2022 第十五届全国激光加工学术会议
15th National Conference on Laser Processing
2022年10月 | 武汉

丝-粉激光共沉积制备 SiC_p 铝基复合材料微观组织调控与力学性能研究

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丝粉激光共沉积技术(WPLD)是制备金属基复合材料(MMCs)的有效方法，本文采用 WPLD 制备 SiC_P 铝基复合材料(AMCs)。激光作用产生的高温使 SiC 与 Al 极易发生界面反应生成有害相，针对该问题本研究对 SiC 粉末进行合金化预处理，将 SiC 粉末与 Ti 粉混合。通过预制粉末对 AMCs 的组织进行调控，并系统的研究其微观组织结构演变及力学性能。结果表明，当添加未处理的 SiC 粉末，SiC 颗粒与铝基体在熔池中发生界面反应生成 Al_4C_3，Mg2Si 等化合物。层片状的 Al_4C_3 降低 AMCs 的力学性能。添加预处理 SiC 粉末后，有效的抑制 SiC 与 Al 的界面反应，制备了不含有害相的 SiC_p 铝基复合材料。通过 XRD、SEM、WDS、TEM 表征手段手段分析了 AMCs 的微观结构特征。研究发现，Ti 能优先与 SiC 溶解产生的 C 反应生成 TiC，且 SiC 表面会吸附铝熔体中的 Ti，在 SiC 表面生成 TiC 薄膜层，避免界面反应的持续进行，游离生成的纳米 TiC 颗粒能成为铝熔体的异质形核核心。引入钛元素合金化后，复合材料的平均抗拉强度提升了 20MPa，铝基体的弹性模量提高了 28.7GPa。该研究阐明 SiC 颗粒预处理对 WPLD 制备铝基复合材料的微观组织结构演变与力学性能的影响，为 WPLD 制备 SiC_p 铝基复合材料工业化提供理论指导。

Wire powder laser co-deposition (WPLD) is an effective method for preparing metal matrix composites (MMCs). This paper used WPLD to prepare SiC_p/Al matrix composites (AMCs). High temperature caused by laser radiation makes SiC and Al interfacial reactions very easy to form harmful phases. In this study, SiC powder was pretreated by mixing with Ti powder to control the microstructure of AMCs, and systematically study its microstructure evolution and mechanical properties. Results show that when untreated SiC powder was added, the SiC particles and the Al matrix in the melt pool reacted to generate compounds such as Al_4C_3 and Mg_2Si. The flaky Al_4C_3 reduced the mechanical properties of AMCs. However, after adding the pretreated SiC powder, the interface reaction between SiC and Al was effectively suppressed, and SiCp/Al composites without harmful phases were prepared. XRD, SEM, WDS, and TEM characterization methods analyzed the microstructure characteristics of AMCs. It was found that Ti could react with the C generated by the dissolution of SiC to form TiC. The SiC surface also absorbed Ti, and a TiC film layer was formed on the SiC surface, avoiding a continuous interface reaction. The free-generated nanoscale TiC particles could become heterogeneous nucleation cores in the Al melt. After introducing Ti alloying, the average tensile strength of the composite material was increased by 20 MPa, and 28.7 GPa increased the elastic modulus of the Al matrix. This study elucidates the effect of SiC particle pretreatment on the microstructural evolution and mechanical properties of aluminium matrix composites prepared by WPLD. It provides theoretical guidance for developing SiC_p/Al composites prepared by WPLD.

关键词：激光沉积；丝粉共送；SiC_p/Al复合材料；组织性能；

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