Interconnect material preparation via milled and ultrasonically $Fe_{80}Cr_{20}$ alloy powder

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ABSTRACT – $Fe_{80}Cr_{20}$ alloy powder prepared by ball milling and ultrasonic technique and was analyzed using Scanning Electron Microscopy (SEM), Particle Size Analyzer (PSA) and Thermo Gravimetric Analysis (TGA). Ball milling prepared under nitrogen gas (N_2) as Process Control Agent (PCA) in milling time of 60 h. Ultrasonic is conducted under atmospheric environment in open circuit machine. Finer surface structure which obtained after ultrasonically treatment. Smallest particle size of 5.23 µm and distribution of 89.57% is achieved using combination between ball milling (Milled 60 h) and ultrasonic technique (UT). TGA result shows that sample after milled 60 h and combination technique decrease mass gain up to 51% and 63% as compared to raw material as well as 49% and 62% as compared to UT samples.

1. INTRODUCTION

Metallic interconnect material is most explored Solid Oxide Fuel Cell (SOFC) component due to it keep the oxidant and fuel separated. Consequently, it must be stable chemically in high temperature operation of 1000 ^{0}C [1,2] where the stabilization and oxidation behavior at high temperature are fundamental in actual application. FeCr is selected as interconnect material due to it has high-strength and high corrosion resistance [3]. In order to achieve high thermal stability, nano range crystallite size and homogenous size is needed [4]. Most commonly method to reduce the crystallite size is high energy ball milling [5].

There are some method to develop homogenous size which are ultrasonic, microfluidizer, ultra-turrax benchtop homogenizer and microfluidics microfluidizer. However ultrasonic technique become most commonly method [6]. Proposed method to prepare the interconnect material is combination between high energy ball milling and ultrasonic technique which called combination technique and not yet full studied in previous research [4-7].

2. METHODOLOGY

Formula of the raw material is $Fe_{80}Cr_{20}$ (80wt% Fe and 20wt% Cr). Ethanol is used as cleaned media before ball milling process. Ball milling process is conducted in milling time of 60 h and ultrasonic technique is conducted using various time of 3 h, 3.5 h, 4 h, 4.5 h, and 5 h in open circuit ultrasonic machine. All samples is analyzed using SEM with Secondary Electron Images (SEI) detector. PSA is based on strength of the diffract light which shows number of the particle and distribution of particle size. Thermal stability is operate as function of temperature to obtain physical properties of the sample. It conducted in temperature of 1100 ^{0}C with the heating and cooling rate is 10 ^{0}C/minute. Raw material as untreated sample and the UT, milled 60 h and milled and UT samples as treated samples.

3. RESULTS AND DISCUSSION

Ultrasonic technique is successfully improve the finer surface structure as shown in Fig. 1(b) and 1(d) which assigned as UT 4.5 h and Milled and UT 4.5 h sample, respectively. Most proper result in each treatment is shown in Fig. 1.

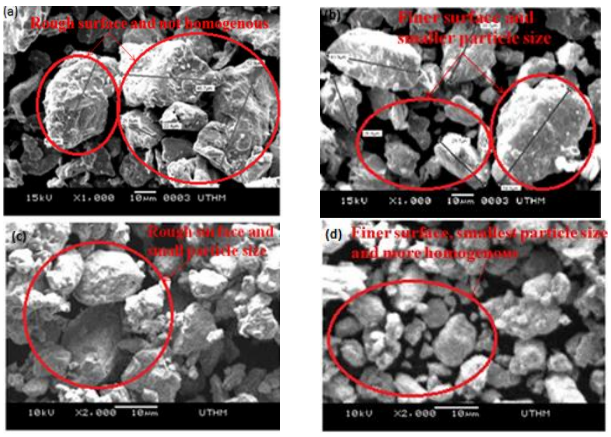

Fig. 1 Surface morphology of (a) raw material, (b) UT 4.5 h, (c) milled 60 h and (d) milled and UT 4.5 h.

Ultrasonic treatment led to surface modification as the effect of cavitations process which produced by high speed bubbles which generate a jet impinging upon the surface material.

Different ultrasonic time increased as finer surface is increased. Finer surface is effect to dense compacted sample. Rough surface has good interparticle bonding, However many oxygen cavities is stuck in the compacted sample [8]. Therefore, finer surface is

required due to good interparticle bonding with no oxygen cavities. When ball milling process, the deformation is not evenly in powder body. Therefore, milled 60 h sample is not homogenous powder size or agglomerate occurred.

The particle size and homogenous particle size is confirmed by PSA result as shown in Fig. 2. The particle size decreased in distribution particle size increased at increasing ultrasonic time. The distribution is relatively high of 89.57% in smallest particle size of 5.23 µm.

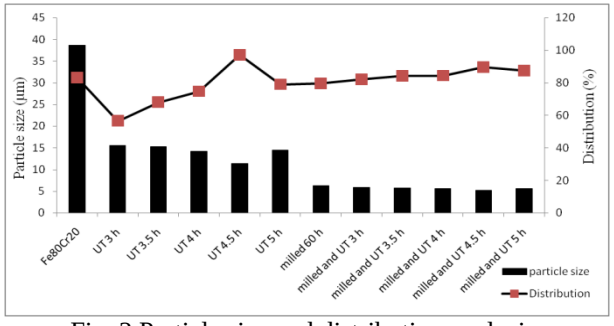

Fig. 2 Particle size and distribution analysis.

Particle size of combination treatment decrease up to 16.58%, 66.56% and 86.47% as compared to milled 60 h, UT samples and raw material, respectively. It caused by the ball slugging the powder when ball milling process and high speed bubbles when ultrasonic technique. Mass change in high temperature is become indication of thermal stability of the sample. It shown by TGA curve (Fig. 3) that shows the mass gain of the treated and untreated samples in temperature of 1100 ^{0}C.

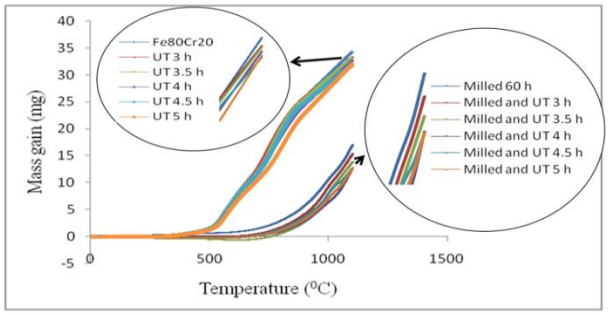

Fig. 3 Mass change curve of the samples.

Fig. 3 shows that the milled 60 h and milled and UT samples have smaller mass gain as compared to raw material and UT samples. It due to by smaller crystallite size as in Fig. 4 which have higher strain and ductile properties. Decreasing mass gain of combination technique up to 63% as compared to raw material.

4. CONCLUSION

Ball milling and ultrasonic treatment show high recommended to prepare the interconnect material like showed by SEM, PSA, and TGA results. Consistence data shows that the method and parameter is well done. However, grain growth is observe when ultrasonic time of 5 h as shown in milled and UT 5 h at PSA which effect to the higher mass gain at TGA curve.

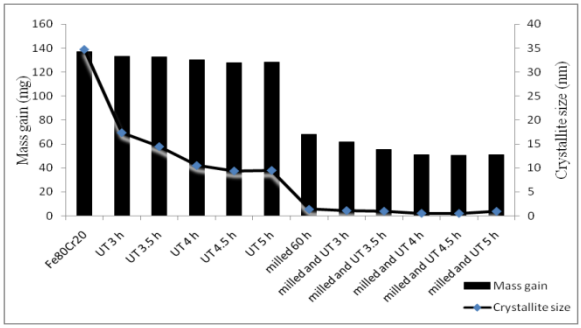

Fig. 4 Mass gain and crystallite size of the samples.

5. ACKNOWLEDGEMENT

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