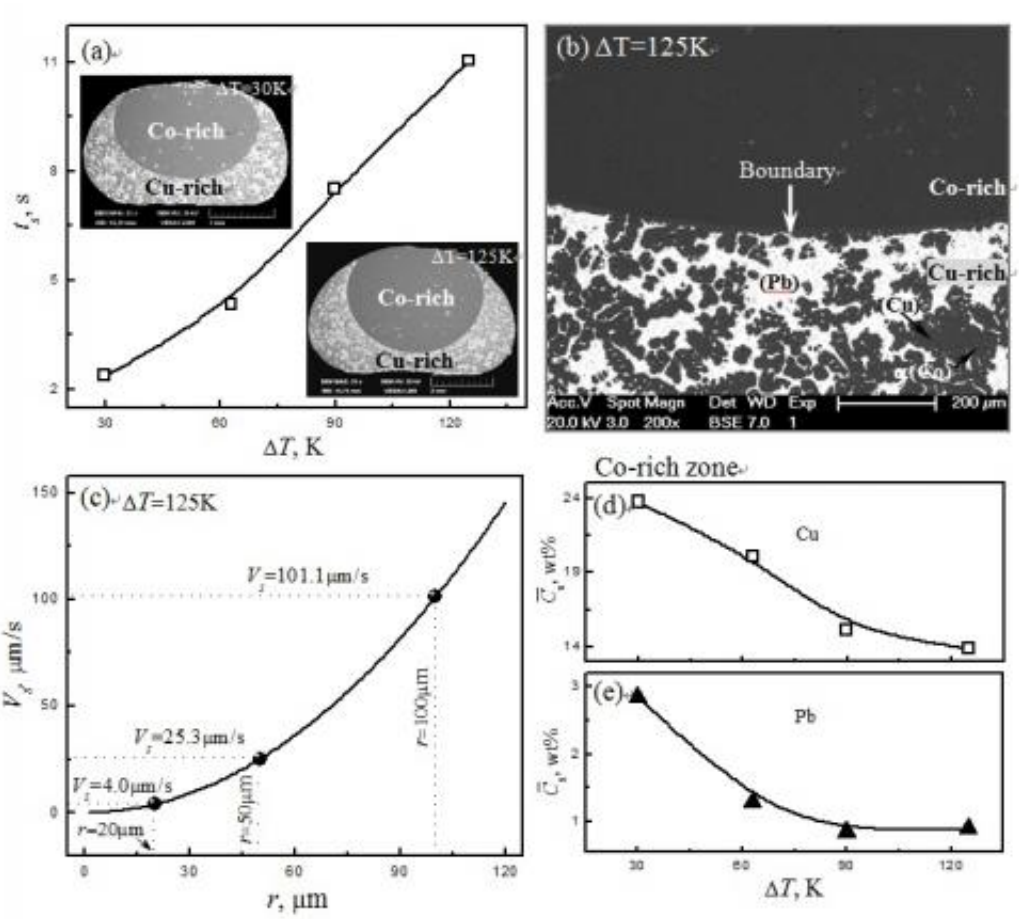
Solute redistribution profiles during rapid solidification of undercooled ternary Co-Cu-Pb alloy

April 10 2014



Macrosegregation forms during phase separation period and phase separation time increases with the increase of melt undercooling (a). It always takes place regardless of undercooling on the Earth's ground. The phase with larger density, such as Cu-rich phase settles down to the bottom (b) due to Stokes motion. The Stokes motion velocity increases with the increase of droplet radius (c). The

solute contents in Co-rich zone decrease with the enhancement of melt undercooling (d) and (e). Credit: Science China Press

Researchers at the Department of Applied Physics, Northwestern Polytechnical University, in Xi'an, China, are engaged in revealing the mysteries of solidification process and the development of new materials using self-designed experimental instrument which can simulate the space environment such as containerless state. Solidification mechanism is of great importance to better understand the relationship between solidification process and microstructure evolution, so that we can follow them to design and prepare new materials which can meet the application requirements.

Dr. Yan and coworkers recently used the glass-fluxing method to realize the containerless processing and investigate the solidification mechanism of ternary Co-Cu-Pb immiscible alloys. This study was published in *SCIENCE CHINA Physics, Mechanics & Astronomy*.

Immiscible alloys possess good properties such as lubrication in bearing materials. It is a promising option for applications in reducing the friction of mechanical transmission part. It is also important for designers to have some basic knowledge of how Co-Cu-Pb alloy solidifies under different conditions, because its mechanical performance is usually controlled by solidification mechanism and microstructural characteristics. However, so far there has been little research on its rapid solidification mechanism under the extremely nonequilibrium condition.

In this work, Co-35%Cu-32.5%Pb immiscible alloy was undercooled by 125 K. Because of the evaporation of Pb element and metestable phase separation, such alloy melt is difficult to obtain high undercoolings.

Here, they used a special denucleating agent, a high-vacuum environment and a periodic melting processing. In addition, the experimental parameters, such as cooling rate, superheating, and holding time, were controlled in order to get a wider undercooling range for comparison.

Metastable phase separation happens in the undercooled Co-35%Cu-32.5%Pb alloy melt and the macrosegregation pattern is characterized by a top Co-rich zone and a bottom Cu-rich zone. The average solute contents of the two separated zones decrease with the increase of undercooling, except for the solute Pb in Cu-rich zone. With the enhancement of undercooling, a morphological transition from dendrites into equaxied grains occurs to the primary α(Co) phase in Co-rich zone. The solute redistribution of Cu in primary α(Co) phase is found to depend upon both the undercooling and composition of Co-rich zone. Stokes migration is proved to be the main dynamic mechanism of droplet movement during liquid phase separation.

Two other relevant papers about the phase separation and containerless solidification of ternary Co-Cu-Pb alloys have been published in J. Alloys Comp. and Appl. Phys. A. "The present work reports interesting experimental results of phase separation in metastable monotectic ternary Co-Cu-Pb alloys." said one journal reviewer. "It is an interesting study. The authors develop a phenomenological concept how phase separation takes place in ternary Co-Cu-Pb alloy system." said another reviewer.

More information: N. Yan, W. L. Wang, Z. C. Xia, B. Wei, "Solute redistribution profiles during rapid solidification of undercooled ternary Co-Cu-Pb alloy", Science China Physics, Mechanics & Astronomy 2014; 57 (3): 393-399. link.springer.com/article/10.1 … 07/s11433-013-5389-6

N. Yan, W. L. Wang, S.B. Luo, L. Hu, B. Wei, "Correlated Process of Phase Separation and Microstructure Evolution of Ternary Co-Cu-Pb Alloy" Applied Physics A, 113 (2013) 763-770.
link.springer.com/article/10.1 … 07/s00339-013-7586-6

N. Yan, W. L. Wang, B. Wei, "Complex Phase Separation of Ternary Co-Cu-Pb Alloy Under Containerless Processing Condition", Journal of Alloys and Compounds, 558 (2013) 109-116.
www.sciencedirect.com/science/ … ii/S092583881300056X

Provided by Science China Press