ESRF	**Experiment title:** The effect of nanocrystalline inclusions on the high frequency dynamics of a metallic glass	**Experiment number**: HS 4653
Beamline: ID28	**Date of experiment**: from: 12/03/2014 to: 18/03/2014	**Date of report**: 31/03/2016
Shifts: 18	**Local contact(s)**: Thomas Forrest	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

V. M. Giordano*, S. Pailhes*, J. Faria*

ILM, Villeurbanne (France)

B. Ruta*

ESRF

Report:

The aim of this experiment was to investigate and compare the high frequency dynamics of the metallic glass (MG) Zr52.5Cu27Al10Ti2.5Ni8 with that of a crystalline/amorphous composite made of the same glass with crystalline nanoinclusions.

The MG has been prepared by casting a liquid alloy in a Cu cylindrical mould, obtaining a cylinder of 3mm diameter and 8cm length. Discs of this cylinder have been cut and treated for preparing three samples: one fully amorphous, one crystallized at 30% with an average crystallite size of 10nm, and one fully crystalline with an average grain size of 20nm (Fig.1). The experiment on ID28 has been run using the Si 9 9 9 reflection, allowing for a major flux, despite the lower resolution (~3 meV). Data have been collected on all three samples at three q-sets going from 1.5 to 25nm^{-1}.

Effects of total or partial crystallization on elastic moduli of metallic glasses have been reported in litterature for a number of systems, amon which Zr-base MG with composition very similar to ours. Howeve,r depending on the heat treatment results are very different: increases of shear and bulk modulus up to 50% for the fully crystalline sample have been reported in some cases while only of 3-5% in other.

Our study provides a detailed picture of the differences in the atomic dynamics in the three invetsigated systems, as we get also the lengthscale dependence of elastic properties as well as acoustic damping, in a qide q-range, spanning two pseudo-Brillouin zones (the maximum of the structure factor is at ~26nm^{-1}).

Our results are more in agreement with litterature data reporting almost no change upon crystallization, as can be seen in Fig. 2 where we report the longitudinal and transverse speed of sound for the three samples. While the longitudinal velocity is the same in all samples, an increase upo partial and full crystallization can be seen in the transverse velocity, however, but only of 6%.

In the second Brillouin zone, the fully and partially cristalline smaples present two different transverse branches, most probably originated by the two different crystalline phases enucleated, while the amorphou single transverse branch is in between them, csuggesting that in the amorphous phase both kinds of local order are present.

Notably, no difference is found in phonon damping, confirming results from molecular dynamics simulation on an amorphous silicon matrix with a nanocrystalline silicon inclusion[1]

Fig. 1 TEM images of the partially (left) and fully (right) crystallized samples. The grain boundaries are marked by black lines in the fully crystallzed samples, while in the partially crystallized one the dark regions correspond to crystallites and the grey matrix to the amorphous part.

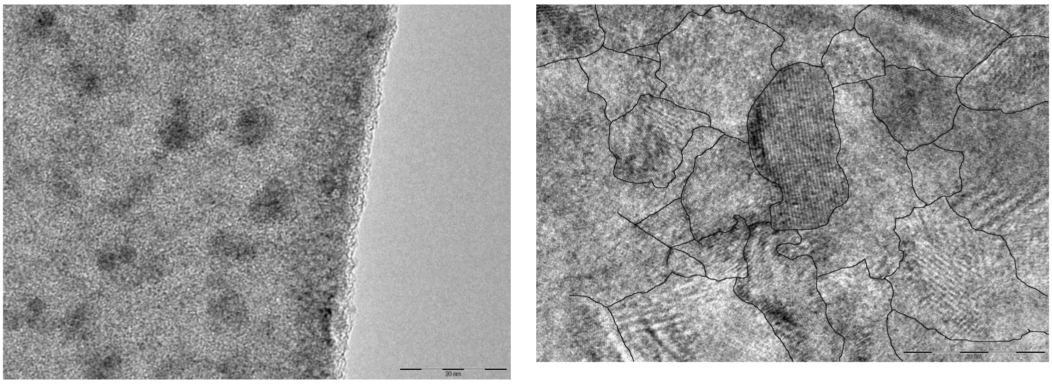
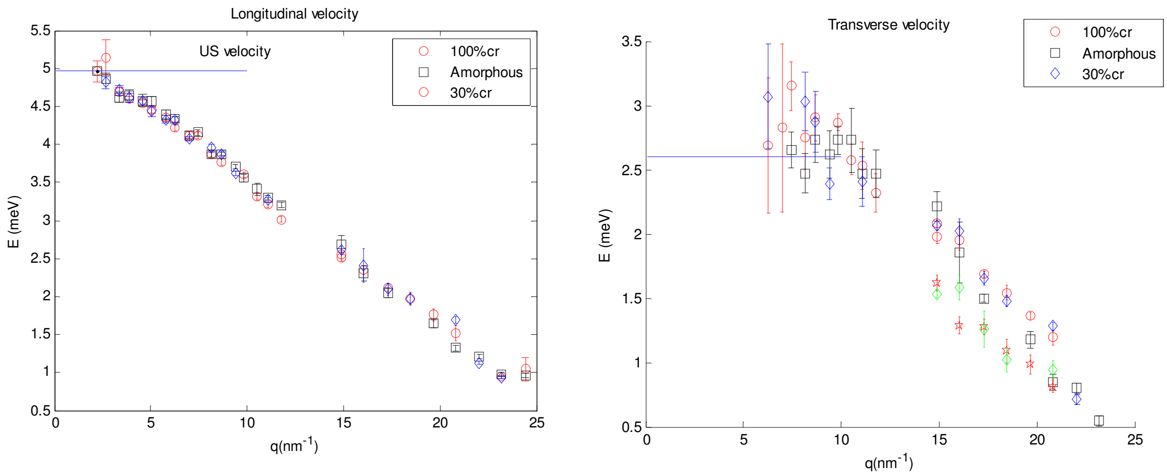


Fig. 2: longitudinal (left) and transverse (right) sound velocity for the three investigated samples, compared with ultrasound values as measured on the amorphous sample (blue horizontal lines)



[1] Nanocrystalline inclusions as a low-pass filter for thermal transport in a-Si, T. Damart, V. M. Giordano, and A. Tanguy, Phys. Rev. B 92, 094201 (2015)