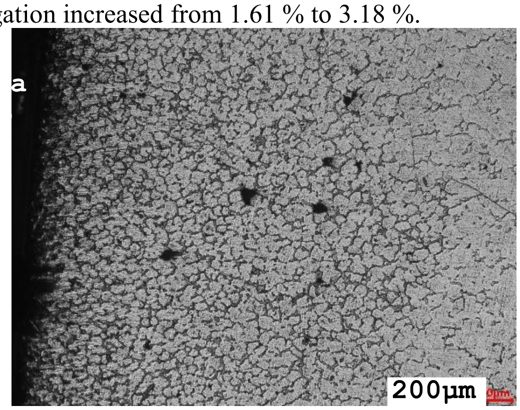
Effect of Directional Solidification on the Thermal and Mechanical Properties of Al-Cu Alloy

Xu Liu, Wentao Jiang, Hongyu Xu, Bo Jiang, Ye Wang*, MaoliangHu, Bo Yu
School of Materials Science and Chemical Engineering, Harbin University of Science and Technology, Harbin 150040, Heilongjiang, China
* Corresponding authors: ohenry1980@163.com (Y Wang)

Abstract: With the increasingly serious global resource and environmental problems and the continuous growth of energy-saving demand, the heat dissipation performance, mechanical properties and lightweight degree of thermal conductive materials directly determine the integration degree and working stability of devices. Aluminum alloy not only has ideal thermal conductivity and mechanical properties, but also has low density. This paper focuses on the influence of directional solidification on the microstructure and thermal conductivity of ZL205 A alloy.

By studying the effect of directional solidification on the microstructure and phase composition of ZL205A alloy, the results show that the phase composition of ZL205A alloy does not change significantly under normal pressure, and the microstructure is still a typical divorced eutectic of α-Al phase + θ-Al_2Cu phase. After the lateral heat preservation measures are applied, the lateral heat dissipation is inhibited. Due to the inhibition of the nucleation of the grains in the direction perpendicular to the directional solidification direction, the size of the α-Al matrix phase increases, the chilling zone becomes narrower and the columnar crystal zone is wider.

By testing the mechanical properties of the alloy under different directional solidification conditions, the results show that the Vickers hardness of the directional solidified ZL205 A alloy increases from 62.66 HV under conventional solidification to 105.62 HV and 127.94 HV under directional solidification without heat preservation measures because of grain refinement, and the performance improvement is very obvious. Similarly, the tensile strength increased from 92.64 MPa to 154.05 MPa, and the elongation increased from 1.61 % to 3.18 %.



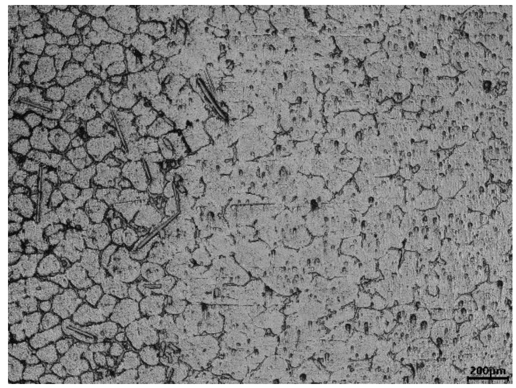


Figure 1 Microstructure of ZL205A alloy along the direction of directional solidification under directional solidification conditions (a) without asbestos (d) with asbestos

Table 1 Test results of physical parameters of ZL205A alloy under different solidification conditions at room temperature

Simples	specific heat J/(g·K)	density g/mm^3	thermal diffusion mm^2/s	heat conductivity W/(m·K)
Conventional solidification	0.896	2.60	36.898	85.958
Uninsulated horizontal direction	0.896	2.60	37.575	95.605
Uninsulated vertical direction	0.896	2.60	39.044	107.005
Insulated horizontal direction	0.896	2.60	38.581	89.904
Insulated vertical direction	0.896	2.60	37.223	89.264

By testing the thermal conductivity of the alloy under different directional solidification conditions, the results show that the average free path of electrons can be effectively improved due to the rapid transport of electrons along the directional growth of columnar crystals formed in the alloy structure, which is no longer affected by the scattering of the original network-like distribution of the θ-Al2Cu phase. The thermal conductivity of the sample obtained by directional solidification without lateral insulation is 107.005 W/(m·K), which is 24.5 % higher

than that of the conventional solidified sample.

Keywords: ZL205A alloy, Directional solidification, Microstructure, Mechanical Properties, Thermal conductivity