

镍钛合金丝的选区激光熔化制造及应用

侍秋禹^{1,2}, 张庆茂^{1,2,*}, 郭亮^{1,2}, 李嘉铭^{1,2}, 严淼宁^{1,2}

¹ 华南师范大学 广东省微纳光子功能材料与器件重点实验室, 广州, 510006

² 广州瑞通生物科技有限公司, 广州, 510470

*Email: zhangqm@scnu.edu.cn

镍钛合金具有超弹性、形状记忆效应、抗疲劳性和低弹性模量等特性, 随着各领域技术的高速发展, 各行各业对复杂形状的镍钛合金器件的需求日益渐增。但是由于镍钛记忆合金的特殊力学性能, 很难通过粉末冶金等传统加工方法直接获得完全致密、形状较复杂的镍钛合金, 导致其应用潜能受限。而选区激光熔化技术无需借助模具, 材料利用率高、尺寸精度高和成型速度快等优点, 结合热处理可以用于较复杂结构镍钛合金器件的成型, 具有广阔的应用前景。目前, 镍钛合金的激光选区熔化制造还处于研究阶段, 制造的镍钛合金和传统工艺制造的相比还有一定的差距, 存在力学性能较差、容易出现开裂及微裂纹等问题。同时, 国内外的研究极少聚焦于制造尺寸较小的镍钛合金。本研究通过对镍钛合金丝选区激光熔化制造的工艺参数——激光功率、激光扫描速度、激光扫描间距及热处理工艺进行优化, 成功制造了直径为毫米级的镍钛合金丝, 同时显著提高了镍钛合金丝的力学性能。同时, 本研究对工艺参数及镍钛合金相转变的影响进行后续分析, 确定不同参数条件下, 选区激光熔化产生的相及相转变温度的变化。在掌握镍钛合金丝选区激光熔化技术的基础上, 通过口腔镍钛矫治丝的实际应用, 初步验证了该技术的优越性及应用前景。

NiTi has the characteristics of superelasticity, shape memory effect, fatigue resistance and low elastic modulus. With the rapid development of technology in various fields, the demand for NiTi devices with complex shapes is increasing in all walks of life. Due to the special mechanical properties of NiTi memory alloys, it is difficult to directly obtain completely dense and complex NiTi by traditional processing methods such as powder metallurgy, which leads to limited application potential. The selective laser melting does not require the use of molds, and has the advantages of high material utilization, high dimensional accuracy and fast forming speed. Combined with heat treatment, it can be used for the forming of more complex structures of NiTi devices, and has broad application prospects. At present, the laser selective melting manufacturing of NiTi is still in the research stage, and the manufactured NiTi still has a certain gap compared with the traditional process, and there are problems such as poor mechanical properties, easy cracking and micro-cracks. Research at home and abroad seldom focuses on the manufacture of NiTi with smaller sizes. In this study, by optimizing the process parameters of selective laser melting of NiTi wire—laser power, laser scanning speed, laser scanning distance and heat treatment process, the NiTi wire with a diameter of millimeters was successfully produced, and the improvement of mechanical properties of NiTi wire was significantly improved. At the same time, this study carried out subsequent analysis on the influence of process parameters and phase transformation of NiTi, and determined the changes of phase and phase transformation temperature generated by selective laser melting under different parameters. On the basis of mastering the selective laser melting technology of NiTi wire, the superiority and application prospect of this technology were preliminarily verified through the practical application of oral nickel-titanium orthodontic wire.

关键词: 增材制造; 镍钛合金; 选区激光熔化; 金属丝

参考文献

[1] 夏岩, 聂真, 袁剑, 郭亮, 张庆茂. 选区激光熔化钴铬合金工艺与性能的研究, 应用激光. 2018, 38(06).