

Effect of clusterization and disorder-order transition in undercooled liquid on kinetics of solidification of glass forming melts

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Experimental and theoretical results obtained in the MULTIPHAS-project (ESA-European Space Agency and DLR-German Aerospace Center) are critically discussed regarding solidification kinetics of congruently melting and glass forming Cu50Zr50 alloy samples. The samples are investigated during solidification using a containerless technique in the Electromagnetic Levitation Facility [1]. Applying elaborated methodologies for ground-based and microgravity experimental investigations, the kinetics of primary dendritic solidification is quantitatively evaluated [2]. Electromagnetic Levitator in microgravity (parabolic flights and on board of the International Space Station) and Electrostatic Levitator on Ground are employed. The solidification kinetics is determined using a high-speed camera and applying two evaluation methods: Frame by Frame (FFM) and First Frame Last Frame (FLM). In the theoretical interpretation of the solidification experiments, special attention is given to the behavior of the cluster structure in Cu50Zr50 samples with the increase of undercooling. A disorder-order transition in the cluster structure of undercooled melts allows us to explain viscosity behaviour and solidification kinetics in glass forming Cu50Zr50 alloy samples. Cluster structures in Cu50Zr50 melt obtained via molecular dynamics simulations and Voronoi tessellation analysis [3] provide basis for the current mesoscopic model for disorder-order transition in the undercooled melt. Particularly, we describe formation of the net of connected and penetrated clusters consisting of growing chains from the single atoms and clusters. Using the developing mesoscopic model, we interpret its predictions as a fragility crossover which characterizes structural changes in the undercooled liquids. These structural changes proceed in the form of transition from strong liquid, which has single atoms and unconnected clusters, to the fragile liquid, which is mainly consist from the net of connected and penetrated clusters.

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