

CHARACTERIZATION OF Fe-Cr ALLOYS IN CH₄ FUELS FOR SOFC INTERCONNECTS

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The chemical stability of ferritic alloy (Fe-Cr alloy) was examined as interconnect under CH₄-H₂O gases to simulate real fuel gas conditions. Oxide scale layers were formed on the alloy surface by the reaction with CH₄-H₂O gases at 1073 K. The surface morphology varied with forming needle-like or plate-like Cr-Mn-oxide spinels, as shown in Fig.1(a). The grain boundary parts increase in the height with Mn-rich composition. The main reaction products in the oxide scale are Mn-Cr-Fe spinels and Cr₂O₃. Figure 1(b) shows microstructure of cross section at the oxide scale/alloy interfaces after CH₄-H₂O treatments ($p(\text{CH}_4)=0.12$ bar, $p(\text{H}_2\text{O})=0.12$ bar). The oxide scale grew on the alloy surface without any voids and cracks. Thus, the oxide scale formation occurred continuously from the alloy surface.

Secondary ion mass spectrometry (SIMS) was applied to measure the elemental distribution of minor and major elements around the oxide scale/alloy interface. Figure 2 shows SIMS depth profiles of several elements at the oxide scale/alloy interfaces. High concentration of Mn⁺ on the oxide scale surface suggests that fast diffusion of Mn in the oxide scale to form spinels. Cr⁺ and Fe⁺ signals show relatively high concentration at the oxide scale. For minor elements distribution, Si⁺ is concentrated at the interface. The distribution of Al⁺ shows high concentration in the alloy, which is consistent with Al₂O₃ inner oxides. The distribution of La⁺ shows relatively high concentration at the oxide scale, while that of Zr⁺ was high in the alloy.

Annealing in CH₄-H₂O made the oxide scale thicker with duration time. Growth of the oxide scale layer thickness followed the parabolic growth relationship with time. The parabolic growth rate constants were in the order of 10⁻⁶ μm²s⁻¹ for all experimental condition. There is no $p(\text{CH}_4)$ dependence of the oxide layer growth.

Light elements distributions were examined by Cs⁺ sputtering and minus secondary ions were measured as a function of depth. Also, in order to check the oxygen diffusivity in the oxide scale, isotope oxygen (¹⁸O₂) diffusion profiles were measured as shown in Fig.3. The isotope oxygen diffusion coefficients were estimated by the ¹⁸O diffusion profiles at 1073 K. The calculated diffusion coefficients were in the order of 10⁻¹² cm²s⁻¹ (10⁻⁴ μm²s⁻¹). This value was far larger than the measured oxide scale growth rates. Therefore, the oxygen diffusion was not rate determining step for oxide scale formation.

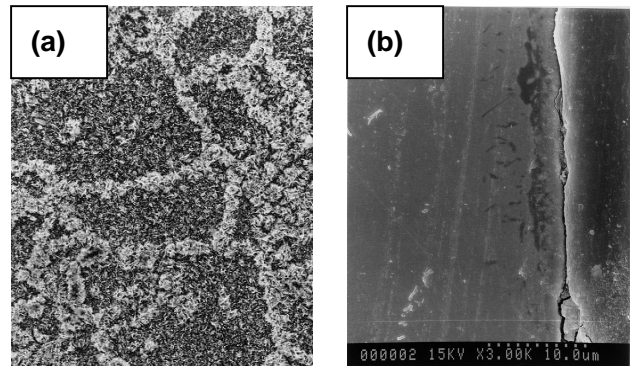


Fig.1 SEM images of oxidized alloy
(a) Surface image after 72 h in CH₄-H₂O
(b) Cross section of oxide scale/alloy interface after 1032 h in CH₄-H₂O

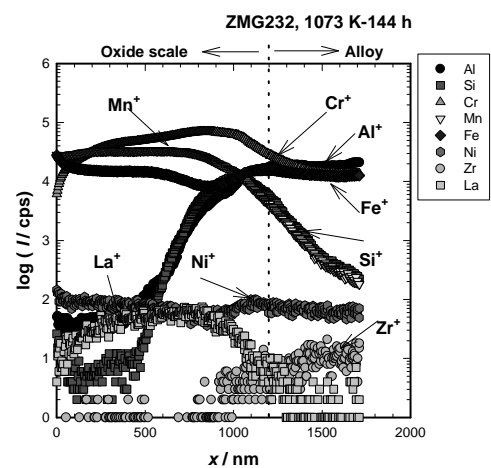


Fig.2 SIMS depth profiles at the oxide scale/alloy interface.

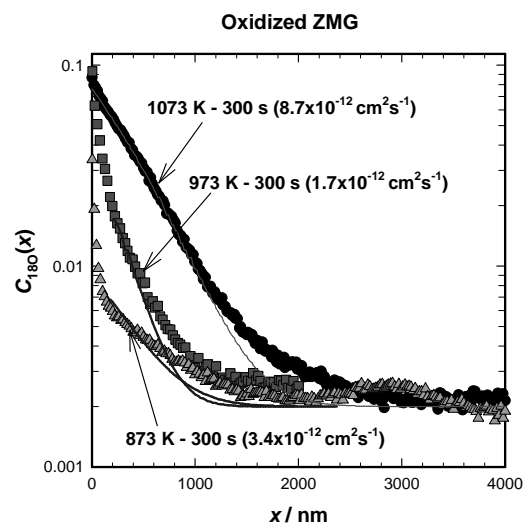


Fig.3 ¹⁸O diffusion profiles at the oxide scale/alloy interfaces for three different ¹⁶O/¹⁸O exchange temperature.