SiC and ZrO2 Weigh Percentage Effects on Microstructure of Al Based Matrix Composite Fabricated by Spark Plasma Sintering Method

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Abstract— *SiC and ZrO_2 particle are succesfully reaction synthesized from powder of Al, ZrO_2 and SiC using spark plasma sintering method. The XRD of sintered composite and microstructure of the aas-sintered products. With the ZrO_2 content increasing, the grains are remarkably refined and the and the ZrO_2 and nano SiC particles are dispersing more uniformly in Al matrix, forming a homogeneous structure with the least porosity.*

Keywords— Aluminum, Aluminum matrix composite, zirconium, spark plasma sintering, silicon carbide.

I. INTRODUCTION

Metal matrix Composites (MMS) have a lot of application in several industries[1].A large number of studies have been carried out by several researchers because of their unique properties [2]. Metal matrix Composite are composed from a Metal matrix phase and had phase as a reinforcement. Among metal matrix composites, AL matrix composite are one of the most applicable MMC in industries such as automobile, aerospace, transformation and military industry recently, the nanosize particulates still under consideration Aluminum and it is alloys are very attractive, powder metallogy because of eutectic phase formation with low melting point [3-4].

Moreover aluminum melting point in sufficient to be used as a matrix phase [5-6].

Among various types of reinforcement, both SiC and ZrO_2 are widely used because of their very good properties. For example, silicon carbide has high elastic modulus, high strength, excellent thermal resistance, good corrosion resistance, very good compact abrlily aluminum matrix phase low cast and it is availability[7-12].

Spark plasma sintering (SPS) is a new and novel sintering process which includes high pulsed direct current and uniaxied pressure simultaneously in order to consoliclate the materials. The SPS technique has high heating and cooling rates and the pressing time is also very fast [9-13].

Silicon carbide with very appropriate mechanical properties and good compatibility with AL and it's. alloys in one of the best additive as on reinforcement phase.

Jenix rina et al, compared The properties of AL- MMC reinforced by Zr at four different amount of volume fraction and showed that Zr particle dispersion is uniform and the Zr phase can strength the matrix phase[14].

Ozben et al investigated the mechanical and machin ability properties of SiC particle reinforced AL-MMC.Results showed that as the reinforcement ratio increased, the strength, hardness increases so[15].

In the present study, SPS method was employes in order to produce nano Al- MMC with SiC and ZrO_2 reinforcement phase. finaly the effects of reinforcement phase on bending strength were investigated.

II. SPARK PLASMA SINTERING

Spark plasma sintering method in a very novel powder deification technology recently.

Spark plasma sintering can be used for synthesis and processing of ceramics, metals and intermetalics; SPS method can be compared with the conventional hot pressing technology.

Also, high density current pulses at low voltage are applied directly to the powder and the pressing tool. This mechanism in to generate a spark discharge and rapid Joule heating between particles of powder.

The fast local increase of temperature and pressure promotes the elimination af adsorbed gas and breaks the oxide layer on the surface of metal particles. Spark plasma sintering method has some advantages such as rapid heating rate and short holding time.

With considering surface activation effect, sintered bodies with meta-stable microstructures in nano sized grains can be achived.

III. EXPERIMENTAL PROCEDURE

3.1. Materials

For the preparation of the current MMC, AL and zirconia powder with more than %99 purity and silicon carbide powder with 20 nm average size and purity of more than %98 weres used as initial materials. In order to fabricate metal matrix composites these powders were mixed based on weigh ration as show in table 1.

Table 1: weigh percentage of initial material powder.

code	AL (%)	SiC (%)	ZrO_2 (%)
1	100	0	0
2	96	2	2
3	94	2	4
4	94	4	2
5	92	4	4
6	92	2	6

In order to abtain homogeneous composite alloys, the mixture was atomized by a plasma rotating electrode process under argon atmosphere with pressure of 40 Mpa. In the present research work the (SPS 20T-10 china) spark plasma device with 40 Mpa pressure, 480°C sintering temperature at 10 Mpa vacuum state and 6 minute holding time were caried out. At the end of holding time, the applied current was swrched off and the sample were kept inside the chamber and cooled to room temperature. The density of the sintered compacts was measured with the Archimedes method, then the specimens were metallographically prepared in the usual, thoroughly cleaned with alcohol and then dried with a hot air blower. Micro structural characterization of the sintered composited was performed using Ziess TEM.

IV. RESULTS AND DISCUSSIONS

4.1. Density

The density of sintered composites were shown at table 2. It in worthy to know that all sintered composites have more than 97 percent relative density and at the worst state, porosity in less than 0.99%. these results shows that the selected sintered temperature in proper.

Table 2: relative density and prosity percentage of sintered composites

Samples	Relative density (%)	Porosiry (%)
1	99.8	0.02
2	98.6	0.09
3	97.9	0.14
4	96.6	0.20
5	97	0.12
6	97.3	0.11

4.2. XRD pattern of sintered composites

Figure 1 show XRD pattern for pure AL. Show in figure 1 there in not no identified peak that in not related to pure AL.

IT in worthy to know that the in XRD shows that no oxidation has been occurred during sintering process.

XRD pattern of sample 6 (%92 Al, %2 SiC, %6 ZrO_2) in showed at figure 2. IT in clear that no oxidation were take placed during sintering procedure.

XRD pattern of samples 2,3,4 and 5 are illustrated at figure 3 and the some results were obtaind as illustrated for sample 1 and sample 6.

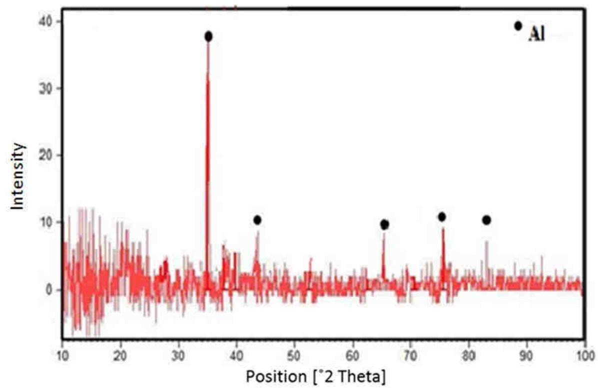

Fig.1: XRD pattern for pure Al

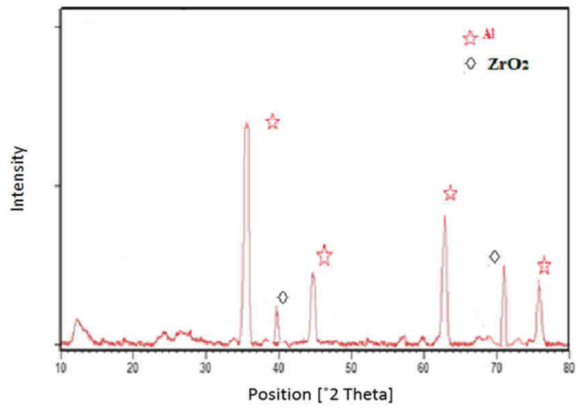

Fig.2: XRD pattern for sintered composite (%92 Al, %2 SiC, %6ZrO_2)

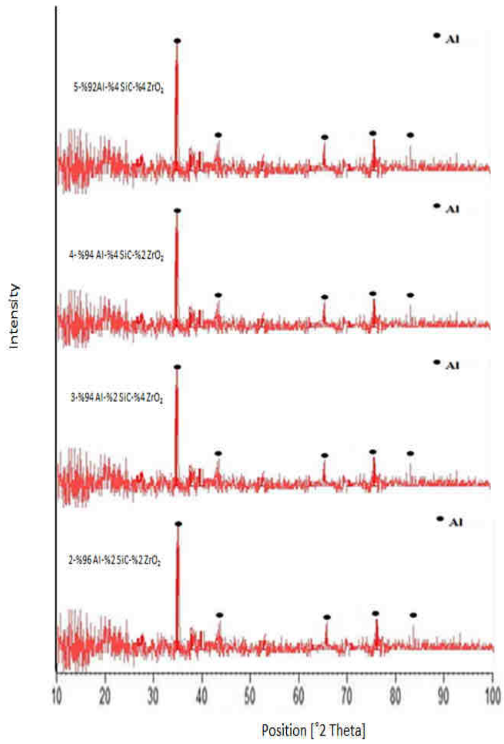

Figure 3. sintered composite XRD pattern for different additive weigh percentage

4.3. Microstructure results

The microstructure of SPS samples show a homogeneous distribution of small pores with a maximum diameter of 0.2 μm for AL sintered. As shown in figure 4, SEM microstructure Image for sintered AL 1 sample illustrate that this homogeneous distribution can be as a result of proper sintering temperature. Figure 5 shows the typical microstructures of sintered composites for different SiC and ZrO_2 weigh percentage. Figure 5 show homogeneous microstructure for sintered composites. In addition , with the ZrO_2 content increasing, the structure of the sintered composites becomes finer with remarkably refined grains of the composites with ZrO_2 and SiC particles remaining on the ground boundaries . From a comprehensive observation of the microstructures, there are pores that existed, which quantitatively decrease with ZrO_2 content increasing.

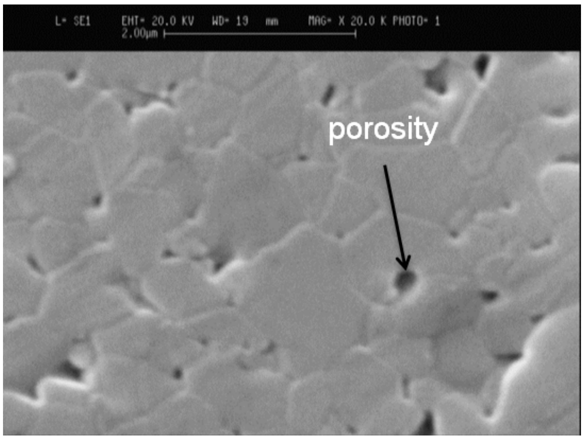

Fig.4: SEM Image for sintered pure Al.

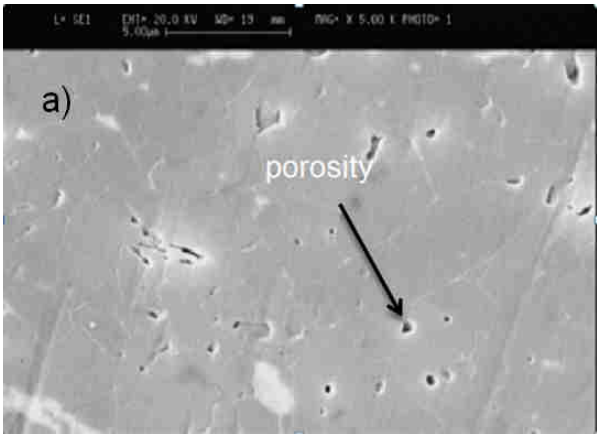

Fig.5. SEM Image for sintered composite %94 Al-%2 SiC-%4 ZrO_2

V. CONCLUSION

Al / Sic / ZrO_2 compositor can be produced from the powder mixture of Al, SiC and ZrO_2 by way of spark plasma sintering method. By using SEM and XRD Image following results were obtained

1- ZrO_2 and SiC particle disperse on the grain boundaries and play a demand rate fore qroaing the matrix phase.

2- using SPS method leads to homogeneous structure with relatively nonporous structure.

3- Rapid sintering mechanism makes no chance fore particle growth, therefore high density and low porosity percentage composites were obtained.

4- XRD Image show that no oxidation and phase decomposition accrued during sintering process.

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