【Grant-in-Aid for Scientific Research(S)】

Science and Engineering (Engineering Ⅱ)

Title of Project : Development of microalloying science and solidification dynamics on the basis of microstructure evolution

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Research Area : Engineering, Material engineering, Metal making engineering
Keyword : Melting / Solidification

【Purpose and Background of the Research】

In solidification processes of metallic alloys, interactions between micro-dynamics (development of dendrites) and macro-dynamics (melt flow and deformation of semisolid) causes various phenomena leading to solidification defects. However, the interaction has not been quantitatively understood due to difficulty of observation. In addition, the scientific strategy of "microalloying (the addition of trace element with < several 100ppm)", which is effective for controlling solidification structure and avoiding defects, is not available so far.

In this research project, dendritic growth, solidification and semisolid deformation are observed in-situ. A micro / macro solidification model for understanding deformation and segregation is developed on the basis of the observation. Fundamentals of microalloying will be also developed for active microstructure control.

【Research Methods】

In-situ observation using synchrotron radiation (SR) X-ray is used to observe solidification of Sn, Al, Cu, Ni and Fe alloys. As shown in Fig. 1, the observation allows fragmentation to be understood qualitatively. Micro X-ray fluorescence analysis (μ-XRF) in SR facilities shows the distribution of trace elements in the microstructure. As shown in Fig.2, Sr, which reduces eutectic Si size, strongly segregates in the Si phase of Al-Si alloys. The distribution gives exclusive information for knowing the role of trace elements on refinement.

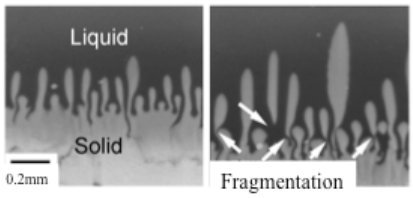

Fig.1 Fragmentation of dendrite arms in Sn alloy (X-ray imaging)

In this project, solidification phenomena (dendritic growth, transformation, deformation and so on) are observed *in-situ* by the developed technique to obtain evidence-based data. Numerical calculations using phase field models and lattice statics are also carried out to verify the observations. On the basis of the observations and calculations, a micro / macro-dynamics model will be developed to understand and to predict the segregation and deformation.

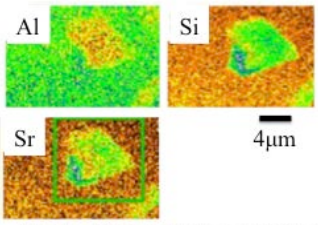

Fig.2 μ-XRF mapping of Al-Si-Sr

【Expected Research Achievements and Scientific Significance】

The micro / macro solidification model that abstracts the micro-dynamics will be used to predict solidification defects in solidification processes. The scientific strategy of microalloying will contribute to microstructure control in various alloy systems. The two approaches is expected to improve solidification processes / casting.

【Publications Relevant to the Project】

- H. Yasuda, I. Ohnaka, A. Sugiyama, et al, "Direct observation of Stray Crystal Formation in Unidirectional Solidification of Sn-Bi Alloy by X-ray Imaging", *J. Cryst. Growth*, **262** (2004) 645.
- H. Yasuda, T. Nagira, M. Yoshiya, A. Sugiyama, et al, "Development of X-ray Imaging for Observing Solidification of Carbon Steels", *ISIJ Int.*, **51** (2011) 402-408.
- T. Nagira, C.M. Gourlay, A. Sugiyama, M. Yoshiya, H. Yasuda, et al, "Direct Observation of Deformation in Semi-Solid Carbon Steel", *Scr. Mater.*, **64** (2011) 1129..

【Term of Project】 FY2012-2016

【Budget Allocation】 104,400 Thousand Yen

【Homepage Address and Other Contact Information】

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