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Dear Haghi, S. M. A., Sajjadi, S. A., Babakhani, A.

We appreciate your active participation in the CCFA-4, also thank you for presenting your paper in this conference, entitled:

In Situ Fabrication of Multi Layers Al-Al2O3 Functionally Graded Composite via Hot Press Method

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The 4th International Conference on Composites: Characterization, Fabrication and Application (CCFA-4)
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In Situ Fabrication of Multi Layers Al-Al_2O_3 Functionally Graded Composite via Hot Press Method

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Abstract

In this study fabrication of three - and five - layer Al-Al_2O_3 graded composite (FGCs) including 5.7-18.7 vol% and 5.7-15.4 vol% of Al_2O_3 phase, respectively via ball milling of Al and ZnO powder and thereafter hot pressing at 580^{0}C was investigated. The synthesis of alumina particulates was accomplished via aluminothermic reaction in Al - matrix. The occurrence of aluminothermic reaction was investigated by XRD analysis. OM and SEM studies were performed to observe porosity, the interfaces between layers, and the alumina particulates. The results showed that five - layer Al-Al_2O_3 FGCs have better gradient in hardness. In addition, maximum hardness and relative density were measured as 137.4 Hv and 99.5%, respectively.

Keywords: FGCs, Al-Al_2O_3, Aluminothermic Reaction

I. INTRODUCTION

Aluminum matrix composites reinforced with particles have high elastic modulus, high special strength and good wear properties, also they have excellent high temperature properties in comparison with conventional aluminum alloys [1]. An in-situ metal matrix composite (MMC) is a multiphase material whose reinforcing phases are synthesized in the metal matrix by chemical reactions during fabrication [2]. In order to fabricate Al - matrix composite reinforced with Al_2O_3 particles, a mixture including a metal oxide less stable than Al_2O_3 with more stoichiometric percentage of Al is mixed. In sintering, a portion of Al reduces the metal oxide phase in the aluminothermic reaction (Equation 1) and the other forms the composite's matrix.

$$3MO+2Al=Al_2O_3+3M \quad (1)$$

Functionally gradient materials (FGMs) are materials with a variation of composition and microstructure along their thickness. Functionally gradient composites (FGCs) are a special class of two-phase FGMs, in which the gradient is introduced via a variation in the two-phase mixture [3]. Various processes are utilized to fabricate FGMs which can be categorized in three basic groups: gas, melt and powder metallurgy processes. Fabrication of Al-Al_2O_3 FGCs is performed using several procedures including hot press [4], pulse current pressure sintering [5], centrifugal casting [6] and pressureless sintering [7].

In this paper, the fabrication of three and five layers Al-Al_2O_3 FGCs via hot press of Al and ZnO powder mixture with simultaneous occurrence of aluminuthermic reaction (Equation 2) was investigated.

$$3ZnO+2Al=Al_2O_3+3Zn \quad (2)$$

II. EXPERIMENTAL PROCEDURE

Al and ZnO powders mixture with particle size of 45µm and 5µm, respectively were ball milled with 280rpm and ball to powder ratio of 15:1 for 60min via planetary ball milling device to fabricate three - and five - layers FGCs (TABLE1). Cylindrical samples with 19.5mm diameter were hot pressed at 580˚C for 30min under 90MPa pressure. XRD Analysis in 2θ=20^0-90^0 was performed on layer 1 of samples. Relative density was measured by Archimedes procedure. Vickers hardness test with 10Kgf load was used. SEM and EDS investigations were conducted in order to microstructure characterizing.

III. RESULTS AND DISCUSSION

XRD results (Fig. 1) from layer 1 indicates the accordance of aluminuthermic reaction and Al_2O_3 formation. The resulted Zn is dissolved in Al matrix and probably partially precipitated in Al particle boundaries. Other XRD picks are duo to the nonrelative compounds resulted from materials and processes.

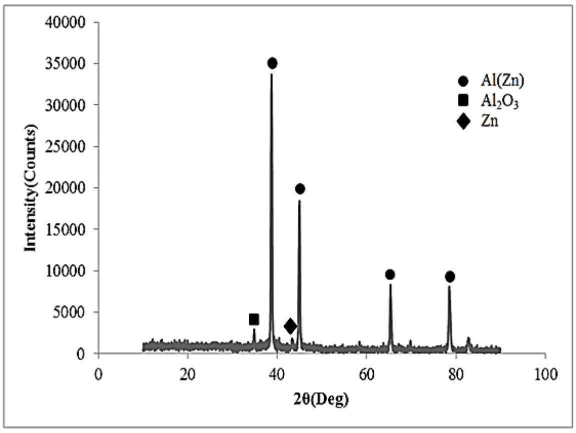

Fig. 1: XRD result of layer 1 hot pressed in 580^{0}c.

The relative density of each sample is shown in table 1. Relative density of near 100% was achived by using hot press method.

TABLE 1: SAMPLES SPECIFICATIONS

Sample No.	Sintering Temp (^{0}C)	Sintering Pres. (MPa)	Al_2O_3 (vol.%)	Relative Den. (%)
1	580	90	15.6	98.5
			10.6	
			5.3	
2	580	90	13.2	99.5
			11.4	
			9.5	
			7.5	
			5.3	

Fig. 2 shows hardness magnitude of each layer for the two samples. It can be seen that sample 2 has better gradient in hardness duo to the lower porosity content. Fig 3 shows SEM micrograph of layer 5 of sample 2. In this figure, the gray matrix is Al and white fine spherical particles in the matrix are Zn precipitates resulted from the aluminothermic reaction.

Fig. 4 shows the EDS analysis from Al powder particle boundaries in the location of white Zn precipitates. The Zn picks are related to the white course particles which are the Zn rich precipitations. Al and O picks indicate the formation of Al_2O_3 particles in the boundaries.

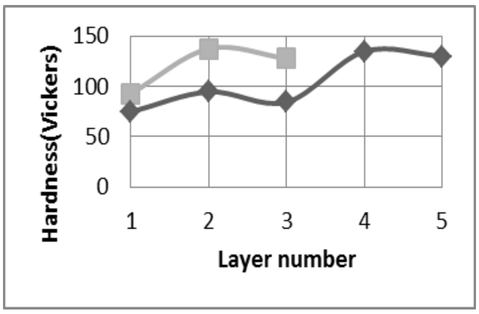

Fig. 2: Hardness of each layer of the two samples.

The presence of C pick is duo to the graphite used for die lubricating in hot press process.

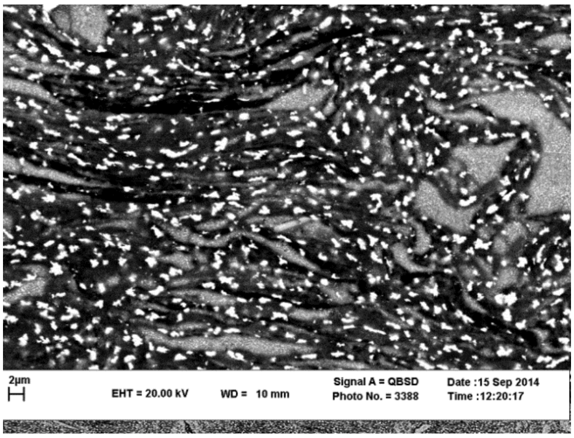

Fig. 3: SEM micrograph of layer 5 of sample 2 .

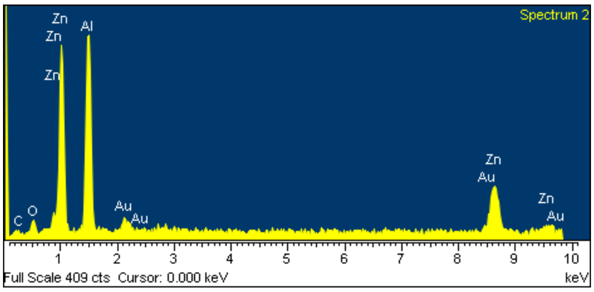

Fig. 4: Spot EDS Analyze from the Al particle boundaries in the location of white Zn precipitates.

IV. CONCLUSIONS

In this investigation, three - and five - layer Al-Al_2O_3 FGCs with relative density of 98.5% and 99.5%, respectively via ball milling of Al and ZnO powders and thereafter hot pressing in 580^{0}c under 90MPa pressure were fabricated. Resulted microstructure consisted of Al matrix including fine spherical Zn precipitates and Al particle boundaries including Al_2O_3 and course Zn rich precipitates.

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