**Evaluation of TiN and HfN as Interlayers between Alumina Diffusion Barrier Coatings and Gas Turbine Blade Base Material**

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An increase in the thermal efficiency of gas turbines is directly related to higher operating temperatures and higher rotational speeds. Besides the development of single crystal superalloys e.g. CMSX-4 as base material, the use of MCrAlY bond coats in combination with PYSZ thermal barrier coatings allows for higher turbine inlet temperatures and an adequate protection against the hot-gas environment, oxidation, corrosion and erosion.

The protective properties of MCrAlY coatings in an oxidizing environment are well established, and so is the use of diffusion barriers to reduce or eliminate interdiffusion between MCrAlY and base material. For this purpose mainly ceramic materials, which are superior to most metallic materials regarding thermal and chemical stability, are considered e.g. sputtered Al-O-N or $Al_2O_3$ coatings or $\alpha$-$Al_2O_3$ coatings deposited by CVD.

Chemical vapor deposition of $\alpha$-$Al_2O_3$ from $AlCl_3$-$H_2$-$CO_2$-HCl gas mixtures on Ni base alloys is often associated with the formation of undesired whiskers instead of dense films (1). The growth of whisker is suggested to be related to the presence of Ni and Co (2) and is explained by a vapor-liquid-solid (VLS) mechanism (3,4). Whisker formation can be suppressed by the use of interlayers e.g. TiN prior to the deposition of CVD-$\alpha$-$Al_2O_3$ (1). In Fig.1 the topography of an $\alpha$-$Al_2O_3$ coated TiN interlayer on a CMSX-4 substrate is shown. It can be seen that the formation of whiskers is clearly suppressed. However, TiN is not stable at temperatures above 1100°C. To meet the requirements for further increase in gas inlet temperatures of gas turbines and also higher temperatures at the diffusion barrier between MCrAlY and CMSX-4 substrate, alternative material are being evaluated. One reasonable material selection criteria is thermodynamic stability. It is well known that HfN is more stable than TiN (5). Therefore we have evaluated the performance of HfN in comparison with TiN with respect to the formation of whiskers as well as the adhesion properties.

In Fig. 1 and 2 the SEM images of the topography of an $\alpha$-$Al_2O_3$ layer on TiN and HfN on a CMSX-4 substrate are shown respectively. It can be seen that no evidence for the formation of whiskers could be detected. Hence HfN and TiN were shown to be efficient in suppressing whisker growth of $\alpha$-$Al_2O_3$ layers on CMSX-4 substrates.

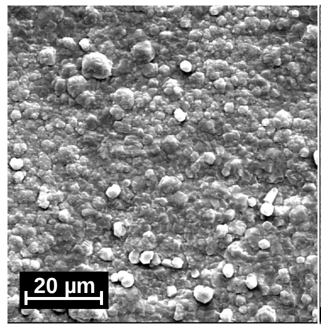


Fig. 1: SEM image of the topography of an $\alpha$-$Al_2O_3$ layer on TiN on a CMSX-4 substrate

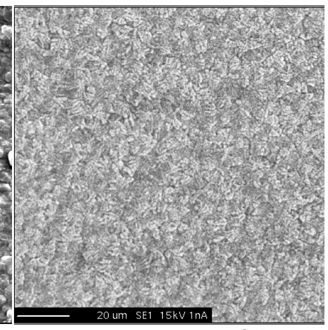

Fig. 2: SEM image of the topography of an $\alpha$-$Al_2O_3$ layer on HfN on a CMSX-4 substrate

The adhesion was evaluated utilizing a scratch tester through critical load measurements. The critical load for the samples based on TiN interlayers was in the range of 25 N to 35 N, while for the HfN layers the values were in the range of 5 N to 10 N. Based on our preliminary data HfN as an interlayer material works equally as well as TiN in suppressing the formation of whiskers but shows potential for improvement with respect to adhesion.

Summary: During chemical vapor deposition of $\alpha$-$Al_2O_3$ on Ni base alloys, whisker formation may occur. We have investigated the effect of TiN and HfN interlayers on the whisker formation as well as on the coating adhesion. We find that the deposition of HfN as well as TiN layers was found to suppress the undesired whisker growth. Furthermore it was shown that the adhesion of the coatings utilizing TiN interlayers was superior compared to the coatings containing a HfN interlayer.

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