Advanced Corrosion Studies of Laser-Powder Bed Processed 420 Stainless Steel

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ABSTRACT

The high corrosion resistance and excellent mechanical properties of AISI 420 stainless steel make the alloy an especially suitable material for fabrication of medical tools and devices. Furthermore, laser-powder bed fusion (L-PBF) facilitates fabrication of unique or specialized metal parts via additive manufacturing. However, little work has been reported on the corrosion properties of L-PBF 420 stainless steel. In this study, two electrochemical techniques are employed to evaluate the corrosion behavior of L-PBF specimens: Tafel curve 4-parameter fitting (TC4) and electrochemical impedance spectroscopy (EIS). Parameters describing corrosion behavior include polarization resistance, Tafel constants, and corrosion current. The corrosion properties of L-PBF test coupons were compared to those of wrought samples. We determined that the L-PBF test coupon fabricated in this study has a significantly higher polarization resistance than the wrought coupon (approximately 360 vs. 110 kΩ respectively) and corrodes approximately four times slower than the wrought coupon (approximate corrosion current density of 0.6 μA cm^{-2} and corrosion rate of 6 μm yr^{-1} for the L-PBF sample vs. 2 μA cm^{-2} and 20 μm yr^{-1} for wrought). Microstructural features of the samples before and after corrosion were also elucidated via electron microscopy (SEM).

INTRODUCTION

Stainless steel is a class of materials with applications ranging from infrastructure[1] to medical devices[2]. A stainless steel is an iron-based alloy with at least 10.5 % chromium content[3]. Stainless steel is often used in applications which require a high level of corrosion resistance. The high corrosion resistance of stainless steel is conferred via its chromium content. Chromium is much more prone to oxidation than iron and forms chromium oxide under oxygenating conditions. The resulting chromium oxide layer passivates the surface and effectively protects the underlying metal from oxidation.