# 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) |
|---|---|
| Dr. Surya Mallapragada<br>144a Spedding Hall<br>Iowa State University<br>Ames, IA 50011 | Dr. Matthew J. Kramer<br>Dr. Mufit Akinc<br>Dr. Andrew J. Thom |

## BUDGET AND COST REPORT

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|---|---|
| **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 | | | | | | | | | |
| **Variance** | 0 | 0 | 0 | 39 | 61 | 75 | 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 |
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## TECHNICAL HIGHLIGHTS

First Quarter Highlights

The Mo-Si-B system, compositions based on the T1 phase, Mo5Si3Bx, have excellent oxidation resistance and creep strength. However, these alloys also have low fracture toughness, and the thermal expansion anisotropy of the T1 phase make these alloys susceptible to thermal stress induced microcracking. These deficiencies in mechanical behavior can be improved by moving towards the Mo-rich portion of the system. Alloys which incorporate the bcc-Mo phase have dramatically improved fracture toughness, but they present a challenge in achieving oxidation resistance on par with Mo5Si3Bx-based alloys. The oxidation resistant phase of these alloys is the T2 phase (Mo5SiB2), and its high boron content renders a borosilicate glass with a viscosity much lower than that formed on the T1 phase. Plasma spraying of the T1-based composition has been investigated and those results indicated that reasonable coating densities can be achieved without excessive loss of Si and B due to evaporation during spray transit time. Preliminary tests on these coatings have demonstrated the feasibility of this technique in providing a stable oxidation barrier to the more metal rich alloy.

Coupons of Mo metal were thermally sprayed at Idaho National Engineering Laboratory in collaboration with Richard Wright. The metal coupons were air sprayed using Ames Alloy 1 and Ames Alloy 3. To evaluate the oxidative response of these coating, the plasma-sprayed tile was first pre-oxidized at 1100°C for 1 hour in ambient air. The Alloy 3 coating, which is essentially pure bcc-Mo, and the Mo substrate were completely oxidized, leaving an intact Alloy 1 plasma-sprayed coating. The coating was then oxidized for 500 hours in flowing air at 1600°C and the mass change as a function of time was determined. The parabolic rate constant, kp, (1.9x10-3 mg2/cm4/hr) was comparable to monolithic Alloy 1 (1.5 x 10-2 mg2/cm4/hr), indicating that the plasma spray process does not have a detrimental effect on the intrinsic oxidation resistance of Alloy 1. The rapid loss of Si during thermal spraying in air is potentially problematic for an industrial process. However, there are a number of work-arounds for this. 1) Relative mass loss of Si can be determined for specific thermal spray conditions and the starting composition altered. 2) Thermal spray in a controlled inert environment is common place now and has been demonstrated as a viable processing route at Ames Laboratory. 3) There are other techniques to applying a siliconized coating; the most common is halide activated pack cementation (HAPC). HAPC is a well studied and industrial viable method for coating monolithic parts. Options 2 and 3 will be pursued next two quarters to evaluate their relative merits.

## ISSUES

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