Quarterly Management Report

WBS Element	Project Title	Contract Number	Contract Start	Contract End
ORNL-2(I)	Mo-Si Alloy Development	FEAA028	10/01/04	09/30/05

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

Prior Year Funds [$K]	8
Total Current Year Commitment $K]	150
Projected Current Year Costs [$K]	150

	O	N	D	J	F	M	A	M	J	J	A	S
Planned Costs	13	26	39	52	65	78	91	104	11	130	143	150
Actual Costs	16	26	35	41	58	75						
Variance	(3)	0	4	11	7	3	91	104	11	130	143	150

MILESTONE REPORT

Milestone Designation	Milestone Description	Due Date	Revised Due Date	Completion Date
ORNL-2(I)-1	Ductilize molybdenum by incorporating MgAl2O4 spinel particles	02/28/05		02/28/05
ORNL-2(I)-2	Determine reasons for toughening of Mo-Si-B alloys by Zr-additions	06/30/05		
ORNL-2(I)-3	Determine tensile creep properties of Mo-Si-B alloys with different Mo solid solution volume fractions	12/31/05		
ORNL-2(I)-4	Fabricate Mo-Si-B-based solid solution alloy for fracture toughness testing	03/31/06		
ORNL-2(I)-5	Prepare amorphous Fe-based alloys by melt-spinning	09/30/06		
ORNL-2(I)-6	Create oxide dispersoids by internal oxidation of amorphous Fe-based melt-spun ribbons	05/31/07		

TECHNICAL HIGHLIGHTS

Previously, Mo-$MgAl_2O_4$ materials with $MgAl_2O_4$ volume fractions of 0.1, 2.5, and 5.0% were fabricated by hot-pressing of powders. A maximum in the room temperature ductility was found for 2.5 vol.% $MgAl_2O_4$ spinel. Metallographic examination revealed that (1) the Mo grain size decreased with increasing $MgAl_2O_4$ volume fraction, and (2) that the tested tensile specimens exhibited surface microcracks with lengths on the order of the grain size. Since the tensile specimens did not show necking it is thought that catastrophic fracture occured once a surface microcrack reached a critical local stress intensity factor. Typically, this will be the largest microcrack in the specimen. The size of the largest microcracks lies in a region of the size distribution in which the statistical significance is poor, since only a very small fraction of the surface microcracks exhibits the large size that can lead to fracture. This is presumably the reason why the ductility exhibits significant scatter - the elongation to fracture of three Mo-2.5 vol% $MgAl_2O_4$ specimens at a strain rate of 1E-2/s was 10.4, 13.5, and 25.6%, respectively. For relatively small $MgAl_2O_4$ volume fractions, the associated reduction in the grain size is expected to reduce the size of the surface cracks. From fracture mechanics arguments, a higher applied stress is therefore required to reach the critical local stress intensity factor required for catastrophic fracture to occur. This, in turn, results in a higher ductility. When the $MgAl_2O_4$ volume fraction increases further, the brittleness of the $MgAl_2O_4$ particles eventually becomes more important than the ductility improvement due to the reduction in grain size, and the ductility decreases. Thus, a reasonable rationalization of the ductility enhancement of Mo by $MgAl_2O_4$ spinel particles has been found. Scruggs, in his 1967 patent, assumed impurity gettering to be the main reason for the ductility enhancement. It is not clear yet to what extent, if at all, gettering is involved in the ductility enhancement found in the present work. In the present work, the fracture mode was exclusively intergranular. It is not clear whether a ductility enhancement would be observed if the fracture mode would be changed from intergranular to transgranular, for example by micro-alloying with Zr. Thus, the present work raises more questions than answers.

ISSUES

None

Report Prepared By	Date
Joachim H. Schneibel	05/25/05