Quarterly Management Report

WBS Element	Project Title	Contract Number	Contract Start	Contract End
	Aluminide Coatings for Power-Generation Applications	4000032193	05/10/41	03/31/07

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

Prior Year Funds [$K]	40
Total Current Year Commitment $K]	0
Projected Current Year Costs [$K]	78

	O	N	D	J	F	M	A	M	J	J	A	S
Planned Costs	2	6	12	15	25	35	40	47	60	73	76	78
Actual Costs	2	6	11									
Variance	0	0	1	15	25	35	40	47	60	73	76	78

MILESTONE REPORT

Milestone Designation	Milestone Description	Due Date	Revised Due Date	Completion Date
TTU-2-1	Task I. Aluminide Coatings on Fe-based Alloys	09/30/05		
	• To set up a laboratory pack cementation system at TTU to coat relatively large specimens for testing in power-generation environment			
	• To compare the oxidation and/or corrosion performance of the pack coatings with the aluminide coatings made by chemical vapor deposition (CVD)			
TTU-2-2	Task II. Aluminide Coatings on Ni-based Superalloys	09/30/05		
	• To investigate the oxidation performance and rumpling behavior of the Pt-enriched gamma + gamma prime coatings on single-crystal superalloys			
	• To synthesize NiAl and/or (Ni,Pt)Al coatings modified with reactive elements such as hafnium by pack cementation using different doping approaches			

TECHNICAL HIGHLIGHTS

Task I – Aluminide Coatings on Fe-Based Alloys

• Finished the setup of a pack cementation coating system at TTU

Even though the CVD aluminizing process can produce aluminide coatings with higher purity, the size of the current CVD reactor at ORNL has limited its coating capacity. The horizontal hot-wall CVD reaction chamber consists of an alumina tube of 5.0-cm i.d. and 61-cm length which is heated by a cylindrical graphite susceptor through a 20 kW radio frequency generator. The effective heating zone is ~ 8cm in axial length, where the temperature variation along the axial direction is within ±5°C. In each CVD aluminization run only two or three coupon specimens with the dimensions of ~1.8 x 1.4 x 0.15 cm can be coated. In order to coat more specimens under identical coating processing conditions, or coat larger-sized specimens for testing in power-generation environment, a more economic and practical route needs to be developed. Pack cementation, as a relatively inexpensive and commercially feasible diffusion coating process, has been used in industry to produce corrosion- and wear-resistant coatings for nearly a decade. In general, this process is very versatile, capable of coating large objects such as long pipes, large plates or complex shaped turbine hardware, although small internal passages could represent a problem. Previous work by Rapp et al. on both thermodynamic calculation and coating development has clearly indicated the potential of pack aluminide coatings for power-generation applications. However, lack of systematic testing data makes it difficult to address some critical issues associated with these coatings, such as the loss of Al from the coating into the substrate alloys and possible compatibility problems between Fe-Al coatings and substrates due to their different coefficients of thermal expansion (CTE).

In the past several months some major components, such as a general-purpose mechanical pump, an alumina tube, some stainless steel gas lines, etc. were procured. Utilizing an existing Lindberg/Blue tube furnace (3-zone heating, up to 1200°C) a pack cementation system has been set up at TTU. Compared with the ORNL CVD reactor, a more uniform and longer effective heating zone up to ~ 28 cm within ±5°C has been achieved. With this system, 10-20 coupon specimens can be easily fit in the chamber during each coating cycle. Small tubing samples can also be coated. Some testing pack cementation runs will be conducted.

Task II – Aluminide Coatings on Ni-Based Superalloys

• Single-crystal Ni-based superalloy specimens were coated with the Pt-enriched g+g' two-phase coatings, and some preliminary cyclic oxidation tests (100 1h cycles at 1150°C) have been completed

Based on the promising oxidation behavior at 1100°C of a directionally solidified (DS) Ni-based superalloy coated with a Pt-enriched g+g' two-phase coating, more DS superalloy specimens with 1.37 wt.% Hf, René 142-C, and some second-generation single-crystals superalloys such as René N5 were electroplated with a thin layer of Pt (~ 7 µm). This was done via an industrial standard electroplating process by Howmet Corporation (Whitehall, MI). The coated specimens were then diffusion treated at 1150°C for 2h in vacuum (< 10-7 torr) at ORNL to form a two-phase microstructure in the coating layer.

In the present study, the cyclic oxidation test was conducted on the coating specimens at 1150°C for 100 1h cycles. The single-phase beta-(Ni,Pt)Al coatings which are the current industrial standard bond coat in thermal barrier coating systems also were included for comparison. These (Ni,Pt)Al coatings were synthesized by first electroplating the substrate with ~ 7 µm of Pt by Howmet Corporation and then aluminizing the electroplated substrate in ORNL's ultra-clean CVD reactor for 6h at 1100°C. After 100 1h cycles at 1150°C, although mass loss was observed for g+g'-coated René 142-C alloy, René N5 specimen with the g+g' coating registered very small mass gain. Note that the g+g' coating on René 142-C synthesized by the industrial Pt electroplating showed poorer oxidation performance as compared with the g+g' coating made by a laboratory plating process, as previously reported. More investigation is needed to elucidate the effect of the Pt plating process on the oxidation performance of g+g' coatings. Localized spallation occurred on the René N5 specimen with the g+g' coating after 100 cycles at 1150°C. However, the same alloy coated with the CVD beta-(Ni,Pt)Al coating did not indicate evident spallation although cracking was found in some regions in the oxide scale. Surface roughness measurement is being undertaken on these coating specimens using laser profilometry to examine the plastic instabilities (or rumpling) of the two types of coatings.

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

ISSUES

Report Prepared By	Date
Ying Zhang	01/20/05