

Supporting information

The effect of SO₂ in the presence of H₂O

Macro appearance

Before exposure the polished FeCrAl alloy, Kanthal APMT, exhibited a grayish metallic luster. After exposure for 1-168 h to O₂/N₂/H₂O + 300 ppm SO₂ at 600°C, the surface had a yellowish luster, likely due to the formation of an oxide scale with a thickness corresponding to the interference color. After exposure for 168 h, the material surface exhibited a mixture of yellow and purple colors.

Water-soluble corrosion products

Figure 23 shows the levels of SO₄²⁻ detected by IC analysis after extraction of the soluble corrosion products formed on the APMT during exposure in the presence of SO₂. The levels of detected SO₄²⁻ were very low for all exposure times, being around ~0.001 mg/cm², after all exposure times. These outcomes are in accordance with the AES and SIMS results, whereby low levels of S were found on the surface.

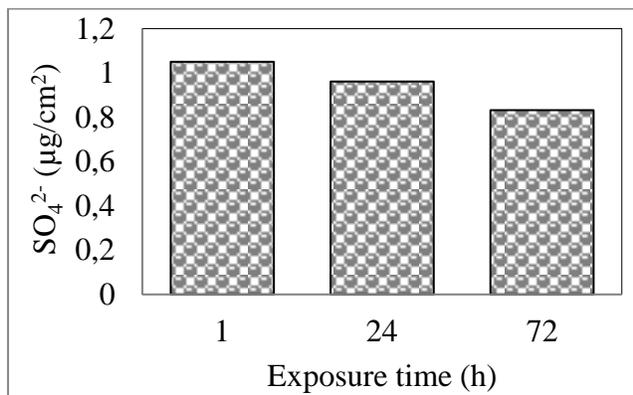


Figure 23. IC analysis showing the amount of SO₄²⁻ present on the surface of APMT after exposure for 1–72 h to 5% O₂ with 40% H₂O and 300 ppm SO₂ at 600°C.

The effect of SO₂ in the presence of KCl and H₂O

Macro appearance

After exposure of Kanthal APMT for 1–168 hours to O₂/N₂/H₂O + 300 ppm SO₂ + KCl, the surfaces of the alloy showed uneven corrosion.

Surface microstructure

Figure 24 shows images of the surface of APMT after 1 h of exposure to the environment of O₂/N₂/H₂O + 300 ppm SO₂ + KCl. The low-magnification image (Fig. 24 a) (50µm bar) was taken in the backscattered mode, whereas the remaining three high-magnification images were captured in the secondary mode (Fig. 24 b-d). In Figure 24a, four regions are labeled 1-4: region 1 (enlarged in Fig. 24 d), that have the shape of the former KCl particles; region 2 (Fig. 24 b) with dark rings (more visible in backscattered mode, Fig. 13); region 3 (Fig. 24 c) with bright base oxide; and region 4 (Fig. 24b) with dark base oxide. Judging from the high magnification secondary images (Fig. 24), it seems that the entire surface (encompassing all the regions) is covered by rounded (about 1 µm in diameter) particles. EDX analysis of the different regions showed that the surface was rich in S, K, and O, so it is reasonable to conclude that these particles are K₂SO₄, as detected by XRD. The regions that have the shape of the former KCl particles are likely to represent KCl that has reacted with the SO₂ in the gas, thereby forming K₂SO₄ with maintenance of the shape of the KCl particle. The ring-shaped regions are likely due to remnants from a vaporized droplet from the application of KCl, which would give the KCl particles the appearance of a ring structure. After the application of KCl, small residues of KCl remain between the discrete KCl particles¹⁵, which explains the formation of K₂SO₄ from the

larger KCl particles and the formation of rings. The EDX analyses revealed the presence of chlorine (Cl) in the base oxide and in the dark regions, the atom% being O:45%, Al:4%, S:6% Cl:2%, K:10% Cr:10%, Fe:23% and O:50%, Al:3%, S:8% Cl:2%, K:13% Cr:8%, Fe:16%, respectively. The observed chlorine may originate from unreacted KCl particles (albeit not detected by XRD) or they may be the result of alloy chlorination.

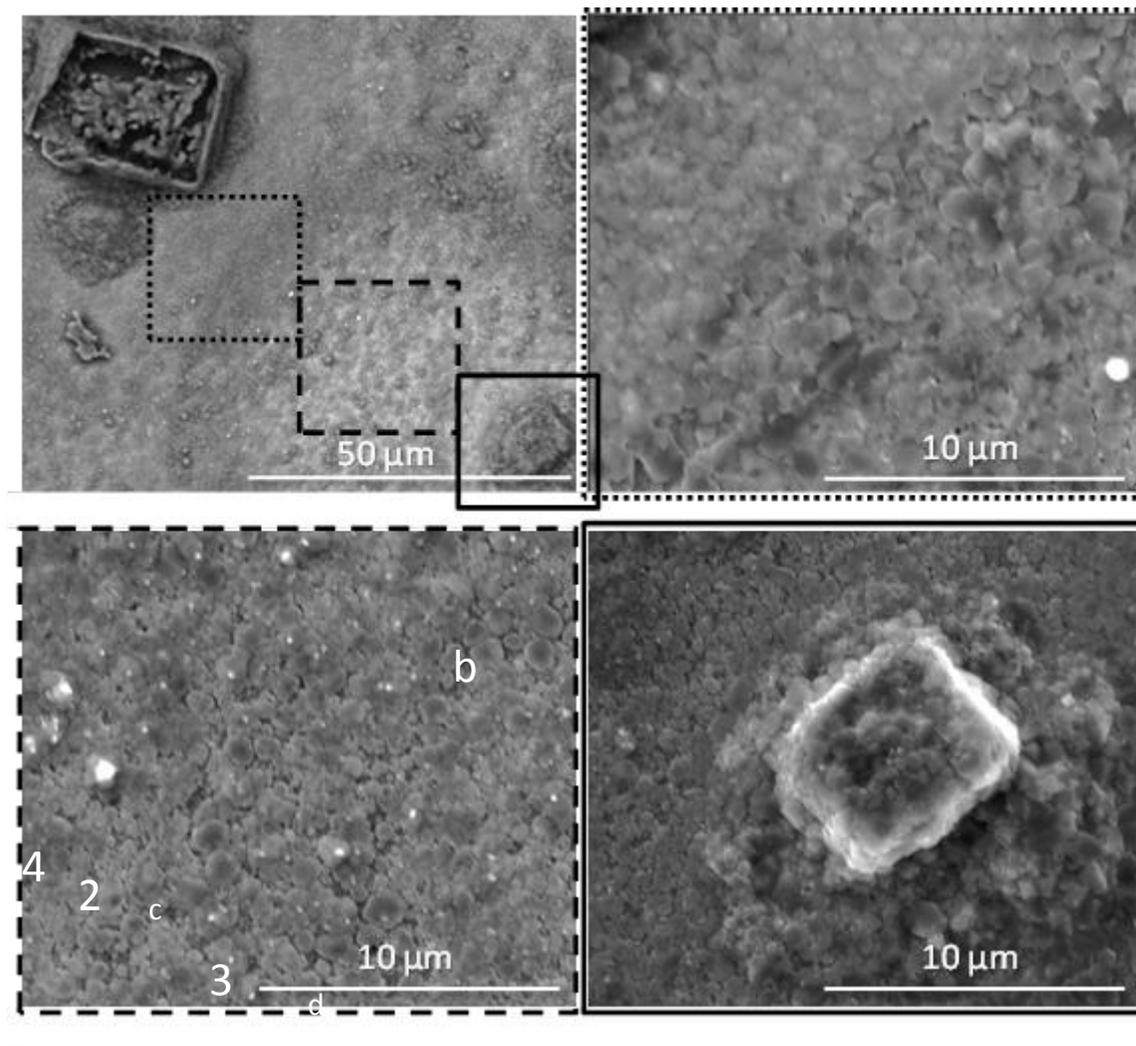


Figure 24. SEM surface images of Kanthal APMT after 1 h of exposure at 600°C to 5% O₂ with 40% H₂O and 300 ppm SO₂ plus KCl. The upper-left image was acquired in the backscattered mode and the other images were acquired in the secondary mode.

The effect of pre-oxidation in the presence of KCl and SO₂

Macro appearance

APMT was pre-oxidized in O₂/N₂ at 1100°C for about 1 h and then exposed at 600°C to O₂/N₂/H₂O + 300 ppm SO₂ for 72 h, with KCl being applied to the material surface. The pre-oxidized material exhibited a lusterless grayish surface, whereas the material that was pre-oxidized and thereafter exposed to KCl and SO₂ at 600°C exhibited small regions of corrosion and bright curved lines on the grayish lusterless surface. Therefore, oxide scale produced during the pre-oxidation does not appear to be completely inert in the exposure environment.