Microscopic investigations of a Cr2O3 scale formed on a substrate with implanted yttrium ions

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Atomic-resolution (S)TEM methods were used to examine the structure of a Cr_2O_3 scale formed on chrome and the Co-40Cr alloy, both of which had undergone yttrium ion implantation at a dose of $2'10^{16}$ at./cm^2 and a beam energy of 70 keV. Oxidation was performed for 100h in air at 800 °C.

Cross-section lamellae for (S)TEM investigations were prepared using focused ion beam (FIB) NEON CrossBeam 40EsB SEM from ZEISS. A layer of platinum was deposited on the surface of the scale, and lamellae with the dimensions of 7´10 μm^2 and a thickness of around 80 nm were then cut from the scale in the perpendicular direction. Microscopic examinations were conducted using the S/TEM Titan Cubed G2 60-300 transmission electron microscope equipped with the ChemiSTEM (FEI) system. Phase identification was performed by means of selected area electron diffraction (SAED). STEM images were observed by means of high-angle annular dark-field detectors. The chemical composition was analyzed using energy dispersive X-ray spectrometry EDS).

The microscopic observations of the scale cross-section revealed that it is composed of micrometre-sized Cr_2O_3 crystallites with flat walls. The STEM-EDS and SAED analyses showed that in the case of both substrates yttrium was located in the interior of the Cr_2O_3 scale, in the form of a layer composed of the $YCrO_3$ perovskite. On the other hand, the presence of yttrium was not observed either in the interior of Cr_2O_3 grains or at the scale/substrate interface.

If the $YCrO_3$ is to be treated as a marker, then its location would suggest that the Cr_2O_3 scale formed on a substrate with implanted yttrium ions grows predominantly as a result of the predominant inward diffusion of oxygen across points defects in the anion sublattice, with a certain contribution of the outward diffusion of chromium.