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Effect of Graphene on The Electrical Conductivity of Different Materials

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Abstract: As a new carbon material, graphene has ultra-high electrical conductivity. Based on the comparison of the conductivity of different graphene composites, this paper introduces the influence of graphene on the conductivity of different materials, explains the principle that graphene changes the conductivity of materials, and prospects the application direction and future development trend of graphene composites.

Keywords: Graphene, Electrical conductivity.

1. Introduction

Graphene is a new material with carbon atoms in the sp2 hybrid connected graphene tightly stacked into a monolayer 2-dimensional honeycomb lattice structure, with excellent electrical conductivity. In recent years, researchers have combined graphene with different materials to improve the electrical conductivity of materials[1]. This paper will mainly explain the influence of graphene or its oxidized derivatives on the electrical conductivity of metal-matrix composite materials, conductive adhesive, Beijing Yang and other polymer composites.

2. Effect of Graphene on The Electrical Conductivity of Metal-based Composites

Metal matrix composite material has the characteristics of good conductive effect, the selection of a suitable material is of great significance to improve the electrical conductivity of the composite material is of great significance. In recent years, with the rapid development of science and technology, many emerging fields such as aerospace, fine metal parts and sensors have put forward higher requirements for the electrical conductivity of materials. graphene's high electron mobility (2105 $cm^2 / (v \cdot s)$) makes it an excellent conductive enhancer of metal matrix composites.

2.1. Copper-based Composites

Carbon nanotubes have excellent electrical conductivity, The main reason is because of its special one-dimensional tubular structure, When the copper matrix is added, Equivalent to providing a new channel in the tube for electronic transport, Because graphene is a two-dimensional honeycomb nanomaterial made of a single layer of carbon atoms, Make the two become complementary to the two types of materials, So graphene / copper is expected to be a composite with ultra-high conductivity, However, graphene, as a conductive enhancer, still has problems such as poor interface binding with copper, uneven reinforcement dispersion, easy to reunite, and poor structural integrity, The mainstream approach is to solve these problems by improving composite interface engagement. There are few reports of enhanced conductivity by graphene / copper composites. It is reported that using ball milling method of graphite pretreatment,(See Figure 1 for details) compared to the same method of pure copper increased by 8%, in addition to sintering preparation of high quality graphene / copper composite, mainly through the composite effect between graphene and copper, to a certain extent make full use of the structural integrity of graphene and excellent conductivity, but the ball milling method of graphene coating on copper surface graphene damage, destroy the integrity of the enhancement structure and distribution uniformity, greatly limit the conductivity improvement space[1]. Therefore, on the basis of selecting suitable materials, it is particularly important to design suitable composite methods to maximize the excellent properties of each material.

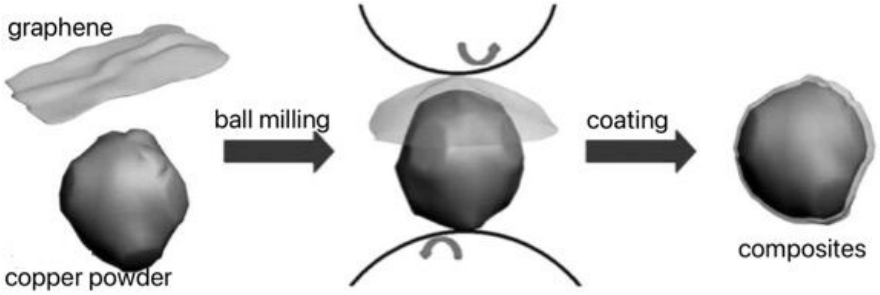

Figure 1. Ball milling method of graphite pretreatment

2.2. Matrix Composite

As in the case of graphene / copper composite, it may also be faced with problems such as poor interface binding, uneven reinforcement dispersion, and easy agglomeration. Therefore, there are very few research results on improving graphene / aluminum composite in the current domestic and foreign research literature. According to related studies, ZM-10-16 vacuum molybdenum wire furnace sintering 0.55% composite (Mg, 0.45% Si, 0.55% B and Al) and graphene, and the relationship between graphene content and conductivity at different sintering temperatures (580℃, 600℃, 620℃). Experiments show that the conductivity at 580℃, 600℃ and 620℃() all show the trend of rising first and then decreasing with the increase of graphene contentthe(See Figure 2 for details). When the reason is that the graphene content is small, there is little agglomeration phenomenon and is evenly distributed on the aluminum substrate. The excellent electrical conductivity of graphene can be fully displayed, and the material conductivity is high at this time. When the content of graphene exceeds 0.3%, the graphene will gradually overlap and reunite, the interface between the graphene and the aluminum matrix increases, the wetting ability becomes worse, and the conductivity decreases[2].

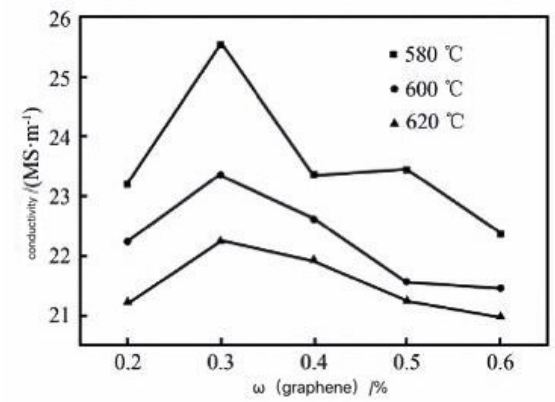

Figure 2. The Relationship between graphene content and conductivity at different sintering temperatures

Through the above two examples of the graphene improved metal matrix composite conductivity, even if the same material for the composite, the composite way is different, different proportion of each material will have a significant effect on the final material conductivity, so to get ultra-high conductivity composite, should try more composite and explore can make the conductivity to the maximum proportion of the material content.

3. Effect of Graphene on The Electrical Conductivity of A Conductive Glue

Conductive adhesive is an adhesive with certain conductivity after curing or drying. It can connect a variety of conductive materials together, enabling the formation of electrical access between the connected materials. In the electronic industry, conductive adhesive has become an essential new material.Conductive adhesive is a new type of functional adhesive material composed of organic polymer matrix resin material as film forming, conductive filler and other additives as filling material. Conductive filler plays the function of electric conductivity in the conductive adhesive system. At present, it is mainly divided into metal conductive filler and non-metal conductive filler and can play a conductive role. Metal conductive filler is more common in silver, copper, nickel, etc., where the price of silver is relatively high, and often appear electric migration phenomenon; copper conductive glue price is cheaper, but the copper powder is easy to be oxidized in the matrix, resulting in electrical conductivity instability. Non-metallic fillers include graphene, graphite, carbon black and carbon nanotubes, etc., but the conductive adhesive prepared by simply adding non-metallic fillers has a high volume resistivity, which is not suitable for occasions with high conductivity requirements, so it is generally mixed with metal fillers.

In this paper, nickel powder as the main conductive filler and graphene as the auxiliary conductive filler are taken to describe the influence of graphene on the conductivity of conductive gel and its mechanism. The experiments show that the volume resistivity of conductive adhesive decreases rapidly first as the mass fraction of graphene increases, and it stabilizes when the mass fraction of graphene reaches about 1.0%. The mass fraction of graphene continues to increase, and the volume resistivity of conductive adhesive shows an upward trend.In the initial phase of rapid decline in volume resistivity, graphene plays the role of "wire connection" in the system due to its excellent conductivity, that is, besides the original "nickel-nickel" conductivity, it also increases the "nickel-nickel-nickel" conductivity. Because graphene is a two-dimensional nanosheet structure, as long as it is evenly dispersed in the conductive colloidal phase, the conductive connection between the nickel powder particles in the body phase is very small. Therefore, the volume resistivity decreases rapidly with the addition of graphene[3].

As the graphene content continues to increase, when the graphene mass fraction is greater than 1.3%, the increased mass fraction no longer continues to enhance the electrical conductivity, but the resistivity rises slowly. This is because the specific surface area of graphene is large, and excessive graphene is easy to reunite, so it can not be evenly dispersed in the body phase, and local accumulation, and only a conductive network can be formed in local and nickel powder particles, and the volume resistivity of conductive adhesive begins to rise slowly. Overall, the relatively optimal conductivity of graphene, which has a mass fraction of 1.0%[4].

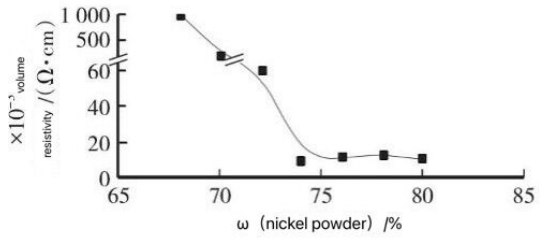

Figure 3. The relationship between the content of nickel powder and volume resistivity

To sum up, adding a proper amount of graphene as the auxiliary conductive filler of the conductive adhesive can build a new conductive network based on the original metal conductivity, so as to effectively improve the conductivity of the conductive adhesive. Nowadays, due to the

miniaturization of electronic components, miniaturization and printed circuit board high density and highly integrated rapid development, conductive adhesive is widely used in microelectronics assembly, including fine wire and printing line, electroplating plate, ceramic adhesive metal layer, metal chassis, bonding wire and seat, adhesive element and flat face through the printing line, bonding waveguide tuning and hole repair, so adding graphene to prepare excellent conductive adhesive is expected to improve the performance of electronic components, become the ideal choice for conductive connection.

4. Three Dimension Conductivity of Wood-graphene Composites

Electricity with natural stereo multi-channel and rich in active functional group-OH, -COOH wood, and set electrical conductivity, hydrophobic and mechanical properties of two-dimensional graphene organic combination, prepared a green, tactile properties excellent 3 d conductive wood, for our plantation timber functional improvement and high added value to provide a new way, and provide a new type of green materials for guide field

GO is prepared by the Hummer method, and then organically combined with Beijing Yang (the name of a kind of wood) by the pulsed vacuum immersion method, which can prepare the three-dimensional conductive material of wood-graphene. The electrical conductivity was tested to explore the effect of GO mass concentration on the electrical conductivity.The experiment shows that with the increase of GO mass concentration, when the graphene spacing generated during high temperature thermal reduction is too low, the efficiency of continuous electron migration is low, and the conductivity is weakened; GO mass concentration gradually increases from 2~4 g / L, and the oxygen functional group on the GO sheet layer is decomposed under high temperature treatment, and the resulting graphene sheet layer has a certain continuity, making the material form a certain conductive path and enhanced conductivity. When the mass concentration of GO is too large, the GO reduction is not sufficient, and the generated graphene sheet layer is greatly stacked in the vertical direction.

Since the wood has a 3-D structure, the wood-graphene composite exhibits 3-D conductivity and shows large differences in the three directions.Wood is a heterogeneous organism in structure, with both anisotropy and porous nature, which makes the wood structure have great particularity and complexity compared with other organic polymer materials. Therefore, the electrical conductivity of the wood-graphene composites in different directions should be tested. The test shows that the electrical conductivity of the material is different in the direction, and the longitudinal conductivity is better than the transverse direction; the radial string conductivity difference is very small. The main reason is caused by the anisotropy of the wood structure. The longitudinal structure of the wood is the cell wall and the cell cavity, in which the cell cavity accounts for a large proportion, while the radial chord structure is dominated by the cell wall. When graphene is evenly attached to the wood surface and cell cavity, a continuous conductive path can be formed in the longitudinal direction, manifested by low volume resistivity and good conductivity; and there is more transverse cell wall structure, so that the transmission of electrons around is blocked, manifested by high volume resistivity and poor conductivity. Therefore, the anisotropy of the wood leads to a large difference in the electrical conductivity of the material in the transverse and longitudinal directions[5].

Like the above metal matrix composites and conductive adhesive, the conductivity of graphene content is also different for wood-graphene composites and generally show the trend of strengthening the conductivity first and then weakening with the increase of graphene content. Different from the above two materials, the wood also has a three-dimensional structure and has an anisotropy, which makes its electrical conductivity very different in the three different directions is also different.

5. Conclusion

Graphene as a material with good conductivity, can conductivity to other materials (such as metal matrix composite material, conductive adhesive, wood) play a certain improvement effect, but the conductive effect of the composite material, add content, and the influence of material structure, so to get composite people expected conductive effect of composite material can start from these three, continuous experiment to explore new composite material with good conductivity.

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