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PII: S0142-1123(18)30172-5
DOI: https://doi.org/10.1016/j.ijfatigue.2018.05.003
Reference: JIJF 4675

To appear in: *International Journal of Fatigue*

Received Date: 18 March 2018
Revised Date: 29 April 2018
Accepted Date: 2 May 2018

Please cite this article as: Jiang, R., Bull, D.J., Evangelou, A., Harte, A., Pierron, F., Sinclair, I., Preuss, M., Hu, X.T., Reed, P.A.S., Strain accumulation and fatigue crack initiation at pores and carbides in a SX superalloy at room temperature, *International Journal of Fatigue* (2018), doi: https://doi.org/10.1016/j.ijfatigue.2018.05.003

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Abstract: Pores and carbides inherited from SX superalloy manufacturing processes usually act as stress concentrators and are preferential sites for fatigue crack initiation. In this study, pore & carbide size, morphology and distribution in a SX superalloy MD2 has been evaluated by X-ray CT. Strain accumulation and fatigue cracking behaviour in MD2, particularly around the pores and carbides, has been investigated by ex-situ SEM-DIC at room temperature along with image-based modelling of the observed MD2 defect populations obtained through X-ray CT imaging. The deformation structures have also been examined by electron channelling contrast imaging under controlled diffraction conditions. The results indicate that the pores & carbides with complicated three-dimensional features are the dominant fatigue crack initiation sites. Deformation is concentrated within intense slip bands and an enhanced strain accumulation around pores is captured by SEM-DIC. Dislocation motion is mainly confined to the γ matrix channels with some dislocation shear cutting of γ′ precipitates also observed ahead of the crack tip. As the crack propagates, strain band density and dislocation density at the crack tip increases correspondingly. Image-based modelling using the observed defect populations in MD2 (micro)structure can effectively predict the stress concentrations and the resultant hot spot for subsequent fatigue crack initiation, which is consistent with the experimental observations.

Keywords: Ni-based single crystal superalloy; pores & carbides; strain localisation; fatigue crack initiation; digital image correlation

1. Introduction