MICROGRAVITY SCIENCES AND PROCESSES (A2)
Science Results from Ground Based Research (4)

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NON-EQUILIBRIUM SOLIDIFICATION, MODELLING FOR MICROSTRUCTURE ENGINEERING OF INDUSTRIAL ALLOYS (NEQUISOL)

Abstract

Within NEQUISOL project, it is envisaged to investigate crystallization kinetics and microstructure evolution in undercooled melts of Al-based alloys. Different techniques are applied for containerless processing of the different alloys. Dendrite growth dynamics and microstructure evolution in deeply undercooled melts is investigated on drops in size of 6-7 mm undercooled by Electro-Magnetic Levitation. The speed of the rapidly propagating solidification front is monitored by means of a high speed camera of maximum frequency of 120 000 pictures per second. Under Earth conditions strong alternating electromagnetic fields are needed to compensate the gravitational force. This, in turn, causes strong stirring effects due to forced convection. Therefore, equivalent experiments are conducted in reduced gravity using the TEMPUS facility during parabolic flight and during TEXUS sounding rocket missions. Experiments on four selected alloys, Al40Ni60, Al70Ni30, Al65Ni35 and Al89Cu11 are in preparation to be conducted on board the ISS using the Electro-Magnetic Levitator currently under development by DLR/ESA. In addition our partner of the University of Alberta operates an Impulse Atomization Facility that combines containerless processing with large cooling rates and reduced gravity on Earth of bulk material of several kilograms in mass. Atomization is an industrial processing route to produce metastable materials in large amount. We present a comparison of first experiments conducted in reduced gravity (parabolic flight, TEXUS) and reference experiments on Earth of measurements of the growth velocity as a function of undercooling of congruently melting Al50Ni50 alloy and the Raney type alloy Al68.5Ni31.5. The latter one is of special interest for industry. The experiments clearly demonstrate how important convection is in heat and mass transport process which control dendrite growth dynamics and, hence, microstructure evolution. A sharp interface theory is presented that takes into account heat and mass transport by forced convection. This mesoscopic model is able to predict the dendrite growth kinetics obtained both

on Earth as well as in reduced gravity. In completion, mesoscopic modelling is combined with macroscopic modelling to describe the entire solidification process beginning with non-equilibrium solidification during recalescence and near-equilibrium solidification during post-recalescence period.

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