Quarterly Management Report

WBS Element	Project Title	Contract Number	Contract Start	Contract End
	Aluminide Coatings for Power-Generation Applications	4000007035	01/21/01	02/29/04

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

Prior Year Funds [$K]	36
Total Current Year Commitment $K]	0
Projected Current Year Costs [$K]	36

	O	N	D	J	F	M	A	M	J	J	A	S
Planned Costs	3	5	20	28	36							
Actual Costs	2	4	19									
Variance	1	1	1	28	36	0	0	0	0	0	0	0

MILESTONE REPORT

Milestone Designation	Milestone Description	Due Date	Revised Due Date	Completion Date
TTU-2-1	Task I. Aluminide Coatings on Fe-based Alloys	09/30/04		
	• To investigate the effect of substrate compositions on the quality and oxidation performance of iron aluminide coatings			
	• To complete the study of long-term interdiffusion behavior (up to 10,000h) between iron-aluminide coatings and steel substrates			
TTU-2-2	Task II. Aluminide Coatings on Ni-based Superalloys	09/30/04		
	• To synthesize the Pt-enriched gamma + gamma prime two-phase coatings			
	• To study the cyclic oxidation behavior of the Pt-enriched gamma + gamma prime coatings			

TECHNICAL HIGHLIGHTS

Task I – Aluminide Coatings on Fe-Based Alloys

• Cast alloys with lower N levels were made and aluminized

Preliminary results have indicated that interstitial elements in the substrate alloys appear to affect aluminide coating quality. In particular, nitrogen in the commercial steel substrates has caused the formation of AlN particles/thin layers at the coating/substrate interface, which results in poor adhesion of the as-deposited coatings. The surface of some as-deposited specimens was not fully covered after aluminization via chemical vapor deposition (CVD), and the uncovered area was found to be rich in Al and N. In general, the interstitial elements such as N and C are added in austenitic and ferritic steels primarily for strengthening; the level of N is controlled in Fe-9Cr-1Mo to improve its creep resistance. The concentrations of the interstitial elements C and N in these commercial steels are relatively high, e.g., the level of N is ~500 ppm in Fe-9Cr-1Mo and ~800 ppm in 304L. As indicated in an earlier study of the formation of aluminide coatings on austenitic stainless steels, as Al diffuses into the steel substrate, a localized transformation from austenite to ferrite occurs and the higher diffusivity in ferrite enhances the Al diffusion. The solubility of carbon in ferrite is substantially lower than that in austenite and thus at the transformation front, the carbon has been found to precipitate out in the form of stable carbides. However, whether nitrogen behaves in a similar way during aluminizing process has not been studied. Also, Agüero et al. have recently observed in their slurry iron aluminide coatings “needle-like” precipitates of an unidentified phase rich in Al at the coating/substrate interface, which could be AlN. Therefore, in order to clarify the effects of these interstitial elements, particularly nitrogen, on coating formation and performance, cast ferritic and austenitic alloys with lower N levels (~200 ppm in Fe-9Cr-1Mo and ~300 ppm in 304L) were made using a laboratory arc-melting and drop-casting process. The cast alloys went through the same thermal processing as the commercial alloys in order to maintain the same grain size and structure. They were then aluminized in a CVD reactor in ORNL. Microstructural analysis and cyclic oxidation testing of the coating specimens are underway for comparison with the commercial alloys that have higher N contents.

• Submitted the final report of this project, “Aluminide Coatings for Power-Generation Applications”, ORNL/Sub/01-47035/01, December 2003.

• Completed a manuscript entitled “Interdiffusion Behavior in Aluminide Coatings for Power Generation Applications”, by Y. Zhang, B. A. Pint, J. A. Haynes, K. M. Cooley, A. Liu, and I. G. Wright, and it is under internal review.

Task II – Aluminide Coatings on Ni-Based Superalloys
• Synthesis of Pt-enriched g+g’ coatings

State-of-the-art thermal barrier coating (TBC) systems, which are used to protect superalloy components in the hot section of gas turbine engines, typically consist of an oxidation-resistant metallic bond coat overlaid with a thermally insulating ceramic top layer. Platinum aluminide diffusion bond coatings are now an accepted industrial standard, outperforming conventional aluminides under high-temperature oxidation, cyclic oxidation, and hot-corrosion conditions. While extensive work has focused on two-phase PtAl2+(Ni,Pt)Al or single-phase (Ni,Pt)Al coatings fabricated by pack cementation or CVD, another type of bond coat having a Pt-enriched g+g’ microstructure has been much less studied. However, recent work in Europe has indicated promising performance for this g+g’-type bond coat. It has been reported that relative to CMSX-4 single-crystal superalloy with a standard NiCoCrAlY bond coat, the new g+g’ bond coat provides a nearly 20-fold increase in life for an optimized microstructure. It is believed that the g+g’ coating could provide a stronger bond coat system that offers high creep strength, thus resisting interface instability between the Al2O3 scale and bond coat. The g+g’ coating system could also offer better compatibility between coating and superalloy substrate (which also has a g+g’ microstructure) and therefore is metallurgically more stable in limiting substrate element diffusion. In addition, the g+g’-type coating could be more cost effective as the aluminizing process is eliminated in coating fabrication. The superalloy used as the substrate for the g+g’-type coating system needs to contain more than ~ 4.5 wt.% Al so that a protective alumina oxide scale can form on it. The present study focuses on synthesis and testing of a Pt-enriched g+g’-type coating on a directionally-solidified (DS) Ni-based superalloy René 142. The DS alloy René 142 is chosen as the substrate alloy primarily because it is widely used in many applications and less expensive as compared with single-crystal superalloys, particularly when considered for large-sized components in land-base turbine engines. Some René 142 coupons were Pt-plated in a laboratory plating system developed at Tennessee Technological University (TTU). The specimens were cut into four pieces; while one was kept as the as-plated condition, the other three were annealed for 2h at different temperatures (1100, 1150, and 1200°C). The specimens will be characterized after annealing treatments to determine whether a two-phase microstructure is obtained.

(Note that g+g’ stands for gamma + gamma prime.)

ISSUES

Report Prepared By	Date
Ying Zhang	01/26/04