Interface chemistry and transport in alumina using TEM and APT

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Alumina (Al_2O_3) is one of the most important structural ceramics because of its various applications, which extend from electronic use to material protection against high temperature degradation in power generation technologies. For all these applications transport kinetics in this oxide is crucial for the functionality and reliability of the component.

Today, it is generally accepted that growth of protective alfa-alumina-oxide scales, on alloys for high temperatures applications, takes place through transport of ions along the oxide grain boundaries (GBs). Although it is recognized that this transport occurs predominantly by inward diffusion of oxygen ions it is also agreed that there exists some amount of concurrent outward diffusion of metal ions along GBs. However, due to experimental difficulties in the past, there are only a few studies attempting to quantify the importance of outward diffusion of aluminum. Moreover, although it is well known that the chemistry of alumina forming alloys can dramatically affect the scale performance, the effect of alloying elements on diffusional fluxes still remains unclear. For example, it has been shown that the addition of reactive elements (RE) such as Zr, Y and Hf can slow down the transport along boundaries and also affect the oxide adhesion but, the reasons for such observations are still being debated.

Recent developments in the field of high resolution microscopy and microanalysis allows for characterization of grain boundary chemistry of oxide scales with nearly atomic resolution and may shed some light on the abovementioned issues. Here, we will present results from TEM, SEM and APT studies aiming to quantify the influence of Hf and Zr in binary Al-Ni alloys on the outward diffusion of aluminum in alfa -Al_2O_3 formed during isothermal oxidation during 100 h at 1100°C.