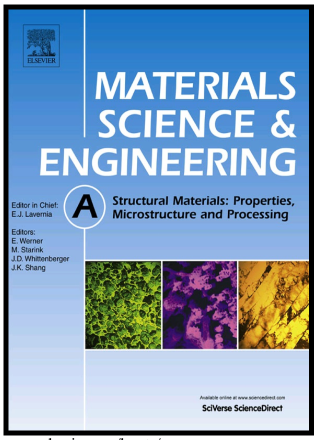

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Selective laser melting of pure tantalum: Densification, microstructure and mechanical behaviors

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Abstract

In this study, selective laser melting (SLM) of pure tantalum (Ta) was systematically investigated, with emphasis on densification, microstructure and mechanical properties of Ta specimen. The high scanning speed of laser resulted in micropores and discontinuous scan tracks, owing to the elevated instability of the liquid induced by Marangoni convection and the balling effect. However, the interlayer thermal microcracks were produced at a low scanning speed, due to the thermal stress and balling effect. The microhardness and tensile strengths of the optimally SLM-processed Ta parts were improved to 445 HV and 739 MPa, respectively, which were considerably higher than those of the specimens processed by cast (110 HV and 205 MPa) or powder metallurgy (120 HV and 310MPa) method, due to the fine-grain strengthening. The fracture morphology of the tensile-failed SLM-processed specimens showed that the porosities and incompletely melted particles are responsible for the fracture of porous sample. While for dense sample, cleavage fracture and minor ductile fracture both account for the fracture. And the failure mechanisms were discussed. The reduced coefficient of friction of 0.3 and lowest wear rate of 7.1×10^{-3} $mm^3\cdot N^{-1}\cdot m^{-1}$ in dry sliding wear tests were obtained for the optimally prepared Ta parts due to the formed adhesion of hardened tribolayers.

Key words: Pure tantalum; Selective laser melting; Microstructure; Mechanical properties

1. Introduction

Tantalum (Ta) is a promising material and has many applications in high-temperature and biomedicine fields because of the high melting point (2996 ºC), high corrosion resistance and good biocompatibility [1, 2]. Ta_2O_5 oxide layers are formed in the oxidizing atmosphere at high temperature, which can stay steadily over the whole pH range in the stability region of water, which is the reason why it has good corrosion resistance [3]. Tantalum is also used as a harder coating on titanium surface for orthopaedic implant applications [4] and used to protect steel and glass substances from wear and corrosion [5, 6]. Trabecular Metal (TM) (Zimmer, Warsaw, IN, USA) is one of the most well-known porous metal bone replacement structures, which is composed of highly porous carbon matrix coated with Ta [7-9]. As early as 1940, Ta had been successfully used in clinical applications as a biomaterial because of the excellent performances

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