

研究论文

磁场作用下偏晶合金凝固组织演变的数值分析

康智强, 王恩刚, 张林, 赫冀成

东北大学材料电磁过程研究教育部重点实验室 沈阳 110819

摘要: 建立偏晶合金难混溶区凝固过程的两相数学模型, 模拟研究了有、无磁场Al-10%Bi过偏晶合金微观组织演变, 研究了温度、速度、第二相体积分等物性参数对凝固组织宏观偏析的影响。结果表明, 在磁场作用下温度场为中心对称分布, 更有利于第二相液滴的均匀分布; 电磁力抵消了部分重力和Marangoni力, 使无磁场时外环流的速度场变为有磁场时斜向下的速度场, 且速度明显降低, 从而减轻了强对流导致的重力偏析; 在磁场的作用下, 试样底部第二相的体积分减小, 凝固组织宏观偏析得到改善。

关键词: 金属材料 磁场 数值模拟 微观组织演变 偏晶合金 宏观偏析

Numerical Analysis of the Microstructure Evolution of Monotectic Alloys in Magnetic Field

KANG Zhiqiang, WANG Engang, ZHANG Lin, HE Jicheng

Key Laboratory of Electromagnetic Processing of Materials, Ministry of Education, Northeastern University, Shenyang 110819

Abstract: A two-phase mathematical model for the solidification process of monotectic alloys through the miscibility gap was established. The effect of magnetic field on the microstructural evolutions of an Al-10%Bi hypermonotectic alloy was investigated, and the effect of temperature, velocity and second phase volume fraction distribution on the macrosegregation were analyzed. The results showed that the centrosymmetric distribution of temperature field in the magnetic field was more advantageous to the uniform distribution of second phase droplets. Because partial gravity force and Marangoni force were counteracted by the Lorentz force, the velocity field changed from the outward circumfluence to the moving downward slope form in the magnetic field, and the velocity reduced obviously, thus the gravity segregation caused by strong convection was suppressed. Second phase volume fraction reduced in the specimen bottom in the magnetic field, and the macrosegregation was improved.

Keywords: metallic materials magnetic field numerical simulation microstructural evolution monotectic alloy macrosegregation

收稿日期 2010-08-30 修回日期 2010-12-03 网络版发布日期 2011-04-18

DOI:

基金项目:

国家高技术研究发展计划2007AA03Z519, 国家自然科学基金项目50574027和50901019, 高等学校博士学科点专项科研基金20070145062, 以及高等学校学科创新引智计划B07015资助项目。

通讯作者: 王恩刚

作者简介:

通讯作者E-mail: egwang@mail.neu.edu.cn

扩展功能

本文信息

- Supporting info
- PDF(956KB)
- [HTML] 下载
- 参考文献[PDF]
- 参考文献

服务与反馈

- 把本文推荐给朋友
- 加入我的书架
- 加入引用管理器
- 引用本文
- Email Alert
- 文章反馈
- 浏览反馈信息

本文关键词相关文章

- 金属材料
- 磁场
- 数值模拟
- 微观组织演变
- 偏晶合金
- 宏观偏析



本文作者相关文章

- 康智强
- 王恩刚

PubMed

- Article by Kang,Z.J
- Article by Yu,E.G

参考文献:

- [1] B.Prinz, A.Romero, L.Ratke, Casting process for hypermonotectic alloys under terrestrial conditions, *J. Mater. Sci.*, 30(18), 4715(1995)
- [2] J.He, J.Z.Zhao, H.L.Li, X.F.Zhang, Q.X.Zhang, Directional solidification and microstructural refinement of immiscible alloys, *Metall. Mater. Trans. A*, 39A(5), 1174 (2008)
- [3] S.Yang, W.J.Liu, Effects of transverse magnetic field during directional solidification of monotectic Al-6.5wt%Bi alloy, *J. Mater. Sci.*, 36, 5351(2001) 
- [4] H.Yasuda, I.Ohnaka, O.Kawakami, K.Ueno, K.Kishio, Effect of magnetic field on solidification in Cu-Pb monotectic alloys, *ISIJ Int.*, 43(6), 942(2003)
- [5] H.Yasuda, I.Ohnaka, S.Fujimoto, N.Takezawa, A.Tsuchiyama, T.Nakano, K.Uesugi, Fabrication of aligned pores in aluminum by electrochemical dissolution of monotectic alloys solidified under a magnetic field, *Scripta Mater.*, 54(4), 527(2006)
- [6] H.L.Li, J.Z.Zhao, Directional solidification of an Al-Pb alloy in a static magnetic field, *Comput.n Mater.n Sci.n*, 46(4), 1069(2009)
- [7] P.Th´evoz, J.nL.Desbiolles, M.nRappaz, Modeling of equiaxed microstructure formation in casting, *Metall. Mater. Trans. A*, 20A(2), 311(1989)
- [8] WANG Tongmin, YAO Shan, ZhANG Xingguo, JIN Junze, M.Wu, A.Ludwig, B.Pustal, A.B ´uhrig-Polaczek, Modelling of the thermo-solutal convection, shrinkage flow and grain movement during globular equiaxed solidification in a multi-phase system I. Three-phase flow model, *Acta Metallurgica Sinica*, 42(6), 584(2006)
- [9] 王同敏, 姚山, 张兴国, 金俊泽, M.Wu, A.Ludwig, B.Pustal, A.Buhrig--Polaczek, 等轴球晶凝固多相体系内热溶质对流、补缩流及晶粒运动的数值模拟I.三相流模型, *金属学报*, 42(6), 584(2006))9
L.Ratke, S.Diefenbach, Liquid immiscible alloys, *Mater. Sci. Eng., R*, 15(7-8), 263(1995)
- [10] M.H.Wu, A.Ludwig, A three-phase model for mixed columnar-equiaxed solidification, *Metall. Mater. Trans. A*, 37A(5), 1613(2006)
- [11] J.Z.Zhao, S.Drees, L.Ratke, Strip casting of Al-Pb alloys-a numerical analysis, *Mater. Sci. Eng., A*, 282(1-2), 262(2000)
- [12] G.Kaptay, On the temperature gradient induced interfacial gradient force, acting on precipitated liquid droplets in monotectic liquid alloys, *Mater. Sci. Forum*, 508, 269 (2006) 
- [13] G.Phanikumar, P.Dutta, R.Galun, K.Chattopadhyay, Microstructural evolution during remelting of laser surface alloyed hyper-monotectic Al-Bi alloy, *Mater. Sci. Eng., A*, 371 (1-2), 91(2004)
- [14] L.Ratke, G.Korekt, S.Drees, Phase separation and solidification of immiscible metallic alloys under low gravity, *Adv. Space Res.*, 22(8), 1227(1998)
- [15] H.L.Li, J.Z.Zhao, Q.X.Zhang, J.He, Microstructure formation in a directionally solidified immiscible alloy, *Metall. Mater. Trans. A*, 39A(13), 3308(2008)

本刊中的类似文章

1. 秦小梅 陈礼清 邓伟 邸洪双.应变速率对TWIP钢Fe-23Mn-2Al-0.2C力学性能的影响[J]. 材料研究学报, 2011,25(3): 278-282
2. 黄始全 易幼平 李蓬川.23Co13Ni11Cr3Mo超高强度钢的高温变形行为[J]. 材料研究学报, 2011,25(3): 283-288
3. 吕滨 孙旭东 孙挺 王毅.用微波均相沉淀法合成Sc₂O₃纳米粉[J]. 材料研究学报, 2011,25(3): 255-258
4. 张妍 周科朝 张晓泳 张斗.用冰模板法制备羟基磷灰石多孔陶瓷[J]. 材料研究学报, 2011,25(3): 289-294
5. 刘立恒 辜敏 鲜学福 喻江涛.粘结剂对颗粒活性炭PSA分离CH₄/N₂性能的影响[J]. 材料研究学报, 2011,25(3): 249-254
6. 周红伟 何宜柱 张文学 蒋建清.Ti600钛合金的氧化行为[J]. 材料研究学报, 2011,25(3): 295-302
7. 魏榕山 丁晓琴 何明华.快速热退火对多层Ge量子点晶体质量的影响[J]. 材料研究学报, 2011,25(3): 259-

8. 曹政 蒋百灵 鲁媛媛 王涛. 磁场非平衡度对CrNx镀层性能的影响[J]. 材料研究学报, 2011,25(3): 313-320
 9. 陈文国 代建清 丁耀民 夏井兵. 热处理对Ba₂Co_{0.6}Zn_{1.0}Cu_{0.4}Fe₁₂O₂₂(Co₂Y)铁氧体磁性能的影响[J]. 材料研究学报, 2011,25(3): 308-312
 10. 陈俊 周国平 刘振宇 邱以清 王国栋. 退火时间对0.15%P铸轧耐候钢冷轧薄带组织性能的影响[J]. 材料研究学报, 2011,25(3): 268-272
-