Revealing the superior corrosion protection of the passive film on selective laser melted 316L SS in a phosphate-buffered saline solution

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Abstract Recently 316L austenitic SS was considered as a biological substitute material in orthodontics, orthopedics and dentistry based on its excellent corrosion resistance, good mechanical properties, as well as low cost. The traditional processing for implantable medical devices, such as dental implants, orthopedic implants, and coronary stents, is manufactured via multiple machining processes after quenched moulding. The manufacturing process becomes simplify with the arrival of the Selective Laser Melting (SLM) process method for such biometal applications. The SLM process permits the one-step fabrication of complex components with relatively low residual stress and can achieve good tensile strength via rapid cooling.

The SLM 316L SS showed preferential formation of Miller phases of (110) gamma austenite phase containing an abundance of sub-grain boundaries, and the intensity of (110) phase enhanced with increasing the laser power. The SLM 316L SS preferential formed Miller phases of (110) and this showed improved breakdown potential compared with wrought 316L SS. The SLM 316L SS maintained the passivation state at 600 mV vs. Ag/AgCl, where wrought 316L tended to produce a more porous film with poor protection. The superior passivation behaviour SLM 316L SS, especially at 200 W, was related to a higher ratio of Cr_2O_3/$Cr(OH)_3$ within the passive film at OCP in PBS solution. The (110) facets of the matrix have a higher W_{sep} value with Cr_2O_3 compare with Fe(111)/ Cr_2O_3, indicating that the inner layer for SLM 200 W 316L depressed separation of the passive film and provided an opportunity for the developing of the whole layer. Abundant grain/sub-gain boundaries of the SLM 316L SS promoted the growth of the passive film and kept the passive film for SLM 200 W 316L staying completeness at 600 mV vs. Ag/AgCl.

The improved passive film formed on SLM 316L SS acted as a better barrier against the corrosive species, even in the simulated inflammation solution with the presence of H_2O_2 at low pH, and suppressed metal ion release. The dissolved concentrations of Fe, Cr, Mo, and Ni were at a lower level compared to wrought 316L SS during the whole simulated inflammation period. However, we also notice that the pores on the surface of SLM 316L SS at 80W promotes the development of pit, inducing severe pitting corrosion and increasing the levels of toxic metal ions in the solution.