IAF MICROGRAVITY SCIENCES AND PROCESSES SYMPOSIUM (A2)
Life and Microgravity Sciences on board ISS and beyond (Part I) (6)

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THERMOPHYSICAL PROPERTIES OF METALLIC ALLOYS IN THE LIQUID PHASE: RECENT RESULTS OF CONTAINERLESS ELECTROMAGNETIC PROCESSING ON THE INTERNATIONAL SPACE STATION ISS

Abstract

The thermophysical properties of metallic alloys in the liquid phase are an important contributing factor for the development of new or the advancement of existing functional and structural alloys. Such values are needed for further improvement and simulations of casting techniques for advanced materials but also to further our understanding of basic properties of the liquid phase. Many advances in current alloy development are concerned with high temperature materials and – or with materials which exhibit a high chemical or solution reactivity in the liquid phase. This makes the development of casting technologies a considerable challenge and renders classical thermoanalytic methods fraught with error or impossible. The key objective of the *Thermoprop* and *ThermoLab* projects is to use containerless processing conditions in an electromagnetic levitation device and the microgravity environment afforded by the International Space Station ISS for the non-contact measurement of thermophysical properties in the liquid phase. With the installation of the Materials Science Laboratory – Electromagnetic Levitator (MSL-EML) on ISS in 2015 such measurements have become possible.

The device was operated successfully for about two years and a series of alloys was processed in the liquid phase including industrial Ni-based superalloys, Fe- and Ti-alloys, as well as Zr-based bulk metallic glass forming alloys. Using sophisticated methods of initiating and analyzing temperature oscillations and liquid surface oscillations and their decay thermophysical properties investigated included the specific heat capacity, the surface tension and viscosity and others in the stable liquid and undercooled metastable liquid states. Entire sets of high precision data of thermophysical properties in the liquid and undercooled liquid regime have thus been obtained over extended periods of time using the MRL-EML device on the International Space Station ISS. In particular, we report on the specific heat capacity in the liquid phase of a Zr-based bulk metallic glass forming alloy which showed new and unexpected results. For this sample crystallization could be completely prevented and as a result a glassy sphere of 7 mm diameter was obtained – the first amorphous metallic pearl fabricated in space.

The experiments were performed within the framework of the ThermoLab project representing a truly international cooperation supported by ESA, NASA, DLR, CNES, SSO and JAXA.