Hussain J. Al-Alkawi
Electromechanical Engineering Department, University of Technology, Baghdad, Iraq.
50089@utotechnology.edu.iq

Sameir A. Aziez
Electromechanical Engineering Department, University of Technology, Baghdad, Iraq
50067@utotechnology.edu.iq

Deana A. Idan
Electromechanical Engineering Department, University of Technology, Baghdad, Iraq
deana_msc@yahoo.com

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Microstructure and Electrical Conductivity of 7075Al alloy/SiC Nano Composites

Abstract- *Analysis using scanning electron microscope (SEM) at high magnification showed that the microstructure of the nano composites exhibited uniform distribution of SiC particles and less porosity. The experimental results revealed that adding Nano Reinforcement to 7075Al alloy improve the electrical conductivity for the metal matrix composites with 3, 6, 9 wt. % SiC were adopted in this work. The maximum enhancements were observed at 9wt. %SiC of 5200(Ω. m) -1 compared with the metal base of 35 (Ω. m) -1.*

Keywords- *7075Al alloy/ SiC ,microstructure ,electrical conductivity*

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1. Introduction

The electrical features of materials are the responses to a used electric field. The technicality of conduction by electrons and how the electron energy of a material affects its ability to conduct. The electrical features of materials were significant when materials chosen are made during the design of an elements or structure. The electrical actions of materials are diverse. Conductivity is the important property for selection the materials used for connecting wires.
Materials can be classified to three groups based on the electrical conductivity.
1-Metals are better conductors, idealistically having conductive rating about 10^{7} $(\Omega .m)^{-1}$.
2-Very low conductive rating materials ranging from 10^{-10} and 10^{-20} $(\Omega .m)^{-1}$, these materials are called insulators.
3-Materials with intermediating conductive ranges from 10^{-6} to 10^{4} $(\Omega .m)^{-1}$ are terming electrical semiconductors [1]. Pakiela et al. [2] produced the Al-Mg-Si alloy has been widely employed as conductors and power lines due to good combination of mechanical and electrical features. This alloy displays high tensile strength and good electrical conductivity. Rasheed et al. [3] measured the electrical conductivity of 6101 and 6201 at room temperature using four- wire technique, average readings of (10) measurement were taken. Hydrostatic extrusion (HE) was adopted to increase the mechanical features without reducing the electrical conductivity. The maximum increasing in electrical conductivity was spotted in ball milling (BM) casing and mechanical moving. Therefore, both thermal and electrical conductivities enhanced in case of mechanical moving.
Li et al. [4] examined the thermal electrical conductivity for aluminum alloy and they concluded that the thermal conductivity is become visible in the mechanical moving situation. Liu et al. [5] aluminum alloys could be made as a very good conductor, their usage to electric and electronic manufacturing was fixed because of low strength. A new planning of micro-structural purpose for improvement mixing of electric conductive and strength in Al alloy is developing basing on modulation of the progression of classical cold-distortion Al matrix and suitably utilize the work-solidify impact to recompense the loss of age-solidify impact due to the harden of the solidify remaining in the materials disruptions and remaining forming by solutes separation acting as commanding strengthening elements with the latter.

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2412-0758/University of Technology-Iraq, Baghdad, Iraq

Saheb and Hayat [6] studied the electrical properties and features of alumina-silicon carbide hybrid nano components. Spark plasma was used as a tool for determining the electrical conductivity, of hybrid nanocomposite. It was found that the addition of hybrid nanoreinforcements to the base alloy displayed raising in electrical conductivity the thermal features tends to reduce. Cui et al. [7] studied a number of conductive Al alloys they found that the grain refinement with boron treatment leads to improve the electrical conductivity and tensile features. The main conclusions can be remarked was the above-mentioned technique is the best way to enhance the mechanical and electrical properties of Al. alloy. Mazahery and Shabani [8] studying the microstructure also mechanical features of nano components treatment with, moving molding the components were basing on the (A356) aluminum alloy supported with nano (Sic) particles rationally regular apportionment of (SiC) reinforced material in the base metal is spotted. Porousness level increases partly with increased particulate contented which could be referred to the increasing surface region of the nano (SiC) particles. The additional of nano particles contributed in increasing in solidity, yielding strength and tensile strength of the components. Matin et al. [9] studied microstructure and mechanical Features of pure Mag. and molding (AZ80) nano-components different weight of (SiC) augmentation nano particles (1.5), (2.5), and (3.5) were adding for the matrix using moving molding technique. They concluded that the increasing in (SiC) particles led to increasing the solidity values, tensile strength and the ultimate strength enhanced constantly of the fabricated components. Also explained that adding augmentation (SiC) particles led is increasing the action stiffen average as compared with the unconfirmed materials. The present work aims to improve the electrical properties especially the electrical conductivity for the 7075 Al- alloy that reinforced by silicon carbide (SiC) with particle size (20-30 nm) by using stir-casting method. Also studied the microstructure of the composites (7075 Al-alloy with the nano SiC) and see how much the nano particle effected on the distribution of SiC particles and porosity.

2. Experimental Work

The electrical test includes the electrical conductivity of the aluminum alloy 7075, as received and the conductivity test, after the addition of silicon carbide nanoparticle, with percentages (3و 6 and 9wt.%). The L.C.R meter inductance (L), capacitance (C), and resistance (R) is an electrical instrument tester used to measure the electrical conductivity. Figure 1 shows the L.C. R meter.

During microstructure analysis or microscopic examination, the material structure was studied under enlargement. Proper preparation of the specimen and the materials surface requires that a small sample of the material selecting accurately and subjected to the microstructure analysis. Then mounting, pounding, polishing and etching to reveal accurate content and microstructure. The specimen must be free form Scratches, strains and others imperfections which tend to mark the surface. Figure 2 shows the microstructure specimens.

The analysis results can be obtained using SEM to understand the microscopic structure and details Figure 3 shows the SEM device used in the microstructure details examination while Figure 4 shows the process which used to prepare the specimens for SEM test.

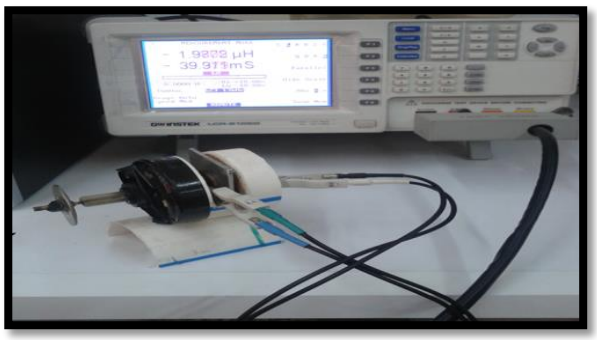

Figure 1: L.C.R meter

Figure 2: The microstructure specimens

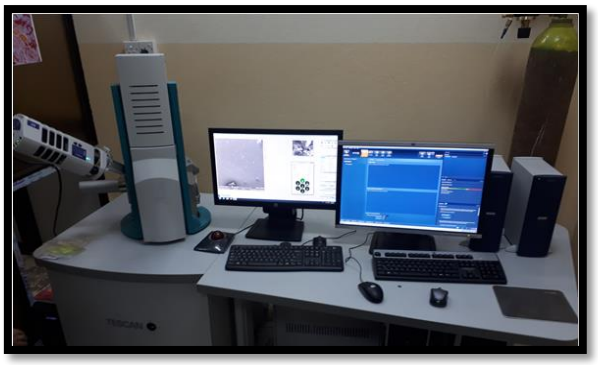

Figure 3: Scanning electron microscopic (SEM)

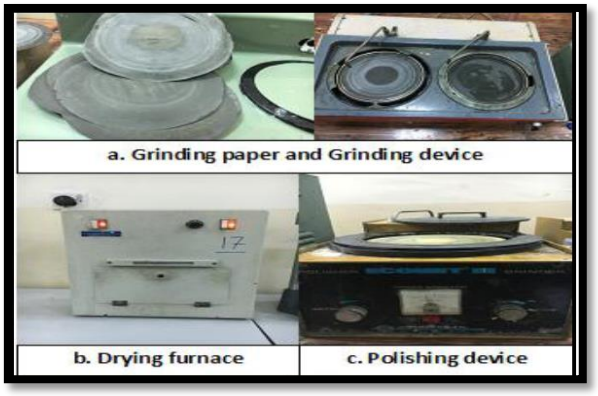

Figure 4: The equipment that used for microscopic imaging

3. Experimental Results and Discussion

I. Electrical Conductivity

The AC conductivity measurements were recorded out in the range of frequencies (0HZ- 1MHZ) at room temperature for as- cast alloy and three nano composites with 3,6 and 9wt% SiC, while the variation of electrical conductivity against frequencies are presented in Figure 5 a ,b , c , d.

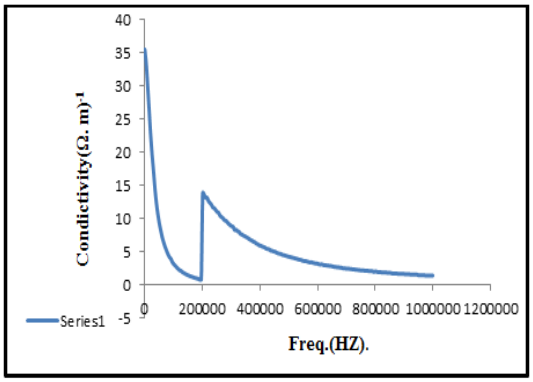

Figure 5 a: AL- alloy 7075 as- cast

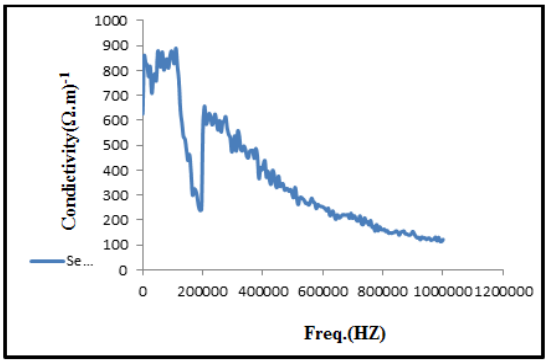

Figure 5 b: AL- alloy 7075 with 3 wt.% SiC

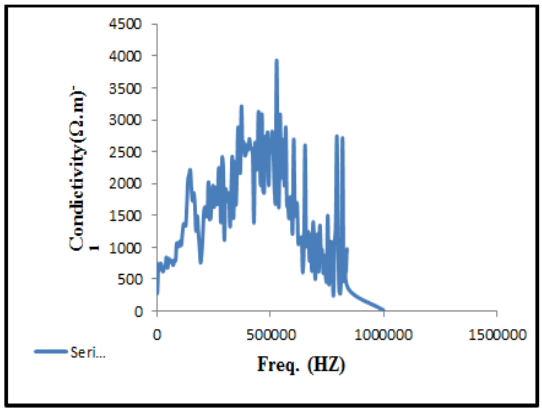

Figure 5 c: AL- alloy 7075 with 6 wt.% SiC

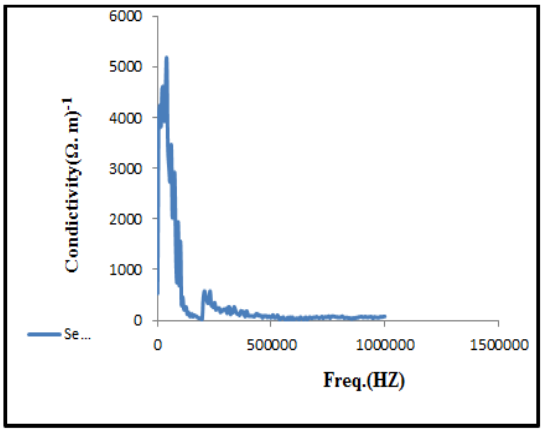

Figure 5 d: AL- alloy 7075 with 9 wt.% SiC

The gathered conductivity finding through experiments can be described as a frequency function, and it can be seen in the Figure 5a,b,c,d for as cast aluminum alloy and (3, 6 , 9 wt.% SiC). It clear that the conductivity improved in the range from (0- 200000 HZ) and then become almost constant. The electrical conductivity for a casting AL. alloy is lower than that of a nano-composites of Al. alloy matrix. As Table 1 unveil the peak value for electrical conductivity in the range of frequency 0-20000 Hz.

Table1: Electrical conductivity with variation of nano SiC in the range of frequencies (0 – 20000Hz).

Max .electrical conductivity (Ω . m)$^{-1}$ in the range of frequencies(0 -20000Hz)			
As- cast 7075 Al-alloy	3wt.%SiC composite	6wt.%SiC composite	9wt.%SiC composite
35	880	4000	5200

It is noted that increasing of wt.% SiC of composites fabricated by stir casting method resulting in increase of electrical conductivity. Rasheed et al. [3] concluded that the highest improvement level in the electrical conductivity could happen with mechanical stirring. They used three methods for fabricating the material and they concluded that the best electrical conductivity was found in stir casting technique. The reliance for electrical conductivity on additives content reveals that a composite shifting from an insulation to a conductive reaction [10]. Pakiela et al. [2] tested two aluminum alloys 6101 and 6201 under hydrostatic extrusion (HE). Testing for microstructure showed that (HE) lead to improvement in grain size up to 0.5 micrometer, HE is an efficacious method to improve the mechanical properties of the mentioned Al alloy without decreasing the electrical conductivity. A light microscopy was used to examine the microstructure of the base metal and nano composites Fgure 5 a, b, c, d, also the electrical properties were taken, both processes were done at room temperature (RT), these test sample was 4 mm thick test were made with different rang of frequencies . Electrical conductivity was enhanced may be due to the following reasons :

1. Less porosity and fairly uniform distribution of SiC into the base metal .
2. High bounding between SiC particles and 7075 aluminum alloy.
3. SiC particles have good electrical properties resulted in improved electrical properties of composites.

II. Microstructure analysis results

During Microstructure analysis, Figures 6 a, b, c and d illustrates the microstructures obtained optically of 7075 Al .alloy with 0, 3, 6 and 9 wt. % SiC particles. Figure 6 a shows the microstructure of as- cast 7075 Al. alloy while Figure 6 b, c, d illustrate the feature of the nano composites with 3,6 and 9 wt.% respectively . A constant arrangement for SiC particles can be seen in Figure 6 b, c, d.

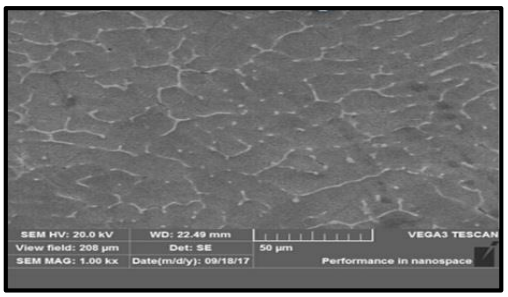

Figure 6 a: SEM of 7075 Al-alloy

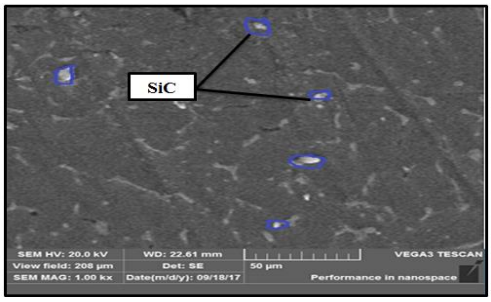

Figure 6 b: SEM of 7075Al- alloy with nano 3wt.% SiC

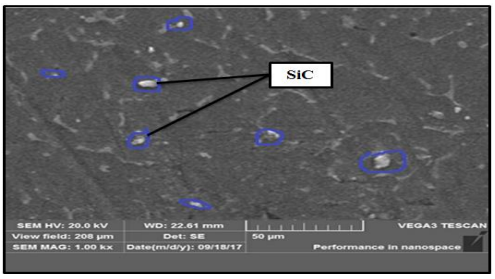

Figure 6 c: SEM of 7075Al- alloy with nano 6wt.% SiC

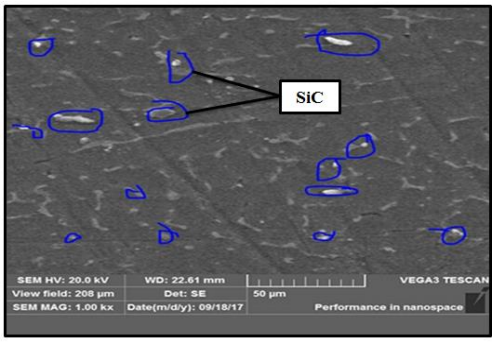

Figure 6 d: SEM of 7075Al- alloy with nano 9wt. % SiC

The microstructure of casted 7075 Al alloy reveals existence of porosity, while the microstructure for composite shows minimum amount of porosity, this porosity can be a result of the following: [11,12] .

1- Shrinkage during solidification.
2- Particles injection may lead to some gas to be trapped in the melt.
3- The gap between the mold and the crucible.
4- Growing in the contact surface with air.
5- Because of stirring process, some gas was trapped.

Aluminum alloy is soft material and the reinforced particles SiC being hard. The hard particles

contributes to rise the mechanical and electrical properties of composites may be to the following reasons :

1- The presence of harder particles of SiC in the composite leads to enhance the tensile, fatigue and electrical properties such as, ultimate , yield stress, hardness, ductility and conductivity [3].

2- The high mechanical and electrical properties of SiC itself attributed to the relatively high mechanical and electrical properties of composites [3].

3- The bounding between the metal matrix and the reinforced material resulted was good that led to growing of the displacement of density for matrix and thus, the composite mechanical, fatigue and electrical properties increased [13].

4- The observed refinement of SiC and distributed in a uniform shape has been attributed to the improved the mechanical, fatigue and electrical properties [14].

4. Conclusions

1- The increasing of the reinforcement content, electrical conductivity increased and the maximum increasing was occurred at 9wt. % SiC.

2- The experimental analysis of microstructure observation showed uniform distribution due to adding the SiC nanomaterial.

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Author(s) biography

Hussain J.M. Alalkawi, Ph.D. Professor in Mechanical Design, University of Technology, Electromechanical Engineering Department. He has been working on different subjects related to Mechanical Engineering Design.

Sameir A. Aziez Ph.D. in Communication Engineering Electromechanical Engineering Department. University of Technology, Baghdad, Iraq. He has been working on different subjects related to Navigation and Communication Engineering.

Diana Ali Idan was born in Baghdad, Iraq, in 1984. She received B.Sc. in Electrical Engineering and Education in 2006 and M.Sc. degree in Electromechanical System Engineering from the Department of Electromechanical Engineering in 2018, University of Technology, Baghdad, Iraq.