Early oxidation stages of Cr-containing alloys

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Fabrication and application of modern technical materials are often linked to thermo-mechanical treatments and subsequent use in aggressive environments, e.g., at elevated temperatures. Often, this leads to the formation of oxide layers, either intentionally or unintentionally. The early oxidation stages in particular are attracting attention recently, as they are discussed to affect the material behavior in the medium and long term in a given environment. Identification of fundamental aspects requires knowledge regarding numerous details, e.g., the first forming oxide phase, the elemental distribution within and close to the oxide layer, as well as the position of the reaction front of oxide formation. Accordingly, analytical access with high spatial resolution is needed already at the early oxidation stages. Such capability is especially provided by means of transmission electron microscopy (TEM). A new TEM facility is under construction at TU Chemnitz and information will be shared regarding the current status of the construction work and the new equipment that will become available soon.

This presentation will provide insights into the early oxidation stages of a wide range of Cr-containing alloys and an exemplary complex concentrated alloy (CCA) [1,2]. The observation of single oxide grains with pronounced inhomogeneous composition is reported in detail, as recently observed for oxide grains that formed on austenitic stainless steel [3]. These oxide grains exhibit sharp concentration gradients over distances of a few nanometers, that do not equalize after several hours at temperatures of a few hundred degrees Celsius. In order to reveal the growth mechanism of these oxide grains, experiments were designed using Mn as a marker and it is shown that the reaction front of the oxide formation is located within the single oxide grains [4]. Furthermore, it will be presented, that the occurrence of the inhomogeneous oxide grains is not limited to a specific crystal phase and that this finding is a parallel in the oxidation behavior of a wide range of Cr-containing alloy. Implications of the findings will be discussed considering thermodynamic and kinetic aspects.

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[2] J. Apell, R. Wonneberger, M. Seyring, H. Stöcker, M. Rettenmayr, A. Undisz, *Corrosion Science*, 109642, 190 (2021)

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[4] R. Wonneberger, G. Kirste, M. Seyring, M. Hafermann, C. Ronning, M. Schaal, F. Otto, T. Fritz, A. Undisz, *Corrosion Science*, 111434, 223 (2023)