Eng & Tech. Journal, Vol.30 , No.17, 2012

Studying the Effect of Glass - Fiber on Electrical Conductivity of Polyamide Composite Material

Nirvana A. Abed Alameer
Technical College/ Baghdad
Email:Nervana_abbas@yahoo.com
Dr. Duha Abed Alameer
Institute of Technical,Museb/ Al-Museb
Dr. Haidar A. Hussein
Technical College/ Baghdad

Received on: 26/2/2012 & Accepted on: 7/6/2012

ABSTRACT

The electrical conductivity of glass fibre reinforced polyamide composite materials was investigated for both weight fraction of glass fibre and frequency. This study is focused on various types of glass fibres (S, E&C) and different weight fractions (10, 20, 30 &40) at frequencies (50, 500, 1000, 10^5 &10^6) Hz. The results exhibited addition glass fibre fillers on matrix material were apparent good electrical conductivity at high weight fraction comparing to their low percentage account of the fillers created conductive path in the matrix material, it reached to (2.52, 2.1&2.21)* 10^{-10} S/cm for C-glass fiber, E-glass fiber and S-glass fiber; respectively at %40 weight fraction. Also that electrical conductivity increased with increasing in frequency due to charges movement in the dielectric material.

Keywords: polyamide, glass fibers(S, E& C), electrical conductivity& frequency

دراسة تأثير الياف الزجاج على الموصلية الكهربائية للمواد المتراكبة للبولي امايد

الخلاصة

تم في هذا البحث دراسة الموصلية الكهربائية للبولي امايد المدعم بثلاثة انواع من الياف الزجاج وبمختلف الكسور الوزنية عند مختلف الترددات. ركزت الدراسة على الياف الزجاج من نوع (S, E&C) عند الكسور الوزنية (10, 20, 30 &40) وبترددات (50, 500, 1000, 10^5 &10^6). اظهرت النتائج ان اضافة الياف الزجاج بانواعة الثلاثة زاد من الموصيلية الكهربائية للبولي امايد عند الكسور الوزنية العالية بسب ان الحشوات خلقت مسار للالكترونات حيث وصلت التوصيلية الكهربائية الى S/cm 10^{-10}*(2.1, 2.21 &2.52)لكل من (S, E&C) عند اعلى نسبة وزنية (40%). كذلك لوحظ زيادة التوصيلية الكهربائية عند الترددات العالية بسبب حركة الشحنات داخل المادة الاساس.

https://doi.org/10.30684/etj.30.17.11
2412-0758/University of Technology-Iraq, Baghdad, Iraq

INTRODUCTION

Polymeric materials have been utilized extensively in the electronics packaging market, due to their low cost, ease of processing, chemical inertness, and attractive electrical properties [1]. Thermoplastic polyamides are linear polymers derived by condensation polymerization of a polemics acid and an alcohol. Depending on the types of the polyemic acid and alcohol, various thermoplastic polyamides can be produced. Glass fibres are the most common of all reinforcing fibres for polymeric matrix composites (PMC). The principal advantages of glass fibres are low cost, high tensile strength, high chemical resistance, and excellent insulating properties. The two types of glass fibres commonly used in the fibres-reinforced plastics (FRP) industry are E-glass and S-glass. Another type, known as C-glass, is used in chemical applications requiring greater corrosion resistance to acids than is provided by E-glass. Several fibbers incorporation techniques in thermoplastic resins have been developed and many of them are now commercially used to produce thermoplastic prepregs. These prepregs can be stored for unlimited time without any special storage facility and, whenever required. [2].

The miniaturization in the microelectronics industry has increasing demands on the low dielectric constant ε, interlayer's to greatly reduce the resistance-capacitance (RC) time delays, cross-talks, and power dissipation in the high-density and high-speed integrated circuits. In addition to exhibiting low ε, the materials used as interlayer must also satisfy a variety of requirements, such as good thermal stability, low moisture absorption, and chemical inertness. Polyamides (PI) have been widely used as dielectric and packaging materials in the microelectronics industry because of their good mechanical, thermal, and dielectric properties [3].

The fundamental building components for all electronic packaging systems consist of active and passive components on an interconnecting substrate. Resistors, inductors, and capacitors are examples of passive components, which represent a class of electronic components that result in no power gain to an electronic application. For example, in current cellular phone applications, the ratio of passive components to active components is nearly 20:1, and nearly 80% of circuit board area is occupied by discrete passive components. Conventional discrete components have to be mounted onto a printed wiring board (PWB) or interconnected substrate thereby resulting in higher parasitics, lower reliability, and large attachment area requirements. Integral passives are defined as functional elements either embedded in or incorporated on the surface of an interconnecting substrate. With increased production emphasis towards efficient electronic packaging, integral embedded passive technology may satisfy such demands. The main advantages of embedded passive components include: (1) no separate interconnects to the substrate, (2) improved electrical performance, (3) lower cost and (4) ease of processing. Due to increased product demands of increased silicon efficiency, package miniaturization, and higher reliability integral embedded technology will be replacing discrete electrical components [4].

Muhammad studied the effect of three types of glass fibres (S, E &C) on polyester matrix in the frequency range 330Hz-3MHz and in the temperature range 25-150 C. The experimental results indicate that έ and ε" increased with addition of glass fibres in polyester resin [5].

Duha and Nirvana studied that Temperature and Frequency dependence of dielectric constant (έ) and dielectric loss factor (ε") in pure polyamide resin and polymer composites with various types of glass fibre(E, S &C) are studied in the frequency range (50, 500, 1000, 10^5 &10^6) Hz and temperature range (30, 60, 90, 110& 120) C°. The results show that (έ) and (ε") increased with the addition of glass fibre in polyamide resin. The value of (έ) decreased with increasing frequency while it increased with increasing temperature [6].

EXPERIMENTAL WORK

The materials studied were polyamides resin ((PA-6), Germany) reinforced by (10, 20, 30& 40) wt% of 10 mm long glass fibres (U.S.A), the mixture was fed into single screw extruder. The samples were cut to (2 & 0.5) cm dimensions which were Polishing the samples surface to improve smoothing by Coating unit (Edwards 306), which precipitates Aluminium (Al) electrodes by using the tungsten wire which is put inside it. Making the electrodes by Al electroplating on the two sample sides to improve the electrical properties, the simplest capacitor structure planer form, consisting of a layer of dielectric material sandwiched between two Al layers. The device precision LCR meter was accurately adjusted then used to measure the resistivity (R) values on the electronic screen. From these value can be fined an electrical conductivity by equation 1. These measurements test for (50 Hz-10^6 Hz.) at room temperature.

$$\sigma = \frac{d}{R.A} \qquad \text{------- (1)}$$

Where: σ: electrical conductivity (S/cm), d: diameter of specimen, cm, R.: electrical resistivity, Ω/cm, A: cross- section area, cm^2

RESULTS AND DISCUSSION

Effect of frequency

Figures (1-4) show the variation of the electrical conductivity with different frequency at room temperature; the results exhibit that electrical conductivity increased with increasing of frequency. The permittivity depends on the dipoles and charges movement in the dielectric material, due to change in the field direction, because of an electric field alternation. The intensity of alternating electrical field was represented by the frequency of applying voltage, that effected by a dipoles of dielectric material into frequency range, this means the electrical polarization changed with an electric field changed.

EFFECT OF WEIGHT FRACTION

The effect of weight fraction of different types of glass fibre reinforced polyamide was investigated in this work, there were (10, 20, 30& 40) % weight fraction. The results showed that weight fraction of fillers were affected on electrical conductivity of composite materials. The electrical conductivity for the C, S &E glass fibre reinforced polyamide shown in tables (1-3) which was exhibit that electrical conductivity of composite materials for fillers reinforced PA higher than matrix material.

Addition glass fibre fillers on matrix material were apparent good electrical conductivity at high weight fraction comparing to their low percentage account of the fillers created conductive path in the matrix material, it reached to (2.52, 2.1 & 2.21)*10^{-10} S/cm) for C-glass fiber, E-glass fiber and S-glass fiber; respectively at (%40) weight fraction whereas electrical conductivity for both polyamide and glass fiber is approximately 10^{-15} S\cm and 0.153 x 10-4 S\cm respectively as shows in figure 4.

EFFECT OF GLASS FIBRE TYPES

The electrical conductivity of composites is governed, in the main, by the type of glass fibre and the quality of the adhesion between glass and resin, the electrical conductivity of glass fibre depending on type these glasses. The Experimental results exhibited that the electrical conductivity values were different according to type of fillers; C-glass fiber reinforced polyamide was affective more than other fillers. The conductive fillers, such as glass fibre as act channels for the electrons to flow through. The electrons are free to flow through the carbon fibers. However, once they reach the end of the fiber, they encounter the polymer matrix, which acts as dam, blocking the flow of the electrons.

CONCLUSIONS

1. Electrical conductivity increases with increasing in weight fraction of fillers.
2. The electrical conductivity values were different according to type of fillers.
3. C-glass fiber reinforced polyamide was affective more than other fillers.

REFERENCES

[1].James R. Webster, “Thin Film Polymer Dielectrics for High-Voltage Applications under Severe Environments”, MSc, Electrical Engineering, Blacksburg, 1998.

[2]. Mallick, P.K. “fibre-reinforced composition”, *materials, manufacturing and design*, Taylor & Francis group, France, 2008.

[3]. fei Chen,Yu- Yong Fan, Yan Ma, “Study on dielectric properties of thermosetting Polyimide”, *Institut Teknologi Bandung*, Indonesia June 17-19, 2007

[4].Yang Rao, Jireh Yue And C. P. Wong, “Material Characterization Of High Dielectric Constant Polymer–Ceramic Composite For Embedded Capacitor To Rf Application”, *Active And Passive Elec. Comp.*, Vol. 25, Pp. 123–129, 2002

[5].Muhammad, A, " dielectric properties of industrial polymer composite materials", university of Punjab, Pakistan, 2005
[6].Duha and nirvana," effect of glass-fibre on electric properties of polyamide composite", kerbala journal, 2011

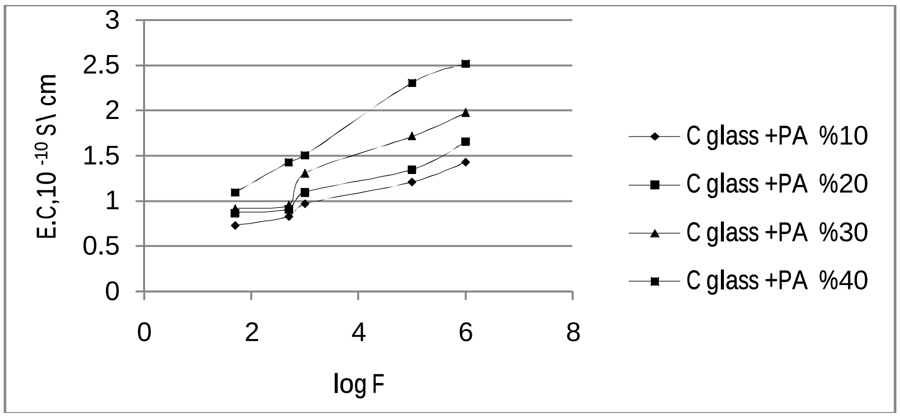

Figure (1): electrical conductivity of C- glass fiber reinforced Polyamide at different frequency.

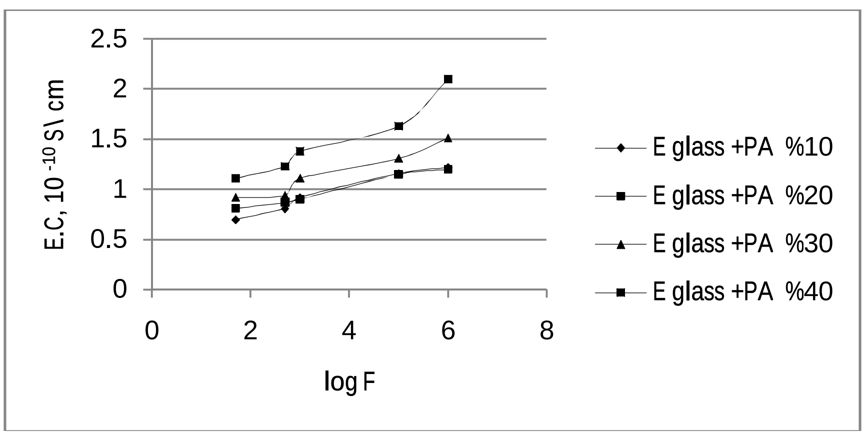

Figure (2): electrical conductivity of E- glass fiber reinforced Polyamide at different frequency.

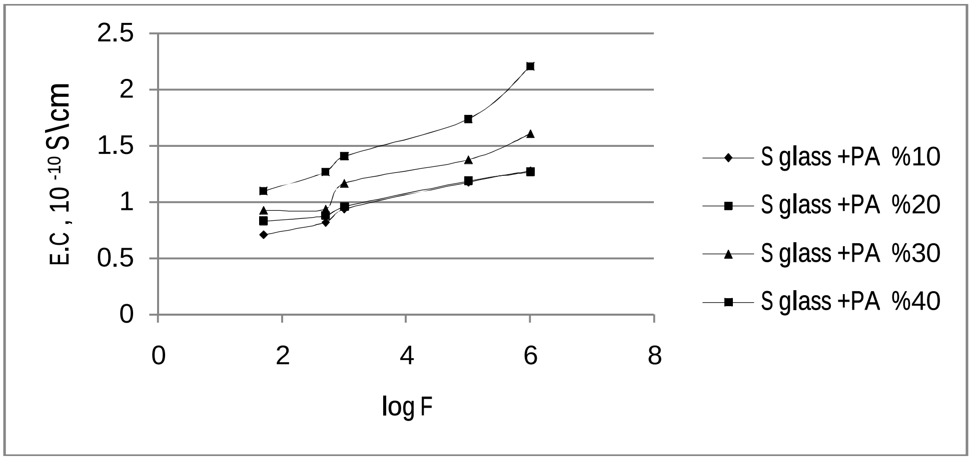

Figure (3): electrical conductivity of S- glass fiber reinforced Polyamide at different frequency.

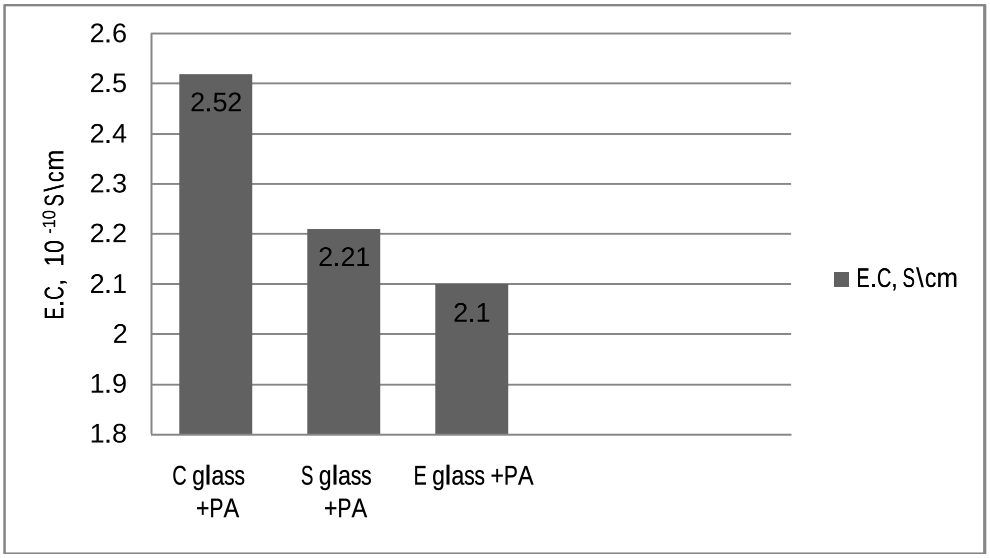

Figure (4): electrical conductivity for different glass fibers at 40% wt. and 10^6 frequencies.