Elevated Temperature Coating Layer Designs for Mo-Si-B Alloys

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High temperature coating layer designs and the corresponding interface compatibility associated with oxide formation upon high temperature exposure have been examined in the Mo-Si-B system. For a base alloy of Mo-14.2 at. % Si-9.6 at.. % B with a threeee-phase microstructure of Mo + Mo_53SiB_2 (T_2 phase) and Mo_3Si oxidation in air at 1000°C and 1200°C yields borosilicate and MoO_2 product layers (Figure 1a). The formation of MoO_2 indicates that the borosilicate layer restricts the oxygen activity by inhibiting partially the penetration of oxygen. For a more complete control of oxygen penetration several coating approaches on selected Mo-Si-B alloy substrates have been explored including thermal spray coatings, silicide diffusion coatings and oxide spray coatings. A number of successful coating strategies have been identified to limit oxygen penetration into the substrate. Among the coating materials examined, titanium oxide (TiO_2) which is in equilibrium with silica and molybdenum oxides has been shown to be more oxidation resistant than a Yttria-Stabilized-Zirconia (YSZ) coating as reflected by a thinner layer thickness of thermally grown oxide upon oxidation at 1200 °C. For silicide diffusion coatings from Silicon pack cementation, a single layer of $MoSi_2$ with MoB particles was synthesized, which transforms into Mo_5Si_3 upon the subsequent high temperature exposure. The Mo_5Si_3 (T_1 phase) layer showed high oxidation resistance due to B transfer from the substrate and the formation of the predominantly T_2 phase layer which acts as an effective Si diffusion barrier. The T_2 phase layer is in a local equilibrium with the T_1 phase which also accounts for the maintenance of Boron solubility in the T_1 phase layer. Similarly, crystalline and amorphous SiO_2 spray coatings yield a significant increase in oxidation resistance compared to the uncoated substrate (Figure 1b-c). The key issue in this case appears to be the control of B to Si ratio in the passive borosilicate layer formed on the substrate. A coating strategy based upon kinetic biasing to limit the oxygen flux and enhance oxidation resistance is presented (Figure 2). Interface layer compatibility and growth kinetics of oxides and other synthesized phases are discussed. The support of ONR (N00014-02-1-0004) is gratefully acknowledged.

FIGURE 1

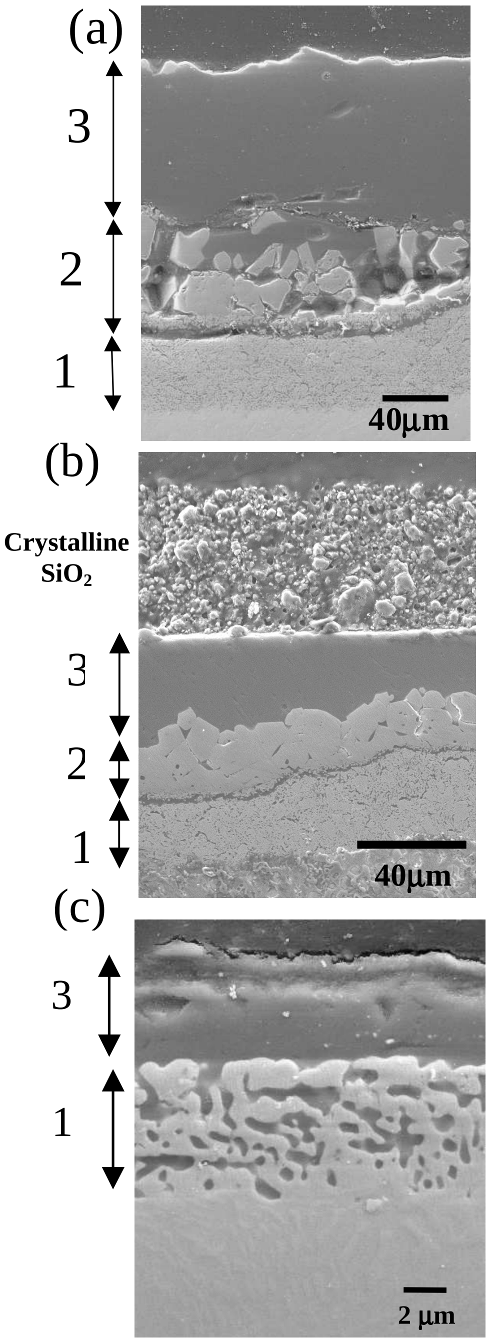

FIGURE 1: Cross section BSE image of (a) uncoated and (b) crystal SiO_2 powder sprayed and (c) amorphous SiO_2 powder sprayed Mo-14.2Si-9.6B (at%) alloy following oxidation at 1200 °C for 100 hr. (The numbers indicate (1) Mo(ss) phase with internal oxide precipitates, (2) MoO_2 and (3) borosilicate layer. The region below (1) in (a) is the alloy substrate.)

FIGURE 2

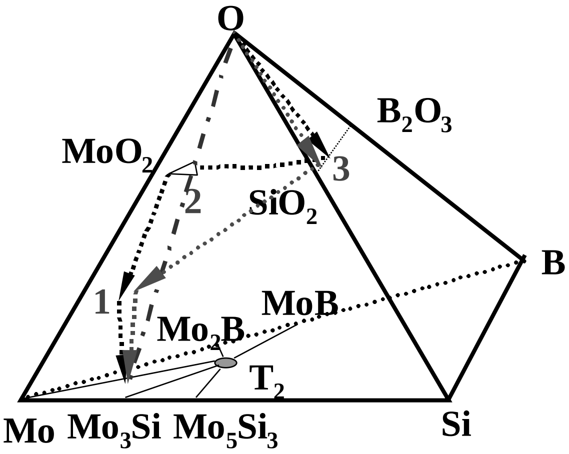

FIGURE 2: Schematic illustration of the diffusion pathway indicating the phase evolution upon oxidation of a Mo-Si-B alloy located in the Mo-Mo_3Si-T_2 three phase field. The SiO_2 spray coating strategy is based upon kinetic biasing to limit the oxygen flux and enhance oxidation resistance (Fig.1b-c). With an amorphous SiO_2 coating (Fig.1c), the formation of MoO_2 phase (layer # 2) is completely eliminated.