High-resolution characterization of the surface oxide formed on austenitic alloys exposed to PWR primary water

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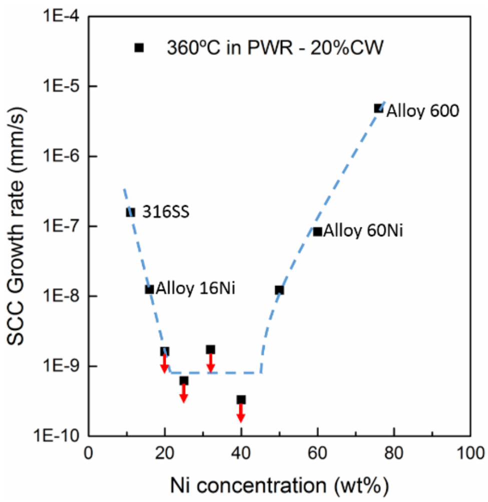

Fig. 1. The relationship between Ni content and crack growth rate of 20% cold-worked austenitic alloys exposed to PWR primary water at 360C.

Austenitic alloys have been extensively used in the nuclear industry as structural components due to their combination of excellent mechanical properties and high corrosion resistance [1]. Although these alloys have a good service record, many can become susceptible to stress corrosion cracking (SCC) under pressurized water reactor (PWR) primary water conditions due to improper fabrication treatments. After several decades of study, a considerable number of factors have been revealed that affect SCC susceptibility, including material composition, pre-existent cold-work, temperature, water chemistry, etc. [2]. Among them, material composition is one of the most important factors that can significantly influence the crack growth rate (CGR). In an early study conducted by Coriou et al. [3], the authors found that the Ni content in the austenitic alloys exhibited remarkable effect on CGR. To further study the effect of Ni content on CGR in high-temperature water, Arioka et al. [2] conducted a systematic research on this topic more recently using a series of austenitic alloys within different Ni content (X%Ni-16%Cr-Fe). In this study, a similar Ni content dependence of CGR was observed, which was named as "Coriou effect" by the authors [2], as shown in Fig. 1. We believe that the study of this phenomenon is of great importance for developing future SCC-resistant materials that can be used in the PWR primary water environment.

The structure and chemistry of the oxide formed on the austenitic alloys were believed to play an important role in SCC [4, 5]. To obtain a mechanistic understanding of the effect of Ni content on SCC, the surface oxide formed on four austenitic alloys within different Ni content (see Fig. 1) exposed to simulated PWR primary water at 340°C for 2000h were studied in detail. High-resolution characterization techniques, including analytical transmission electron microscopy (ATEM), atom probe tomography (APT), transmission Kikuchi diffraction (TKD), and 3D FIB sectioning, are combined together to reveal the micro-structure and chemical composition of the surface oxide formed on different alloys. With the information obtained from the high-resolution characterization techniques, it should be possible to understand the effect of Ni content on the SCC susceptibility of austenitic alloys.

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Acknowledgements

The authors would like to thank Prof. Lefu Zhang at Shanghai Jiao Tong University for providing the samples used in this study and for useful discussions. Zhao Shen is also grateful to China Scholarship Council for providing financial support. The EPSRC (EP/K040375/1 and EP/N010868/1) is acknowledged for funding the 'South of England Analytical Electron Microscope' and the FIB/SEM used in this research.