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Hot Compaction of Silver Coated Aluminum Matrix Nanocomposite

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Abstract— *Aluminum-based composite materials are among the most important materials used in light industries because of their light weight and good properties such as wear resistance and high resistance relative to weight. In this research, an aluminum composite supported by a mixture of alumina and graphene coated with silver was prepared. The chemical composition was studied using X-rays, microstructure using an electron microscope (SEM), hardness using a Vickers device, and chemical corrosion using an electrochemical cell. The X-ray confirmed all used elements. The SEM image shows an excellent distribution of the alumina-graphene ceramic and silver metal. The silver-coated aluminum/(alumina-graphene) sample achieved a hardness of 66.34 HV. The sample demonstrated high resistance to chemical corrosion, which was estimated at 0.019 mm/year. The SEM image of the corroded surface revealed that the grain boundaries were the weakest places through which the atom bonds were broken and the corrosion process occurred.*

Keywords— *Aluminum composite; silver; Graphene; Alumina; Hardness; Corrosion*.

I. INTRODUCTION

Aluminum has about one-third density of steel. Easy to machine, cast, and extrude.It is ductile and malleable and can be molded easily. Aluminum is one of the few metalsthat maintains its full silver reflectivity color when in fine powder form [1-4].

Today, aluminum has become the second most widely used metal in buildings aftersteel, and is used in all construction sectors [5-6]. From commercial buildings to residential buildings, it is a lightweight, strong metal that is naturally resistant to corrosion so it is considered a durable material [7-10].

Due to the problem of low mechanical resistance that aluminum faces, especially when used in high-load working conditions, recently researchers have intensified theirresearch efforts on the possibility of producing aluminum in the form of composite materials [11-15], especially in the automobile and aircraft industries, which require obtaining high resistance and rigid parts with the lowest possible weight [11-14].

The most suitable materials used as reinforcements for aluminum include alumina,graphene, silicon carbide, titanium carbide, silica, and others using powdertechnology[1,3,12-16]. Through this, obtained composite materials can withstand operating conditions at high temperatures and friction.

This research aims to study the effect of coating aluminum composite powder with silver on chemical composation, microstructure, hardness, and chemical corrosion properties.

II. MATERIALS, METHOD, AND CHARACTERIZATION.

In this study aluminum (100-200 µm), alumina (50-100 nm), and graphite (5-10 µm) were used to fabricate aluminum matrix nanocomposite. A 80 wt% Al and 10 wt%(98%Al_2O_3-2%GNs) powders were coated with 10 wt% silver by the electroless coatingprocess [17-18]. The reason for using the silver electroless powder deposition as a metallurgy process was to solve the problem of incompatibility between the metallic elements (aluminum) and the ceramic element (alumina and graphene). The hot compaction was used to fabricate the material. The sample within the die was heated to 560 ºC for 50 min. Figure 1 shows the steps of the sample fabrication. The fabricated sample was evaluated using the X-ray diffraction, scanning electron microscope, Vickers hardness tester, and a corrosion cell.

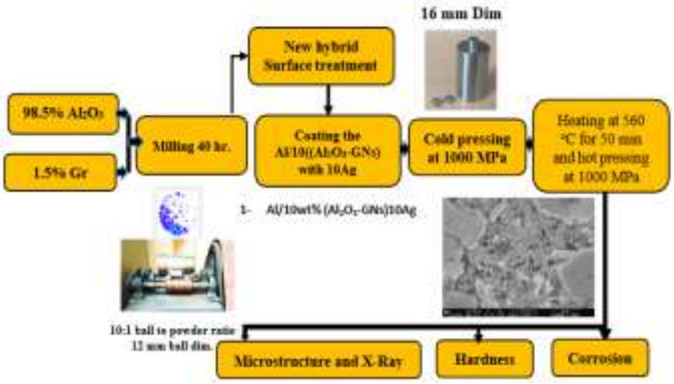

Fig. 1. Fabrication steps

III. RESULT AND DISCUSSION

A. X-ray

Figure 2 shows the chemical analysis of the manufactured Al composite using X- rays. The analysis confirmed all the elements used in the manufacture of aluminum composite. All elements are of high purity with all peaks appearing intensely.

The intensity of peaks in the X-ray diffraction (XRD) patterns is affected by the crystal structure, the number and arrangement of atoms within the unit cell, the crystal lattice orientation, and the X-ray wavelength. Also, it can be affected by the quality ofthe sample, the settings of the instrument, and the method of the data analysis. Overall,the intensity of XRD

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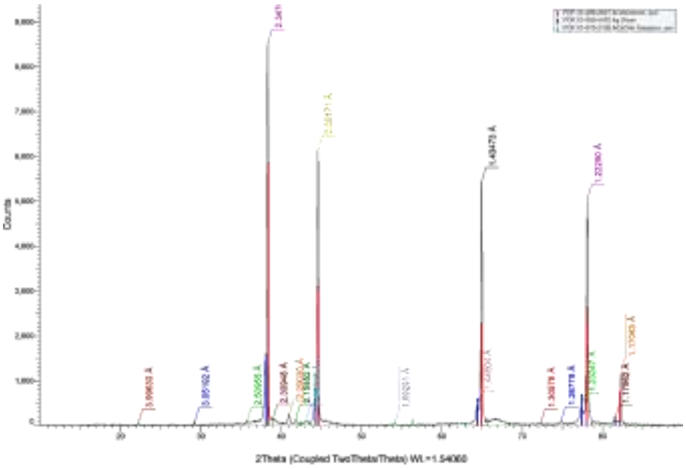
peaks provides valuable information about the crystalline structure and composition of the material being studied. Aluminum appeared with 88%,silver with 5.8%, and aluminum hydroxide with 6.2%. The reason for the appearance of aluminum hydroxide may be that the sample was produced in an atmosphere not protected by any inert gas.



Visible	Icon	Color	Index	Name	Compound Name	Formula	S-Q
Yes			1	PDF 01-089-2837	Aluminum, syn	Al	88.0%
Yes			2	PDF 01-080-4432	Silver	Ag	5.8%
Yes			3	PDF 01-070-2138	Diaspore, syn	AlO(OH)	6.2%

Fig. 2. X-ray of the fabricated aluminum/10(Alumina-Graphene) 10 silver

B. Microstructures

Figure 3 shows the Al-10(Al_2O_3-GNs) powder sample after coating with silver. The coated process was successes. The aluminum and (Al_2O_3-GNs) hybrid was coatedwith silver. The free silver precipitated particles was dendritic. Homogenous distribution between all elements are clear.

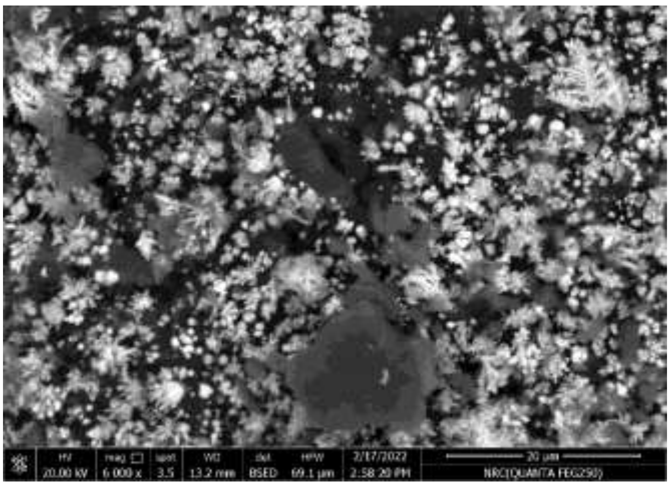


Fig. 3. Aluminum/ (Alumina-Graphene) coated with silver

Figure 4 shows the microstructure of the fabricated sample. The white silver was greatly distributed with the aluminum matrix. It is appeared with the matrix and aroundthe particles of alumina and graphene. The aluminum is gray and the (Al_2O_3-GNs) hybrid is dark gray. An intermetallic was checked on the grain boundaries of aluminum.

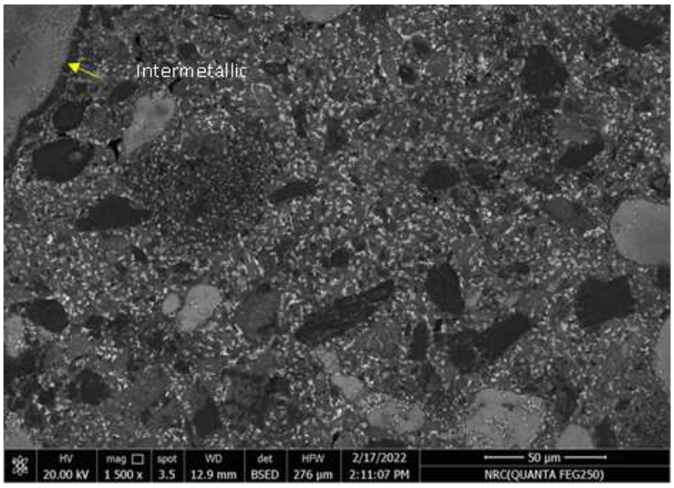


Fig. 4. The microstructure of the fabricated sample

C. Hardness

The Al-10(Al_2O_3-GNs) sample was recorded 66.34 HV. The microstructure of the indenter penetration is shown in Figure 5. The aluminum has 30 HV [15]. Duet to thehigh hardness of alumina and graphene, the hardness of the fabricated sample was increased. Also, the homogenous distribution and good adhesion have a great effect ofincreasing the aluminum matrix nanocomposite.

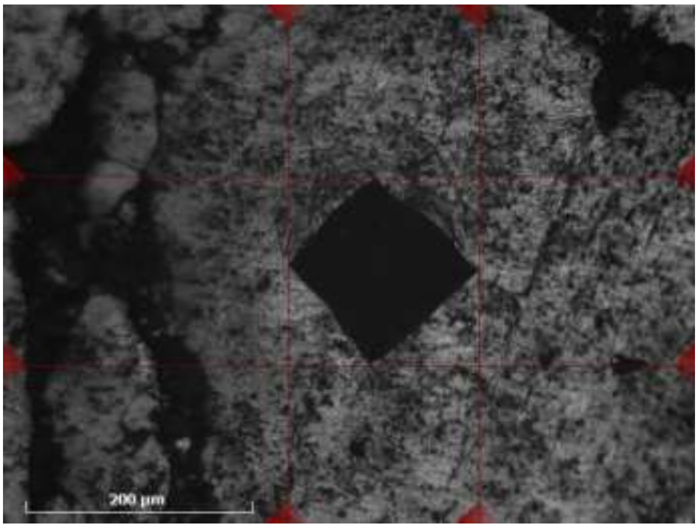


Fig. 5. Microstructure of the hardness indention indentation

D. Corrosion behavior

The Potentiodynamic polarization curve of the fabricated sample is shown in Figure 6.Table 1 illustrates that, the sample recorded Ecorr. =-0.794 V and Jcorr. = 8.98E-7 (A/cm^2). The corrosion rate was 0.0190 mm/year. It recorded high Rb=1369 Ω.Alumina and graphene are ceramic materials characterized

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by high chemical stability. Their presence in homogeneous distribution and good adhesion contributed to improving the chemical corrosion resistance of aluminum.

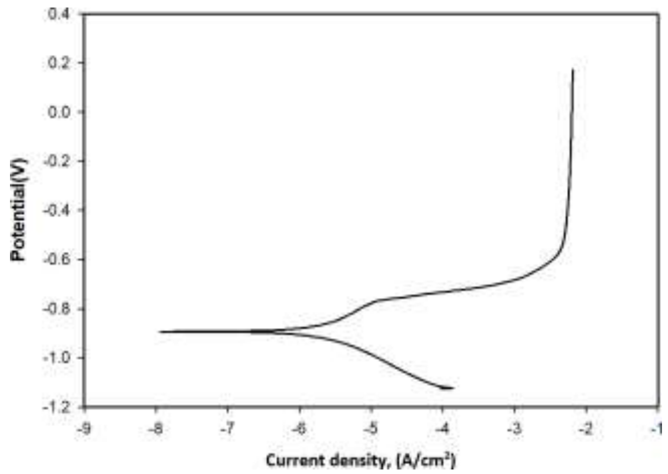

Fig. 6. The Potentiodynamic polarization curve of the fabricated sample

TABLE 1: Corrosion parameters and corrosion rate of the fabricated sample.

Specimen	Corrosion rate(mm/year)	Ecorr(V)	Jcorr(A/cm^2)	Bc(V/dec)	Ba(V/dec)
Al/10(Al_2O_3-GNs)10Ag	0.0190	-0.794	8.98E-7	0.223	0.027
Specimen	**Rp(Ω)**	**Rs(Ω)**	**CPE.Y0(F)**	**CPE.N**	
	1369	38	9.6E-5	.75	

E. Corrosion Microstructure

Figure 7 shows the microstructure of the aluminum surface. It is clear from themicroscopic structure that the attack of the electrolyte and the establishment of the corrosion process occurred at the grain boundaries and the places containing the reinforcement materials, where the areas of cohesion are considered weak and containsome micro-pores that allow the penetration of the electrolyte and the occurrence of corrosion. The intermetallic compounds formed during the manufacturing process haveweak corrosion resistance, so corrosion appears greater at the grain boundaries.

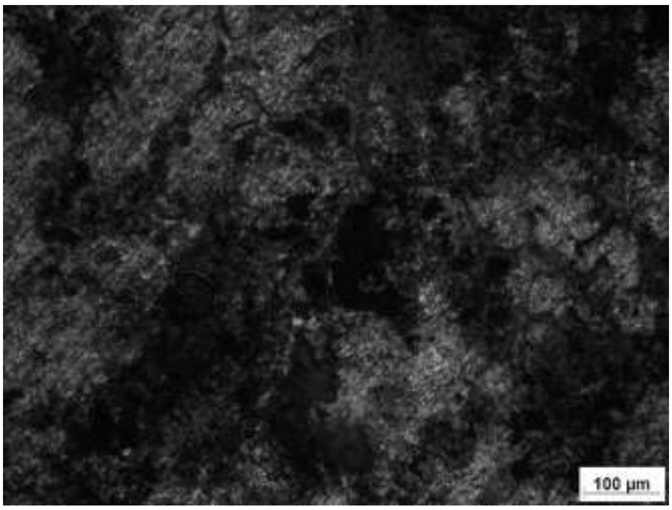

Fig. 7. Microstructure of the corroded surface

IV. CONCLUSION

1) The microstructure shows homogenous distribution for silver and the otherreinforcements Al_2O_3 and GNs.
2) The fabricated sample recorded high hardness 66.34 HV comparing with thepure aluminum 30 HV.
3) The fabricated sample recorded low corrosion rate 0.0190 mm/year.
4) The corrosion was established at the grain boundaries.

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