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激光增材制造 FeCoCrNiAl 系高熵合金的组织及性能研究

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摘要:为了获得高致密无裂纹的含 Al 高熵合金，保证其兼具高强度高塑性的力学性能。我们在利用团簇模型解析传统奥氏体耐热合金的基础上，采用高熵合金化策略，设计了系列[(Al，Nb)-(FeCoNi)$_{12}$]Cr$_3$ 高熵合金成分，并运用激光增材制造技术制备出薄壁状合金块体。实验结果表明，高熵合金沿建筑方向呈多道熔池，FeCoCrNiAl 系合金微观组织为树枝晶，随着 Nb 的加入，合金的热裂纹得已消除并且平均晶粒尺寸明显减小，枝晶间 NbNi$_3$ 相的含量逐渐升高。此外，随着 Nb 含量的增加，平均显微硬度显著提高，合金的屈服强度和断后伸长率得到提升；其中，Al：Nb=2：4 时，该沉积态合金强度塑性达到最优，屈服强度为 419Mpa，断裂伸长率为 14.18%。对此合金进行 600℃时效热处理 4 小时后，析出较多的 NbNi$_3$ 相，强度和塑性持续上升。
关键词：激光增材制造；高熵合金化；热裂纹；力学性能

Abstract: In order to obtain high density and crack free Al alloy with high entropy, ensure its mechanical properties of high strength and plasticity. Based on the analysis of traditional austenitic heat resistant alloys by cluster model, we designed a series of high entropy alloy components of [(Al, Nb)-(FeCoNi)12]Cr3 by high entropy alloying strategy, and prepared thin-walled alloy blocks by laser additive manufacturing technology. The experimental results show that the high entropy alloy is a multi-channel molten pool along the building direction, and the microstructure of the FeCoCrNiAl alloy is dendritic. With the addition of Nb, the hot cracks are eliminated and the average grain size decreases obviously, and the content of NbNi3 phase gradually increases in the interdendritic. Therefore, with the increase of Nb content, the average microhardness increases, and the yield strength and elongation after fracture increases. When Al: Nb= 2:4, the strength plasticity of the deposited alloy reaches the optimum, the yield strength is 419 Mpa, and the elongation is 14.18%. After aging heat treatment at 600℃ for 4 h, more NbNi$_3$ phases were precipitated, and the strength and plasticity of the alloy continued to rise.
Keywords: Laser additive manufacturing ;High entropy alloying;Hot crack; Mechanical property.

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