Quarterly Management Report

WBS Element	Project Title	Contract Number	Contract Start	Contract End
UT-2(A)	Study of Microstructure and Mechanical Behavior of TiAl Alloys.	11X-SP173V	09/15/93	07/31/07

Performer Name and Address	Principal Investigator(s)
The University of Tennessee Department of Materials Science and Engineering Knoxville, TN 37996-2200	P. K. Liaw

BUDGET AND COST REPORT

Prior Year Funds [$K]	1
Total Current Year Commitment $K]	98
Projected Current Year Costs [$K]	98

	O	N	D	J	F	M	A	M	J	J	A	S
Planned Costs	73	76	80	82	84	87	89	92	94	98	101	104
Actual Costs	71	73	75	79	81	83	85	87	92			
Variance	2	3	5	3	3	4	4	5	2	98	101	104

MILESTONE REPORT

Milestone Designation	Milestone Description	Due Date	Revised Due Date	Completion Date
UT-2(A)-1	Characterize the effects of W on the microstructures and phases of the Ti-Al-Nb-W-B alloys.	04/30/05		04/30/05
UT-2(A)-2	Provide the optimal composition and heat treatments of the Ti-Al-Nb-W-B alloy to obtain the desirable microstructure for high-temperature applications.	06/30/05		06/30/05
UT-2(A)-3	Conduct the microstructure investigation on the large ingot, composed of the optimal composition, Ti - 45Al-7Nb-0.15B-0.4W.	09/30/05		09/30/05
UT-2(A)-4	Analyze the homogeneity and the composition of the large ingot.	12/31/05		12/31/05
UT-2(A)-5	Analyze the microstructural differences in the large magnetic-floatation ingot and the small drop-cast samples.	04/30/06		04/30/06
UT-2(A)-6	Investigate the high-temperature residual beta-phase of the large ingot after different heat-treatments, study the related influence on the TiAl phase diagram.	08/31/06		08/31/06
UT-2(A)-7	Compare the microstructures of the as-cast and post HIP samples of the large ingot, conduct different heat-treatments.	12/31/06		12/31/06
UT-2(A)-8	Perform microstructure analyses of the heat-treated TiAl-based samples.	03/30/07		03/30/07
UT-2(A)-9	Conduct tensile tests on the as-cast and heat-treated TiAl-based samples.	06/30/07		

TECHNICAL HIGHLIGHTS

The TiAl intermetallic alloys with their low densities, improved oxidation resistances, good creep resistances, and high-temperature strengths made them very attractive materials for high-temperature applications. Efforts to enhance the ductility, and refine the grain size in these materials have focused on the addition of alloying elements. The addition of Nb provides the most effective method for improving the room-temperature ductilities, fracture toughnesses, and oxidation resistances. The addition of W can result in an enhancement of mechanical properties, such as yield strengths, ultimate tensile strengths, and the refinements in microstructures. The boron addition in lamellar TiAl alloys has a significant effect on room-temperature tensile ductilities.

In the past period of time, a literature survey on the relationship between the microstructure and the mechanical properties of the TiAl intermetallic alloys, and the effect of additional elements, such as niobium, tungsten, and boron, on the microstructures and mechanical properties of the intermetallic alloys have been conducted.

Heat treatments of the Ti-44 at.%Al-8.5 at.%Nb-1.5 at.%W-0.05 at.%B sample have been performed as follows: at 1,100C for 48 hrs; at 1,240C for 10 hrs; at 1,310C for 5 hrs; and at 1,400C for 2 hrs. Based on these experimental temperatures, heat-treating temperature ranges for the newly fabricated TiAl-based alloys have been scheduled, as shown below.

Four newly fabricated materials have been received from the Oak Ridge National Laboratory. These alloys are: Ti-45Al-7Nb-0.15B; Ti-45Al-7Nb-0.15B-0.2W; Ti-45Al-7Nb-0.15B-0.4W; and Ti-45Al-7Nb-0.15B-0.7W (#52, #53, #54, and #55) in atomic percent. Heat treatments have been conducted on these alloys. After HIPping the as-cast alloys at 1,250C, 150 MPa for 4 hrs, and heat treated at 1,250C for 16 hrs to obtain equilibrium structures, additional heat treatments have been conducted: 900C for 360 hrs; 1,265C 18 hrs; 1,280C for 14 hrs; 1,295C for 10 hrs; and 1,310C for 5 hrs. The reason for scaling the temperatures between 1,265C and 1,310C is to determine the transus temperature of the alpha phase.

With the application of the optical microscope, scanning-electron microscope (SEM), and transmission-electron microscopy (TEM), microstructures and compositions of the TiAl-based samples have been carefully analyzed. A fine fully lamellar structure can be obtained after heat treating at a temperature slightly below the alpha-phase transus temperature. With the application of the electron microprobe, the beta-phase was found in sample #55, Ti-45Al-7Nb-0.15B-0.7W. This trend indicates that when the amount of W exceeds 0.5 at.%, the beta-phase can be triggered to form.

Combining the study on the microstructures related to different heat treatments with the result from differential thermal analyses (DTA), the alpha-phase transus temperature has been determined to be in the range of 1,295-5C and 1,290+5C.

After heat treatments and sample characterizations, the Ti-45Al-7Nb-0.15B-0.4W alloy is determined to be a newly developed TiAl-based alloy, which has good properties and promising applications. A fine grain size, smaller than 50 um, can be reached using this composition without any hot deformations or cyclic heat treatments.

The large ingot, with the desirable composition obtained from previous experiments, Ti-45Al-7Nb-0.15B-0.4W, is fabricated through the magnetic-floatation-melting method. An average grain size of 60 um can be obtained. Microstructures of the as-cast, homogenized, and heat-treated samples have been investigated. The beta-phase has been found in the alloys.

Analyses of the homogeneity of the microstructure and composition in the as-cast ingot has been conducted. The difference in the microstructures of the small drop-cast samples and the large magnetic floatation samples has been studied.

The amount of the high-temperature residual beta-phase can be reduced after desirable heat treatments. Studies on the phase diagram of this newly developed TiAl-based alloy has been conducted.

Heat-treatments have been conducted on the as-cast and HIPped samples of the large ingot. Optimal heat treating temperature and heat-treating time have been selected in order to obtain desirable phase structures for the mechanical test.

Tensile tests will be performed on the samples, which have the optimal microstructures.

The hot deformation technique on the large ingot samples will be conducted if necessary.

ISSUES

None

Report Prepared By	Date
P. K. Liaw	05/10/07