金属学报 2010, 46(01) 77-83 DOI: ISSN: 0412-1961 CN: 21-1139/TG

论文

一种镍基单晶高温合金的高温度梯度定向凝固组织及枝晶偏析

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摘要:

采用双区加热和液态金属冷却法 (LMC) 相结合, 对一种含4%Re (质量分数) 的镍基单晶高温合金进行了高温度梯度定向凝固. 结果表明: 与传统的“ 高速凝固法 (HRS) ”(温度梯度G=20-40 K/cm, 抽拉速率V=50-100 μm/s, 一次枝晶间距 λ_1=200-400 μm)相比, 该技术可以显著提高凝固界面前沿的温度梯度 (G=238 K/cm) 和抽拉速率 (V=500 μm/s). 随着抽拉速率的提高, 凝固界面形态呈现出平面、胞状、粗大枝晶和细枝晶形态, 一次枝晶间距不断减小, 通过固态相变析出的γ'强化相也被显著细化, 当G=238 K/cm, V=500 μm/s时, λ_1和枝晶干γ'相平均尺寸分别减小到61.3和0.04 μm. 电子探针测定表明, 随着抽拉速率的提高, 枝晶偏析呈现先增大后减小的趋势. 这是高温度梯度条件下, 固相反扩散作用强烈影响元素在枝晶中分布的结果.

关键词: 镍基单晶高温合金 高温度梯度 枝晶偏析 微观组织

MICROSTRUCTURE AND MICROSEGREGATION IN A Ni-BASED SINGLE CRYSTAL SUPERALLOY DIRECTIONALLY SOLIDIFIED UNDER HIGH THERMAL GRADIENT

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Abstract:

In order to understand the effect of high thermal gradient on the microsegregation of refractory elements in Ni-based superalloys, a Ni-based single crystal superalloy containing 4% Re (mass fraction) was prepared by dual heating zone melting and liquid-metal cooling (LMC) directional solidification technique. Comparing with the traditional high rate solidification (HRS) method with thermal gradient G=20-40 K/cm, withdrawal rate V=50-100 μm/s and primary dendritic arm spacing λ_1=200-400 μm, this technique can significantly increase the thermal gradient (up to 238 K/cm) and withdrawal rates (up to 500 μm/s). Planar-like and cellular-like solid-liquid interfaces, coarse dendrite and fine dendrite were sequentially obtained with increasing withdrawal rates. Under the condition of G=238 K/cm and V=500 μm/s, the primary dendritic arm spacing λ_1 and the mean size of γ' precipitates (in dendrite core) obviously decreased to 61.3 and 0.04 μm, respectively. In addition, the microsegregation increased initially and then decreased with increasing withdrawal rate, especially for the microsegregations of W and Re. EPMA line scan indicated that solid-back diffusion has an obvious influence on the microsegregation for the fine dendrite structure under high thermal gradient directional solidification.

Keywords: Ni-based single crystal superalloy high thermal gradient microsegregation microstructure

收稿日期 2009-06-23 修回日期 2009-09-30 网络版发布日期 2009-12-17

DOI:

基金项目:

国家自然科学基金项目 50771081和50827102以及国家高技术研究发展计划项目2007AA03Z552资助

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(张卫国, 刘林, 黄太文, 赵新宝, 余竹焕, 傅恒志. 金属学报, 2009; 45: 592)

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