Effect of nitrogen on the failure behavior of nitrogen-doped diamond-like carbon films on stainless steel surface

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Abstract Stainless steel (SS) has a high sensitivity to localized corrosion in chloride ion environments [1,2]. In order to improve its resistance to localized corrosion in the marine environment. Nitrogen-doped diamond-like carbon (N-DLC) films with different nitrogen content were prepared on the surface of 304 SS using plasma-enhanced chemical vapour deposition technology. Localized failure mechanisms of the N-DLC films under long-term exposure to sodium chloride solutions have been investigated. The results demonstrated that nitrogen doping significantly affected the failure behaviour of the N-DLC films. When undoped, the number of pore defects in the film is high, providing a channel for the corrosive medium to attack the substrate metal. Meanwhile, due to the high internal stress within the undoped film, extensive exfoliation of the film occurred under the effect of the growth of oxides at the film-substrate interface. The DLC film on 304 SS is subject to stress corrosion cracking failure during long-term service in sodium chloride solution. However, when nitrogen doping is 10 sccm, the pH of the micro-zone solution was highly variable due to the dissolution of nitrogen in the film and the processes of formation and hydrolysis of NH_4^+ [3]. A large number of residual metal cations dissolved from the substrate combine with oxygen at the corrosion pits mouth to form oxides. This can aggravate the occlusion effect of the pits and severe pitting corrosion of 304 SS occurs under autocatalytic effects [4]. The N-DLC film with 5 sccm nitrogen addition showed the excellent durability properties. The evolution mechanism of oxidation and dissolution behaviors in the presence of variations in local hydrochemistry is also discussed.

Keywords diamond-like carbon film, localized corrosion, hydrochemistry, solubility, failure mechanisms

Reference

[1] Kappes M A. *Corros. Rev.*, 2020, 38 (1): 1-24.
[2] Frankel G S, Sridhar N. *Mater. Today*, 2008, 11 (10): 38-44.
[3] Chen D X, Liu M N, Liu X H, et al. *Corros. Sci.*, 2021, 186: 109468.
[4] Soma Y, Kato C, Yamamoto M. *Corrosion*, 2014, 70 (4): 366-374.