

Glassy and liquid metals, from microscopic to macroscopic dynamics

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The relaxation dynamics of glass-forming metals control some of their key mechanical properties. The dynamics of the glassy state control the change from homogeneous to heterogeneous plastic deformation when applying deformation at different velocities, as well as it determines the physical aging behaviour that can produce a ductile to brittle transition. At higher temperatures, in the glass transition region and the supercooled liquid state, the dynamics control the rheological behaviour and the ability of thermoplastic forming. X-ray Photon Correlation Spectroscopy (XPCS) gives access to the microscopic dynamics of glasses from the atomic length scale up to the nanometer scale. This is the range of scales in which it is expected that the cooperative dynamics of supercooled liquids and glasses can be observed. On the other hand, mechanical spectroscopy, creep experiments and stress relaxation give access to the macroscopic dynamics [1]. An important remaining task still to do is to theoretically connect the microscopic and macroscopic dynamics, thus unveiling the atomic and nanometer-scale mechanisms of the macroscopic behaviour.

This poster presents mechanical relaxation and XPCS data obtained for various glass-forming alloys, namely $\text{Pd}_{40}\text{Ni}_{40}\text{P}_{20}$, $\text{Pd}_{40}\text{Ni}_{10}\text{Cu}_{30}\text{P}_{20}$ and $\text{Zr}_{46.75}\text{Ti}_{8.25}\text{Cu}_{7.5}\text{Ni}_{10}\text{Be}_{27.5}$, comparing the times and shapes of the macroscopic and microscopic relaxation functions in the glassy, glass transition and supercooled liquid regions, thus covering relaxation times from the order of thousands of seconds to the order of few seconds. At temperatures above the glass transition, the macroscopic dynamics are coincident in shape and time with the microscopic dynamics measured at the maximum of the structure factor. The distribution of times at this length scale is reproduced in the stress relaxation function, with similar values of stretched exponents. On the other hand, in the glassy state, the macroscopic relaxation is dependent of the level of external force applied in the experiments, changing from partial to complete relaxation at the same temperature but different levels of stress. In this case the microscopic relaxation time seems to control only the partial relaxation observed when applying low stresses. Furthermore, the broad spectrum of relaxation times observed macroscopically in this region is not reproduced in the microscopic dynamics where compressed relaxation functions are always observed.

References

[1] - J.C. Qiao, Q. Wang, J.M. Pelletier, H. Kato, R. Casalini, D. Crespo, E. Pineda, Y. Yao, Y. Yang, *Progress in Materials Science* **104**, 250 (2019).