Specific Heat Capacity in the Liquid Phase of Metallic Alloys Measured by Non-Contact Calorimetry in a Containerless Electromagnetic Processing Device on Board the International Space Station

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The specific heat capacity of a metallic alloy in the liquid phase is an important thermophysical property. Among other properties it is required for the modelling of heat transport and solidification in industrial melt processing. It is also relevant for the modelling of undercooling and nucleation, for the evaluation of the thermodynamic functions in the undercooled liquid phase and for bulk metallic glass forming alloys for an evaluation of the thermodynamic contribution to the glass forming ability. Moreover, at high undercooling the temperature dependence of the specific heat capacity, similar to that of the viscosity, reflects the rate of change of the entropy on approaching the glass transition. In general, structural changes in the liquid phase will also be reflected in the temperature dependence of the specific heat capacity.

For many metallic alloys, however, the measurement of the specific heat capacity in the liquid phase is complicated by the often quite high chemical reactivity. Moreover, investigations of the undercooled liquid phase require the absence of container walls to avoid heterogeneous nucleation. Containerless processing in an electromagnetic levitation device (eml) under reduced gravity conditions was applied in a series of investigations on board the International Space Station for the measurement of the specific heat capacity of metallic alloys in the liquid phase. The method is based on modulated induction heating and the measurement of the temperature response. Quantification requires proper calibration of the modulated em-hating power input. Basic elements of the method will be described such as the choice of proper modulation frequencies, calibration and processing. The application of the method will be demonstrated with the multicomponent Zr-based bulk metallic glass forming alloy VIT106a and the industrial alloy Ti-48Al-2Cr-2Nb (GE 48-2-2). In VIT106a a maximum of the specific heat capacity in the liquid phase close to the liquidus temperature was observed. To our current understanding this maximum reflects a change in the structure of the liquid phase which has also been detected by scattering experiments. The GE 48-2-2 alloy exhibited an unexpected stability in the undercooled liquid phase allowing the measurement of the specific heat capacity in the undercooled and stable liquid phase over an unprecedented temperature range.