechanical and physical properties of glasses have put them at the focus of an intense research activity for both fundamental understanding and technological applications [1]. Notwithstanding, their intrinsic non equilibrium nature still poses formidable problems to broad applications, and one of the main challenges is to avoid aging during processing and annealing. This requires an understanding of the microscopic mechanisms beyond aging and of the relation between the structure and the atomic motion, which is still missing due to the lack of information on the dynamics with both experiments and simulations [2].

Thanks to improvements in the collection of sparse scattering signal and in coherent flux, X-ray Photon Correlation Spectroscopy (XPCS) has recently emerged as the very only technique able to measure the atomic motion in both crystalline and amorphous materials [3]. By collecting series of diffraction data with coherent X-rays, XPCS measures the particle dynamics though the temporal evolution of the intensity fluctuations in the generated speckles patterns.

Measurements on metallic glasses have revealed the existence of microscopic structural rearrangements, which cannot be explained by any current theory [3]. In these systems, the dynamics evolves from a diffusive atomic motion in the supercooled liquid phase to a stress-dominated dynamics in the glass, characterized by a complex hierarchy of aging regimes as in complex soft materials. By combining dynamical (XPCS) and structural (XRD) studies we have been able to quantitatively link for the first time this anomalous atomic motion to microscopic structural mechanisms usually observed in diffraction studies, providing a broader unique view of the glassy state [4].

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