Oxidation behaviour of RuAl thin films: influence of the diffusion barrier

M. A. Guitar & F. Mücklich

Functional Materials, Materials Science Department, Saarland University, Saarbrücken D-66123, Germany

RuAl is a B2-structured intermetallic material with high melting point (2050ºC) which possesses outstanding thermodynamical stability in high-temperature aqueous environments. Moreover, RuAl presents good oxidation-resistance up to at least 1200ºC and strength at high temperatures. The good oxidation and corrosion resistance is due to the formation of a slow-growing protective Al_2O_3 layer, which has been found to be dense and compact even after oxidising during 100 hours at 1000°C. Furthermore, the RuAl thermal expansion coefficient (CTE) is nearly equal to that of Al_2O_3 in a wide temperature range, which makes this intermetallic optimal as a protective coating material in applications that demand oxidation resistance (e.g. working layers for moulding dies).

The present work describes the study of the oxidation behaviour at elevated temperatures on nanocrystalline RuAl thin films. Stainless steel (SS) was selected as substrate due to its technical relevance. The RuAl thin films were synthesized from high-purity (99.99%) Al and Ru targets using a PVD magnetron sputtering. A Ti-adhesion layer (50 nm) was deposited onto the substrate previous to the Ru-Al deposition in order to improve the adhesion. To study the oxidation behaviour of this SS/RuAl thin film system, isothermal oxidation treatments were carried out in ambient air at 750°C and 900°C for short times (up to 1h) and the subsequent analysis of the oxide scale was performed using STEM and X-ray diffraction. Moreover, the oxidation kinetics and oxide layer growth morphology was studied with and without diffusion barrier so as to determine how the Fe affects the intermetallic performance.

Oxidation tests showed the formation of a dense, compact and well adhered oxide scale. However, the presence of diffused Fe and Cr at the grain borders from the substrate in the RuAl films was also observed in the oxidised samples. To avoid this effect, an Al_2O_3 and W diffusion barrier was deposited between the subtrate and the RuAl film. Coating detachment was observed by depositing first Al_2O_3 onto the substrate and oxidizing at 900°C.

RuAl thin films exhibit parabolic oxidation kinetics. The surface colour and reflectivity did not change with the oxidation time and also no apparent increasing in roughness was observed after oxidation at 750°C.

The importance of analyzing the oxidation behaviour of these thin films lies on the fact that usually, bulk intermetallics show different oxidation rates compared to those of thin films and therefore, new studies in the aforementioned intermetallic system are needed.

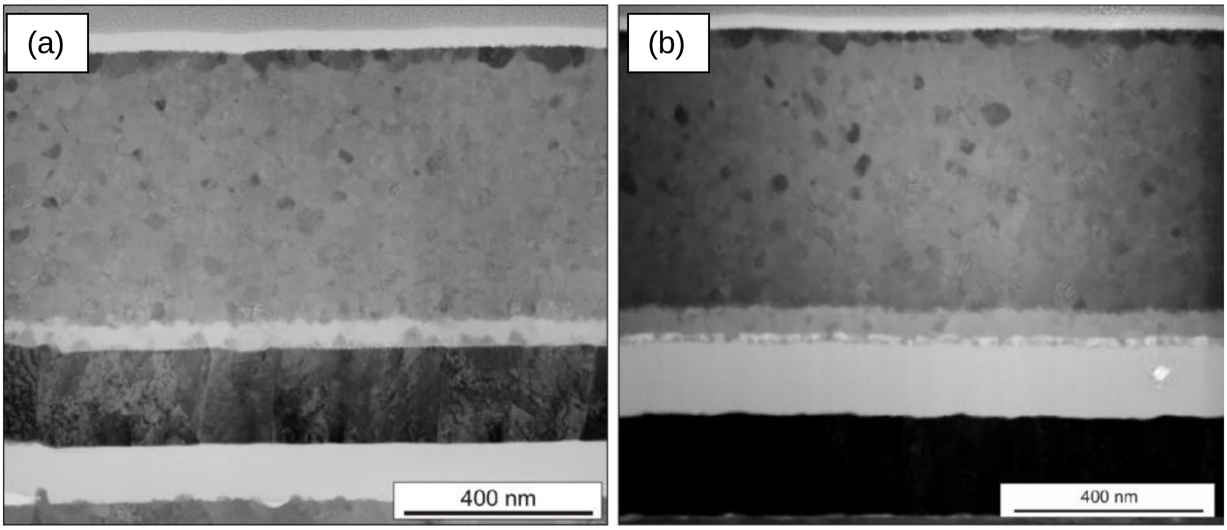

Figure 1: RuAl thin films oxidised at 750°C for 45 minutes using (a) Al_2O_3 + W and (b) W + Al_2O_3 as diffusion barriers.