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Hydrogen embrittlement of Ti6Al4V fabricated by laser beam powder bed fusion

Decheng Kong

*School of Materials Science and Engineering, Shanghai Jiao Tong University,
Shanghai 200240, China*

dechengkong@sjtu.edu.cn

Abstract Hydrogen embrittlement (HE) behavior of Ti6Al4V produced by laser beam powder bed fusion (PBF-LB) was investigated via tensile tests with/without electrochemical H-charging, and the heat treatment (HT, 950 °C for 2 h) effects on HE mechanisms were also explored. Decreased resistance against HE after long-term H-charging is verified for the HT PBF-LB Ti6Al4V and this phenomenon is not obvious for the as-built (AS) PBF-LB counterparts. To understand this observation, we carried out microstructural characterization experiments including backscattered electron (BSE) image, electron backscatter diffraction (EBSD), transmission electron microscope (TEM), and hydrogen analyses based on X-ray diffraction (XRD) and thermal desorption spectrometry (TDS). These results and others reveal that the β phase introduced by the HT process attracts more hydrogen ingress compared with the full acicular α' martensitic phase in the AS PBF-LB parts. The lattice expansion of the hydrogenated β phase compels a localized stress field near the phase boundary, leading to an increased workhardening rate under H-charging for the HT PBF-LB Ti6Al4V. Consequently, brittle titanium hydrides occur along with the α/β interfaces after H-charging, and the micro-voids preferentially initiate therein and coalesce to micro-cracks under plastic deformation. Therefore, a larger ductility loss is verified for the HT PBF-LB Ti6Al4V compared with the AS PBF-LB counterparts under the same H-charging condition.

Keywords Hydrogen embrittlement; Ti6Al4V; Laser beam powder bed fusion; Hydride; Heat treatment