Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 119 (2017) 121–130

Energy Procedia

www.elsevier.com/locate/procedia

International Conference on Technologies and Materials for Renewable Energy, Environment and Sustainability, TMREES17, 21-24 April 2017, Beirut Lebanon

Effect addition of graphene on electrical conductivity and tensile strength for Recycled electric power transmission wires

Fadhil A. Chyada Akram R. Jabur[a]*, Hussein A. Alwan[b]

[a] *Department of Materials Engineering/University of Technology , Baghdad 10001, Iraq*
[b] *Ministry of Electricity, General Directorate of Electric Energy Transmission - Middle Euphrates, Iraq.*
** E- mail: 130020@uotechnology.edu.iq, Mobile: 009647718099679*

Abstract

In this study, effect of artificial aging and cold rolling on the conductive and tensile properties of graphene reinforced aluminum matrix composites has been investigated. Graphene reinforced aluminum matrix composites were prepared by pyrolysis method. Graphene nanopwoder have been applied as reinforcing phase in molten pure aluminum (99.5%). Al wires (scrap wire damaged) are melted and graphene nanopwoder (0.5 %) can be added. Al-graphene alloy was cast into a diameter of (10 mm) and height of (20 mm) billet by steel mold. After that, the Al-0.5 % graphene rod was cold rolling at room temperature in a (10 mm) diameter rod form into a (3.5 mm) diameter wire. Both the electrical conductivity and tensile strength of alloys improved by cold rolling+ artificial aging treatment. The improvement of electrical conductivity of (B_1) alloy is (8.9%) comparing with (A as cast) alloy, while the improvement in tensile strength of (B_1) alloy compared with (A) alloy is (168.6%). Raman spectroscopy was carried out in order to indicate the number of graphene layers of the prepared samples, also to give good data about the structure of the prepared samples. FESEM studies showed a highly dimpled structure, characteristic of ductile failure. The results show that electrical conductivity and tensile strength are improved by the addition of graphene.

Peer-review under responsibility of the Euro-Mediterranean Institute for Sustainable Development (EUMISD).

Keywords: *Graphene; Aluminum matrix composites; Electrical Conductivity; Tensile Strength; Raman Spectroscopy; Scanning Electron Microscopy (SEM).*

---

* Corresponding author. Tel.:
E-mail address: akram.jabut@gmail.com

Peer-review under responsibility of the Euro-Mediterranean Institute for Sustainable Development (EUMISD).
10.1016/j.egypro.2017.07.055

1. Introduction

Carbon is arguably the most versatile chemical element in nature. One illustration of this is covered by two of its 3D allotropes: diamond and graphite. While diamond is a very hard, transparent insulator, graphite is a soft, opaque conductor. Furthermore, carbon is a prolific atomic connector, able to form more compounds than any other element in nature, and allows unique and complex structures to take shape [1].

Carbon is the material prima for life and the basis of all organic chemistry. Because of the flexibility of its bonding, carbon-based systems show an unlimited number of different structures with an equally large variety of physical properties. These physical properties are, in great part, the result of the dimensionality of these structures [2].

From time to time, different structures of carbon had been discovered, such as fullerene class known as the “buckyball”, a spherical molecule comprised solely of carbon atoms with the formula 60, was made in 1985 by Kroto *et al.* [3] and has since been used in organic based solar cells [4, 5]. Another fullerene class was later fabricated by Iijima in 1991 known commonly today as carbon nanotubes[6]. bio resistive coatings [7] and transparent conductive films [8], microelectronic transistors. The discovery of another carbon allotrope, graphene, by Novoselov *et al.* in 2004 [9].

The exact history of graphene and how it appeared on the scientific horizon is fascinating. In theory, as an integral part of various three-dimensional materials, graphene has been studied since the 1940s. [10,11]. In 1947 Philip Wallace wrote a pioneering paper concerning the electronic behavior of graphite that sparked interest into the exploration of graphene[11]. However it was not until the recent work of Novoselov *et al.* [9,12] and Zhang *et al.* [13] that interest in graphene escalated due to reports of its unique properties[14].

Graphene is a single layer of sp2-bonded carbon atoms that are packed in a honeycomb lattice [15]. It should be noted that multilayer graphene can have up to ten layers, and still be called graphene. Few layer graphene (FLG) has three to nine layers. The limit where graphene becomes graphite is ten layers. The atomic structure of graphene gives rise to exceptional electrical, optical, mechanical and thermal properties [15]. The most interesting electrical properties are high electron mobility and ballistic transport of charge carriers. However, these properties come with a twist; graphene is zero-bandgap semiconductor, or semimetal. Its sp2-hybridized two-dimensional single-atom thick-layer structure and unique thermal, electrical and mechanical properties, graphene has been extensively investigated in recent years [9,16,17,18]. Graphene has a very high specific surface area (2630 $m^2\ g^{-1}$), an electron mobility exceeding 15000 $cm^2V^{-1}\ S^{-1}$ at room temperature, and a thermal conductivity of about 5000 $Wm^{-1}K^{-1}$. Moreover, graphene has an am bipolar field-effect and quantum Hall ferromagnetic characteristics [19,20,21,22]. Graphene has a breaking strength of 42N/m. Steel has a breaking strength in the range of 250-1200 MPa= 0.25-$1.2x10^9$ N/m^2. For a hypothetical steel film of the same thickness as graphene (which can be taken to be 3.35Å=$3.35x10^{-10}$ m, *i.e.* the layer thickness in graphite), this would give a 2D breaking strength of 0.084-0.40 N/m. Thus, graphene is more than 100 times stronger than the strongest steel. The sheet conductivity of a 2D material is given by acoustic phonons. The mobility is theoretically limited to μ=200,000 $cm^2V^{-1}s^{-1}$ at a carrier density of n=1012 cm^{-2}. The 2D sheet resistivity, also called the resistance per square, is then 31 Ω. Our fictional hammock measuring $1m^2$ would thus have a resistance of 31 Ω. $\sigma=en\mu$.Using the layer thickness we get a bulk conductivity of 0.96x106 $\Omega^{-1}cm^{-1}$ for graphene. This is somewhat higher than the conductivity of copper, which is 0.60x106 $\Omega^{-1}cm^{-1}$[23].

2. Experimental

2.1. Preparation of graphene by pyrolysis method

This method considered as one of the simplest and cheapest methods to produce graphene paper (GP) which uses asphalt as source for carbon atoms. The graphene precursor is a plastic roof cement, which consists primarily of asphalt (TAR) but included some impurities such as clay, cellulose and water.

This method had been modified by mixing amounts of used TAR with amount of 30 % alcohol (99.99 ethanol).

Through this method, reaction vessel is a (60 mL) casserole crucible with an inner crucible (20 mL) which filled with (10 g) of asphalt precursor and inserted in the larger casserole crucible and well glass covered as