Synopsis

Selective laser melting (SLM) of metallic powders is an additive manufacturing technique that is widely employed to produce 3D components, and is fast becoming an important method for manufacturing near-net shape and complex metallic parts. In this thesis, a comprehensive investigation on the effect of SLM on the mechanical and corrosion properties of the Al-12Si (AS), 316L stainless steel (SS), and 18(Ni)-300 grade maraging steel (MS) is investigated, with particular emphasis on the developing (micro- as well as meso-)structure -property correlations. Detailed microstructural characterization combined with quasi-static tensile, fracture toughness, fatigue crack growth, and unnotched fatigue tests were conducted. The effect of post-SLM heat treatment as well as the scanning strategy (linear vs. checker board hatch style) was examined and the results are compared with those of conventionally manufactured (CM) counterparts. The SLM alloys exhibit a mesostructure, in addition to the finecellular structure along the boundaries. In a case of SLM-AS, the fine cellular structure imparts higher strength at the cost of ductility, while the mesostructure, which arises due to the laser track hatching, causes the crack path to be tortuous, and in turn leads to substantial increase in fracture toughness. This imparts significant anisotropy to the toughness while tensile properties are nearly-isotropic. The experimental results of SLM-SS also show thathigher tensile strengths properties with a marked reduction ductility. In spite of these, the fracture toughness, which ranges between 63 and 87 MPa.m$^{0.5}$, of the SLM-SS is good, which is a result of the mesostructure induced crack tortuousity.Both tensile and toughness properties of SLM-SS were found to be anisotropic in nature.Upon aging SLM-MS, nanoscale precipitation of intermetallic compounds occurs within the cells that, in turn, lead in marked improvements in tensile strengths properties, but substantial reductions in ductility and fracture toughness. Overall, the mechanical performance, except ductility, of the SLM-MS after aging is found to be similar to that of CM-MS. Importantly, the lack of ductility does not lead to a reduction in toughness. Although the SLM-MS alloy possesses a mesostructure, no significant anisotropy in the mechanical behavior is observed. The unnotched studies on SLM-AS, -SS, and -MS reveal that the tensile residual stresses, gas-pores, and unmelted powder particles, can degrade the unnotched highest fatigue properties considerably and hence need be

eliminated for high fatigue strength. Room temperature, electrochemical corrosion resistances (CRs) of SLM-AS, -SS and -MS in 0.1M NaCl solution were also evaluated and compared with those CM counterparts. While SLM improves CRs of AS and SS, it degrades that of MS. The results are discussed in terms of microstructural refinement and porosity that are common in SLM alloys.