Corrosion and Stress Corrosion Cracking Behaviors of Binder Jet Printed 316L

Introductory part,Abstract: This study systematically investigated the corrosion and stress corrosion cracking (SCC) behavior of binder jet-printed (BJP) 316L. The results confirmed that both inherent porosity and the presence of δ-ferrite have a detrimental impact on the material's resistance to both localized corrosion and SCC. To address this, hot isostatic pressing (HIP) and femtosecond laser texturing (FLT) were identified as effective methods for significantly improving these properties.

Binder jet printing technology is a type of additive manufacturing technology. Compared to traditional manufacturing methods, it offers unparalleled advantages in the design and manufacturing of complex components. In contrast to additive manufacturing techniques that use laser heat sources, metal materials produced by this technology contain almost no non-equilibrium microstructures [1].

It was confirmed that the binder-jet-printed 316L exhibited high porosity and δ-ferrite content. During immersion corrosion tests (25 wt% $MgCl_2$, 75 °C, 70% RH), these features induced localized corrosion (Fig. 1). Similarly, in the SCC tests under identical conditions, they initiated cracks and promoted crack propagation (Fig. 2).

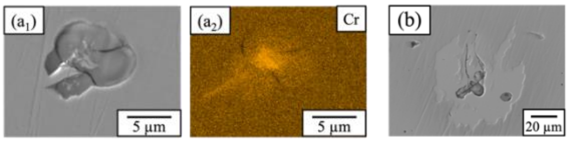

Fig. 1. Features of localized corrosion in the BJP specimens after immersion testing: (a_1, a_2) around the δ-ferrite, (b) around pores.

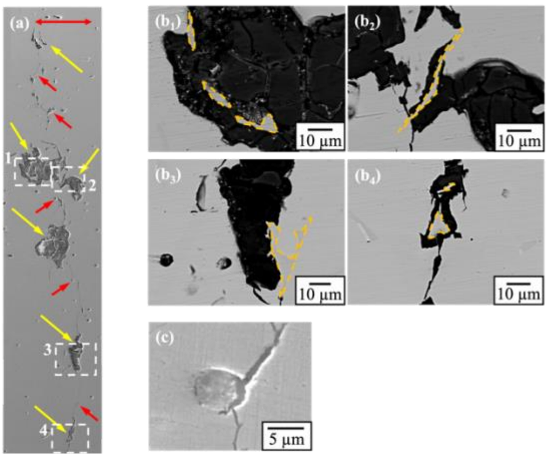

Fig. 2. (a) a crack observed in BJP specimens after SCC test. The yellow arrows in (a) indicate the pits formed around δ-ferrite, and the red arrows in (a) indicate the pores observed in the crack path. The yellow dotted curves in (b1-b4) indicate the δ-ferrite.

To address this, we implemented a HIP process (1160 °C, 104 MPa, 240 minutes), which effectively reduced porosity and the δ-ferrite content in the BJP 316L. This optimization led to a significant improvement in performance, as evidenced by the absence of any localized corrosion or stress corrosion cracking in subsequent tests.

We also applied Femtosecond Laser Texturing (FLT) to the surface of the BJP 316L (Fig. 3). This treatment induced superhydrophobicity, placing the material in a Cassie-Baxter state. This state retards the contact between the corrosive medium and the underlying bulk material, thereby improving the SCC resistance.

This research project led to two publications:

(1) ***Corrosion Science***, 2025, 252: 112968;
(2) ***Acta Materialia***, 2026, 302: 121615.

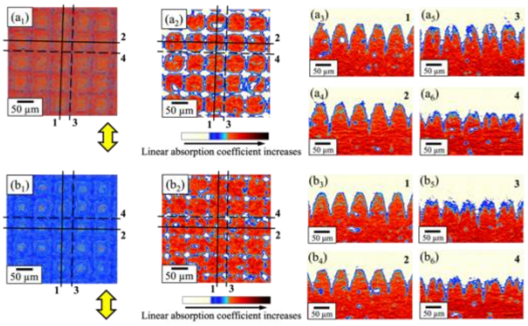

Fig. 3. Surface morphology of FLT-treated BJP 316L.

References

[1] T.H. Becker, P. Kumar, and U. Ramamurty, Fracture and fatigue in additively manufactured metals, Acta Mater. 219, 117240 (2021)

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Yida Xiong (Sun Yat-sen University)
E-mail: xiongyd6@mail.sysu.edu.cn