OXIDATION PROTECTION OF Mo-Si-B ALLOYS BY MAGNETRON-SPUTTERED COATINGS

Reinhold Braun, DLR - German Aerospace Center, Institute of Material Research, Germany
reinhold.braun@dlr.de
Annika Lange, now with Schott AG, Germany
Uwe Schulz, DLR – German Aerospace Center, Institute of Materials Research, Germany

Key Words: Mo-silicides, oxidation, coatings, intermetallics, magnetron sputtering.

Mo-Si-B alloys with melting temperature above 2000 °C are attractive high temperature materials offering significantly enhanced operating temperatures compared to those of the currently used Ni-based superalloys. However, their oxidation behavior is poor at temperatures below 1000 °C, suffering from evaporation of MoO_3. Above 1000 °C oxidation is characterized by a transient state showing considerable mass loss followed by a steady state condition with reduced mass change. To mitigate this degradation by oxidation, application of coatings is an appropriate method ensuring the formation of slowly growing protective scales.

The presentation summarizes recent results on overlay coatings that were deposited on coupons of a Mo-9Si-8B (in at.%) alloy using magnetron sputtering. A double layer design was applied: a 2 µm thick intermediate Mo_5SiB_2 layer to prevent interdiffusion and approximately 5 µm thick protective topcoats with different chemical compositions: Mo-45Si-25B, Mo-55Si-10B, Mo-29Si-15B, Mo-48Si-24Al, Mo-71Si-8Al (all in at.%). The amorphous as-deposited coatings were annealed in a vacuum furnace. In the boron containing Mo-Si topcoats, the $MoSi_2$ and MoB phases formed as well as the Mo_5Si_3 phase in the Mo-29Si-15B coating. In the annealed Mo-48Si-24Al and Mo-71Si-8Al topcoats, the C40-$Mo(Si,Al)_2$ and $C11_b$-$MoSi_2$ phases were observed, respectively. The oxidation behavior of the coated samples was investigated at 800, 1100 and 1300 °C under cyclic condition in laboratory air. The dwell time at high temperature was 10 or 20 h and the samples were tested for up to 10 cycles. Microstructural examinations of the coated samples were carried out using scanning electron microscopy, energy-dispersive X-ray spectroscopy, glow discharge optical emission spectroscopy and X-ray diffraction measurements.

All coated samples exhibited significantly reduced mass loss at 800 and 1000 °C in comparison to the bare substrate material, indicating oxidation protection by the applied coatings at least for 100 h. A borosilicate scale grew on the boron containing Mo-Si topcoats. At temperatures below 1000 °C, their oxidation resistance was improved by a high amount of boron, whereas lower boron contents were beneficial at higher temperatures. Thermal expansion mismatch between coating and substrate caused buckling and failure of the protective layers at 1300 °C. On the aluminum containing topcoats, a scale with a mixture of silica and mullite-like oxides formed at 800 °C; in addition, outer aluminum borate needles grew on the Mo-48Si-24Al topcoat. At 1000 °C both coatings with Al additions formed dense scales of SiO_2 and a mullite-like pha

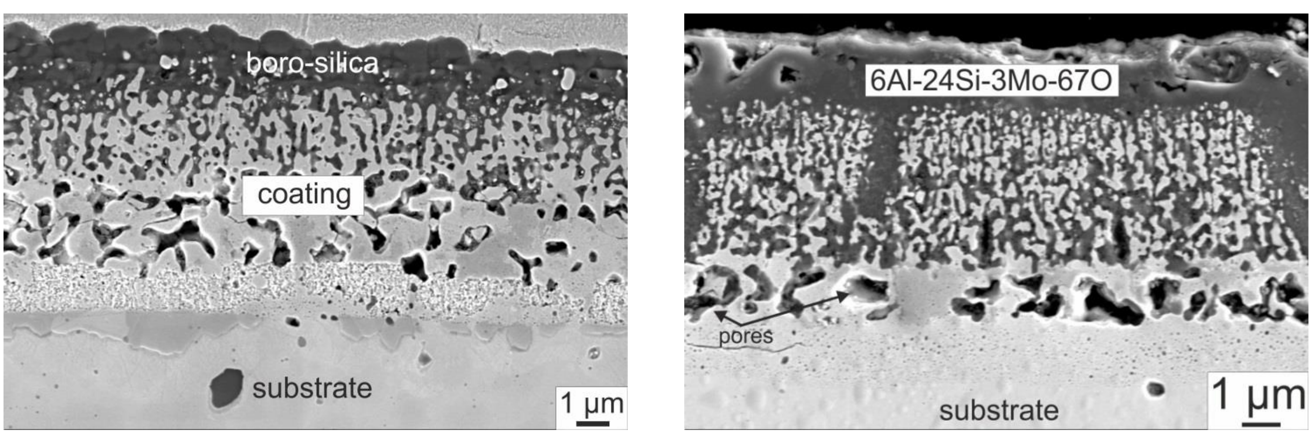

Figure 1– Mo-9Si-8B samples with Mo_5SiB_2 interlayer as well as (left) Mo-55Si-10B and (right) Mo-71Si-8Al topcoats after oxidation at 1000 °C for 100 h in air