Experimental report

14/09/2016

Proposal: **6-05-971** **Council:** 4/2016

Title: Atomic Dynamics of Bulk Metallic Glasses under Tensil Stress

Research area: Materials

This proposal is a continuation of 6-05-946

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Samples: $Pd_{77.5} Cu_6 Si_{16.5}$

Instrument	Requested days	Allocated days	From	To
IN6	8	6	08/07/2016	14/07/2016

Abstract:

Abstract: In the application of bulk metallic glasses (BMG) their mechanical properties are the most important. They show an extreme strength at ambient temperature, but fail abruptly when yield is reached. This catastrophic yield is most likely related to their heterogeneous structure, consisting of soft regions, to our present knowledge, in which the instability is initiated, and a network of hard regions surrounding them. In our experiment we have shown that the deformation of this heterogeneous atomic structure is reflected in a change of the Generalized Vibrational Density Of States (GVDOS) and that the stress-temperature scaling obviously also applies to the atomic dynamic of glasses. We now want to investigate in detail the beginning of this change of the GVDOS and whether any completely elastic strain region exists in BMGs.

Report on experiment 6-05-971

Atomic Dynamics of Bulk Metallic Glasses under Tensile Stress

In the previous experiment (6-05-946) we found a strong influence of stress on the atomic dynamics of the metallic glass $Pd_{77.5}Cu_6Si_{16.5}$ at stresses – according to the indication of the dilatation gear – at and above 100N (14 MPa for our samples with 3 mm diameter). The changes concern the Generalized Vibrational Density-of-States (GVDOS) in its full range of frequencies, as is shown in Fig.1:

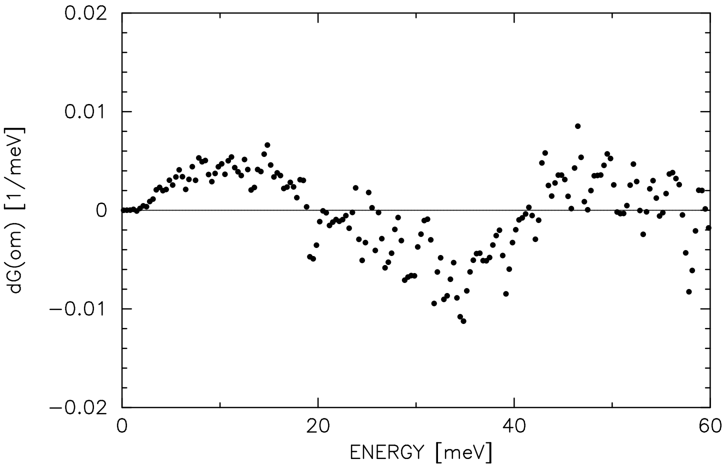

Fig.1:Difference of the GVDOS of unstressed minus stressed (100N, 14 MPa) PdCuSi. The loss of intensity below 20 meV and above 42 meV and the corresponding intensity gain near the Debye cut off energy (32 meV) is very obvious. The GVDOS narrows.

Measurements up to 400N showed no change of the GVDOS at stresses larger than 100N. The aim of the present experiment therefore was to find below 100N the stress, at which a first clear change of the GVDOS can be observed and the further development of the atomic dynamics with increasing stress up to the final status observed in the previous experiment. Even though we scanned very carefully the region below 100N we did not yet reach this point as can be seen in Fig.2.

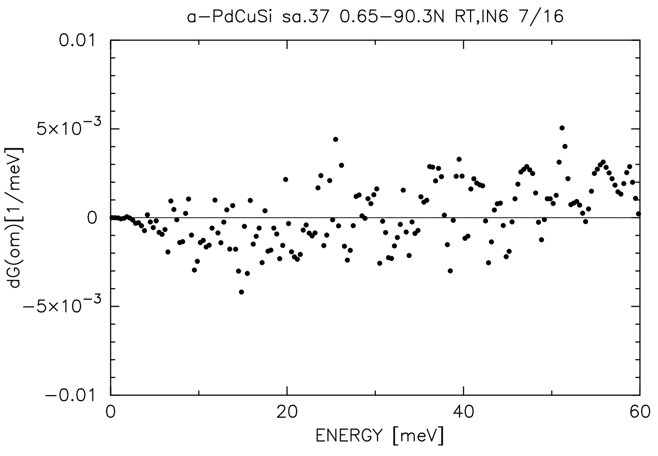

Fig.2: Difference of the GVDOS measured at 0.6N and 90.3N. There is no systematic deviation from zero intensity up to the end of the GV DOS (55 meV)

The reason for this is most likely a wrong stress-indication of the dilatation gear, which we used in the previous experiment. The apparatus including software and hardware is nearly a quarter of a century old, its stress-maximum is 15000N, and it is therefore usually used well above 500N. In fact our own dilatation experiments (without neutrons) using this gear, which we performed before the previous experiment, already indicated this problem by the nonlinear increase of the dilatation below 100N (see Fig.3).

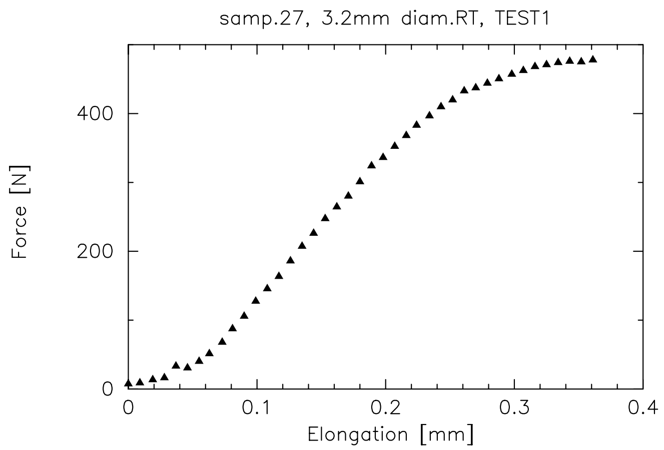

Fig.3: Dilatation test with a 3.2 mm diameter PdCuSi stick

Being suspicious about the accuracy of the dilatation gear at stresses below 100N, we therefore changed the dilatation method in the present experiment, using lead weights to produce the necessary stresses (1 kp ^ 9.81N). This limits the error to that of the two balances, with which we measured the weight of the lead blocks, and to the very small deviation of the gravitational acceleration at IN6 from g = 9.81 m/s^2. Using now this considerably more accurate method we thus limited the searched region of action from below up to 90N, but still have to continue to higher stresses, most likely well below 200N.

We would like to thank Uta Filippich for producing our samples, Richard Ammer for the sample holder and Jerome Halbwachs for his efficient help at the start-up of the experiment.