In-situ observation of initial oxidation of nickel-based single crystal superalloys of different generations

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Abstract Since the advent of the second generation of single crystal superalloys, the concentration of Cr in turbine blade alloys has been limited to a low level (about 5% or less) due to the application of thermal barrier coatings. The shrinkage and expansion of the coating due to thermal oxidation may cause the coating to peel off and cause internal alloy failure, especially in advanced thin-walled turbine blades. The initial oxidation surface morphology and element distribution are generally considered to be the key to understanding the failure behavior of superalloys. In this work, the initial oxidation behavior of typical third - and fourth-generation single crystal superalloys was systematically investigated in situ at nanometer scale using environmental transmission electron microscopy. With the increase of oxygen partial pressure, the oxide nucleates at the γ/γ' interface and expands along the γ channel to grow into the γ' phase. In the thin-foil sample, oxidation promotes the diffusion of matrix elements from the internal γ phase and γ' phase to the γ/γ' interface of the alloy. With the increase of Re content, the oxidation resistance of superalloy decreases due to the evaporation of Re_2O_7 at the γ/γ' interface. This study provides technical guidance for optimizing the composition of advanced single crystal superalloys and improving their oxidation resistance.

Keywords： in situ, oxidation, single crystal superalloy, γ/γ' interface, nanometer scale