ROBL-CRG	**Experiment title:** Short range structure of bulk amorphous metallic alloys	**Experiment number**: 20_02_011
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Report:

Zr-Ti-Al-Cu-Ni alloys belong to the family of new multicomponent metallic glasses with extended supercooled liquid region which can be obtained not only by rapid quenching but also by slow cooling from the melt. This allows preparation of thin ribbons as well as of bulk glassy samples. The question wether or not structural differences exist in the amorphous state due to different cooling rate could be answered by the diffraction measurents. Fig. 1 compares the X-ray diffraction patterns of amorphous $Zr_{57}Ti_5Cu_{20}Al_{10}Ni_8$ alloy obtained by rapid quenching and by copper mold casting. Small differences in the scattering curve indicate a somewhat higher degree of order in the slowly cooled sample. These differences are similar to that during annealing of the rapidly quenched material. The sample prepared by copper mold casting corresponds to a relaxed amorphous state.

Annealing at elevated temperatures allows structural investigations of the progress of crystallization and the development of stable or metastable nanoscale phases from the supercooled liquid. This offers the possibility to produce bulk nanoscale materials or amorphous/nano(quasi)crystalline phase mixtures by crystallization. Amorphous $Zr_{62-x}Ti_xCu_{20}Al_{10}Ni_8$ with 3 at% Ti formes quasicrystals as the first stage of crystallization [1]. With increasing Ti content the formation of nano-quasicrystals was concluded from

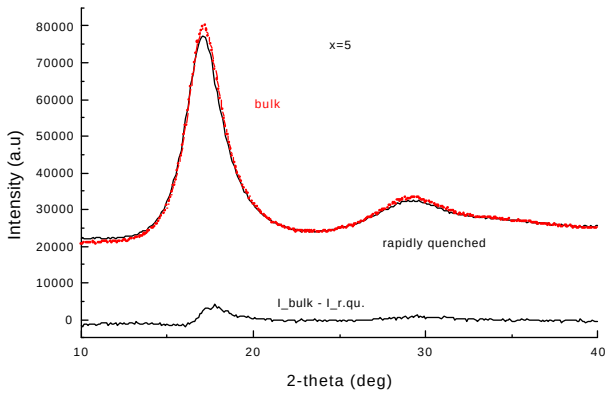

Fig. 1: Comparison of diffraction patterns of amorphous $Zr_{57}Ti_5Cu_{20}Al_{10}Ni_8$

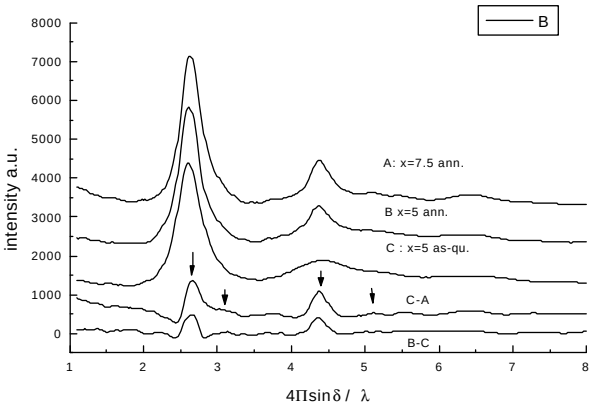

Fig. 2 : Diffraction patterns of as-quenched and annealed states $Zr_{62-x}Ti_xCu_{20}Al_{10}Ni_8$

conventional X-ray diffraction measurements [1]. Fig. 2 shows the obtained diffraction patterns for the alloys with 5at% and 7.5at% Ti in the as-quenched state as well as after annealing above the first crystallization peak in DSC. The XRD of the annealed states are characterized by an increase of the intensities of the first and the second maximum but strongly broadened. The formation of an ultrafine nanostructured state 2-3 nm in size can be concluded from the diffraction curves for Ti content ≥5 at.%. There are only small differences between 5at% Ti and 7.5at%Ti content. The calculated difference curves between the annealed state and the as-quenched state, also shown in Fig. 2, indicate clearly that the structure of the nanophase is different from the quasicrystalline state obtained for 3at% Ti. The position of maxima in the difference curve are in agreement with a fcc structure. The diffraction curves point to still existing amorphous phase. Further experiments including Transmission Electron Microscopy and Neutron Small Angle Scattering work and are in preparation to get additional informations on the microstructure of the annealed samples.

[1] L.Q.Xing, J.Eckert, W. Löser, L.Schultz: High-strength materials produced by precipitation of icosahedral quasicrystals in bulk Zr-Ti-Cu-Ni-Al amorphous alloys, Appl.Phys.Lett. Vol.74, No. 5,(1999) 664-666