Quarterly Management Report

WBS Element	Project Title	Contract Number	Contract Start	Contract End
	Novel Processing of Mo-Si-B Intermetallics for Improved Efficiency of Power Systems	W-7405-ENG-82	06/01/00	09/30/05

Performer Name and Address	Principal Investigator(s)
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BUDGET AND COST REPORT

Prior Year Funds [$K]	30
Total Current Year Commitment $K]	180
Projected Current Year Costs [$K]	150

	O	N	D	J	F	M	A	M	J	J	A	S
Planned Costs	5	9	17	39	61	75	101	111	121	131	141	150
Actual Costs	5	9	17	39	61	75						
Variance	0	0	0	0	0	0	101	111	121	131	141	150

MILESTONE REPORT

Milestone Designation	Milestone Description	Due Date	Revised Due Date	Completion Date
	Conduct exposure tests on example thermal barrier coatings composed of molybdenum silicides. This will be to demonstrate the concept of a protective	01/30/05		01/30/05
	Complete microstructural analysis and evaluation of oxidation barrier coatings. Evaluation of the coatings for mechanical adhesion and chemical compatibility.	04/30/05		04/30/05
	Conduct 1600°C exposure tests of optimized molybdenum silicides in simulated combustion environment. Evaluation of the most promising alloy prior to doing	07/30/05		07/30/05
	Complete microstructural analysis and evaluation of combustion environment testing at 1600°C. Evaluation of mechanism of scale formation,	09/30/05		09/30/05

TECHNICAL HIGHLIGHTS

Second Quarter Highlights

The tasks completed this quarter include developing coating strategies to protect the bcc-Mo+T2 (Mo5SiB2)-based alloys from oxidation. Two different coating processes were investigated. First, the T1-based alloy was plasma-sprayed onto Mo substrates to determine the feasibility of protecting the bcc-Mo+T2(Mo5SiB2)-based alloys. This work showed that air plasma spraying leads to excessive loss of Si, shifting the overall phase assemblage of the coating to a T1+T2 composition. The microstructural evolution of the coating upon annealing was studied. The second coating strategy involved siliconizing the surface of the bcc-Mo based alloy by the halide activated pack-cementation (HAPC) process. This vapor-phase process deposits Si onto the surface of the alloy, which reacts at the deposition temperature of 900°C to form a conformal layer of MoSi2. The microstructure and oxidation resistance of the coating were investigated as a function of HAPC processing parameters.

Both the plasma sprayed tiles and the HAPC coated substrates were examined by X-ray diffraction (XRD, Scintag XDS 2000, Cupertino, CA) to identify the phases formed, and both the surface and cross-section were examined by scanning electron microscopy using backscattered electron imaging (SEM/BSE, JEOL, JSM 6100, Peabody, MA) with energy dispersive spectroscopy (EDS, Oxford Instruments, Valley, CA). For oxidation testing, the coated substrates were first oxidized in air at 1100°C to form a protective glassy scale. For the plasma sprayed tiles, this step resulted in the complete oxidation of the plasma sprayed Alloy 3 coating and the underlying Mo foil, leaving an intact Alloy 1 plasma-sprayed coating. The samples were then heated to 1600°C in ambient air. For quantitative measurement, the oxidation coupons were suspended from a sapphire wire in a vertical tube thermo-gravimetric analyzer using an electrobalance sensitive to 0.01 mg (Cahn-2000, Cahn Instruments, Inc., Cerritos, CA). The surface and cross-section of the oxidized samples were analyzed similarly as the coated samples.

The evaluation of the thermally sprayed Alloy 3 coating, showed it to be much thinner and more porous than the Alloy 1 coating, was dominated by very large and irregular pores exceeding 50 m in size. The matrix phase of the coating was bcc-Mo (from XRD analysis) containing measurable Si in solution (3.5 at% by EDS). There was a minor amount of finely distributed T2 phase. No distinct interface was evident between the Mo substrate and the Alloy 3 coating, indicating that annealing promoted formation of an intimate bond between the Mo-phase components of the coating and the substrate. A uniform coating layer with a thickness of about 8 m formed on the substrate.

The HAPC of the Alloy 3 was examined by SE/EDS and XRD analysis confirmed that the coating was MoSi2. Although the edges of the coupon were rounded prior to HAPC, the MoSi2 layer still cracked in that area. However, the density and phase control of the HAPC is very promising. Analysis of the phase reactions suggests that the coating must include some boron to provide the appropriate chemistry at the near surface to improve the oxidation resistance. Work in the next quarter will include testing a number of pack cementation chemistries to improve the conformal coverage of the coatings and to optimize their performance at high temperatures.

ISSUES

Andy Thom, a staff member who has been working on this project for has taken a new position at another institution. We have replaced him with a post doctoral candidate, Yali Li.

Report Prepared By	Date
Matthew J. Kramer	05/31/05