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Crystal structure dependent solidification of undercooled glass-forming melts

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Solidification from undercooled melts, either crystallisation or glass formation, is an important physical phenomenon of great technical and academic interests. Properties of the solid materials depend crucially on the solidification conditions. The competition between crystallisation and glass formation determines the stability of the undercooled melt and its glass forming ability.

We investigate solidification behaviour of the congruent melting, glass-forming intermetallic melt $\text{Zr}_{50}\text{Ni}_{50}$. Employing electrostatic levitation (ESL) and high-speed video diagnostics, crystal growth velocity from the undercooled melt has been measured up to an undercooling of 300 K. Two distinct solidification behaviours of the $\text{Zr}_{50}\text{Ni}_{50}$ melt have been identified, which differ in their recalescence temperature profile, growth velocity as a function of undercooling, and the resulting microstructure. With the help of in-situ synchrotron diffraction combined with ESL, we were able to associate the different solidification behaviours to two different phases nucleated from the undercooled melt: the stable orthorhombic ZrNi phase and the metastable cubic B2 phase. Both the stable and metastable phases occur statistically, independent of the degree of undercooling, and no difference in the liquid short range order can be detected intimately prior to solidification. We show that the slower growth of cubic phases might be a general feature in these Zr-based alloy melts, which could be one of the origins of their glass forming ability.

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