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Structure and Dynamics in Bulk Metallic Glass forming liquids with minor additions

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Enhancing the glass-forming ability of alloys via the minor addition of specific elements is a technique currently at the forefront of BMG design. The addition of only 4 at.% Al or Ti to binary Zr50Cu50 increases its critical casting thickness from 2 mm to at least 5 mm. However, the physical picture of how minor additions improve the glass-forming ability of alloys is still largely incomplete. Using in-situ synchrotron X-ray diffraction and quasi-elastic neutron scattering (QENS), we investigate the interplay between melt structure and mass transport quantities like viscosity and self-diffusion, as well as the solidification behavior of the (Zr50Cu50)96(Ti,Al)4 alloys. Combined with electrostatic levitation (ESL), we are able to measure the liquid properties of these chemically reactive alloys over a large temperature range. At the liquidus temperature of Zr50Cu50, the self-diffusivity in the investigated (Zr50Cu50)96Al4 and (Zr50Cu50)96Ti4 alloys is almost a factor of two lower than in Zr50Cu50. For the (Zr50Cu50)96Al4 alloy, this is in line with the observation that minor Al addition leads to higher melt viscosities. However, despite the different microscopic dynamics, the average packing fractions of Zr50Cu50 and (Zr50Cu50)96(Ti,Al)4 melts are very similar. Hence, contributions from chemical short range order are expected to play an important role in the melt. The ternary alloys also exhibit different crystallization behavior compared to that of Zr50Cu50, which vary with overheating temperature and cooling rate. Both the sluggish dynamics and the complex solidification could contribute considerably to the improved glass-forming ability upon minor addition.

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