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PII: S0142-1123(17)30315-8
DOI: http://dx.doi.org/10.1016/j.ijfatigue.2017.07.019
Reference: JIJF 4415

To appear in: *International Journal of Fatigue*

Received Date: 23 May 2017
Revised Date: 15 July 2017
Accepted Date: 17 July 2017

Please cite this article as: Habib, K., Koyama, M., Tsuchiyama, T., Noguchi, H., Fatigue crack non-propagation assisted by nitrogen-enhanced dislocation planarity in austenitic stainless steels, *International Journal of Fatigue* (2017), doi: http://dx.doi.org/10.1016/j.ijfatigue.2017.07.019

Fatigue crack non-propagation assisted by nitrogen-enhanced dislocation planarity in austenitic stainless steels

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-The Fe-25Cr-1N steel exhibited a non-propagating fatigue crack at the fatigue limit.

-Roughness-induced crack closure contributes to the non-propagating crack.

-Enhanced planar dislocation and high dislocation pile-up stress play a key role.

-The crack propagation occurred along the $\{111\}_\gamma$, even in the long crack

Abstract

Rotating bending fatigue tests were conducted to assess the fatigue crack propagation behavior of the Fe-25Cr-1N and Fe-18Cr-14Ni austenitic steels in terms of the microstructure, crack propagation paths, and non-propagating fatigue crack characteristics. The Fe-25Cr-1N steel exhibited a non-propagating fatigue crack at the fatigue limit (310 MPa), but this did not occur in the Fe-18Cr-14Ni steel at the fatigue limit (110 MPa). The non-propagating fatigue crack observed in the Fe-25Cr-1N steel was produced by roughness-induced crack closure. This phenomenon was caused by the enhanced planar dislocation and high dislocation pile-up stress resulting from the suppression of cross-slip, which inhibited the dislocation emission from the crack tip. The Fe-25Cr-1N steel exhibited a lower fatigue crack growth rate than the Fe-18Cr-14Ni steel because of the enhanced dislocation planarity produced by the Cr-N interaction. The Cr-N interaction affected the fatigue crack growth behavior as follows. The short crack region exhibited a planar glide dislocation pattern, but multiple slip systems were activated as the crack lengthened. As the dislocation pattern remained planar on each slip plane, the crack propagation occurred along the $\{111\}_\gamma$ slip planes, even in the long crack. Moreover, the dislocation pile-up