Application and Analysis on Graphene Materials

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Abstract. Graphene is made up of carbon six-member ring cycle of two dimensional honeycomb lattice structure, it can warp as zero dimension of fullerenes, roll into a one-dimensional of carbon nanotubes or stack into a three dimensional graphite. Because of this kind of structure makes it not only have excellent electrical and mechanical properties, but also can be used as reinforced metal matrix composites, which can be used in catalyst carrier, energy storage and environmental protection. It has become a hot topic in recent years. Based on the existing research both at home and abroad, this paper focuses on the importance of the choice of graphene dispersion method to improve the mechanical properties of graphene materials, and summarizes the existing problems of graphene reinforced metal matrix composites.

1. Introduction
In recent years, graphene, as a unique structure of carbon materials, has gained more and more attention because of its excellent mechanical, electrical and thermal properties. The successful development of graphene super battery has solved the problem of insufficient battery capacity and long charging time of new energy vehicles, which greatly accelerated the development of new energy battery industry. Recently, the U.S. NASA developed graphene sensors applied in the field of aerospace, which can be used to detect the trace elements of the earth's upper atmosphere and structural defects on the spacecraft. This series of research has paved the way for the application of graphene in the new energy battery industry. Due to the characteristics of high conductivity, high strength and ultra-thin, the advantages of graphene in the field of aerospace industry are also extremely prominent. Graphene has great application prospect in many traditional industries and strategic emerging industries, it has a high research value.

2. Theoretical study of graphene material mechanics
Adding one percent of graphene in the plastic makes the plastic good electrical conductivity; Adding one thousandth of the graphene can increase the heat resistance of the plastic by 30 degrees Celsius. On this basis, thin, light, stretchable and super-strong new materials can be developed to make cars, airplanes and satellites. Gradually along with the mass production and large size problem, the industrialization application of graphene is speeding up, based on the existing research results, the commercial application of the first field would be on a mobile device, aerospace, new energy battery field. As graphene materials have become more and more applicable, researchers at home and abroad have conducted various researches on graphene. Cheng[1] and his team reported for the first time that the template CVD was grown with the mirror foam, which was 3DGFs, and it was experimentally determined that the speed of the electron and phonons that the graphene material changes with temperature was determined. Zhou J[2]It is found that the uniform distribution of the enhanced phase
can improve the performance of graphene composite materials. The dispersion of graphene in the matrix is not only influenced by the dispersion process. Xin Gao[3] Experiments found that using the method of charge attract the negatively charged graphene oxide join the positively charged after surface treatment of aluminum powder, was prepared using powder metallurgy graphene composite material, the hardness and tensile strength of composite materials with the content of graphene enhanced decreases first. Da Kuang[4] It was found that the quality fraction of graphene with composite electrodeposition technology was 0.12%. During the performance test found hot line and conductivity increased by 15% and 35%, the hardness and elastic modulus were 5.68 GPa and 5.68 GPa, tensile properties test results show that compared with the pure nickel metal substrates, compound talk to a 2.4 -fold increased the tensile strength, breaking strength increased 2.7 times. Junxian Guo[5] Research using the molecular dynamics method research of graphene - copper elastic properties and the deformation mechanism of composite materials, the results showed that graphene can improve the elasticity and yield strength of composite materials, showed that graphene has important influence on the interface mechanics performance of the copper. Ruoff[6] has found that Ferric nitrate(Fe(No3) 3) and sulfuric acid ((NH4) 2S2O8) were used to etch the nickel foam, which was much more slowly and gentler than that of diluted hydrochloric acid. It is important to control the density of 3DGNs, which determines the transmission speed of the electrons and phonons that change with temperature in the material. Halpin [7] gives a semi-empirical formula for the elastic modulus of composite materials for short-term comfort and reinforcement, which is expressed as: 

$$E_C = \left( \frac{1+2/3\eta_L pf}{1-\eta_L f} \right) E_m$$

$$E_H = \left( \frac{1+2/3\eta_L pf}{1-\eta_H f} \right) E_m$$

In this formula, $E$ is the elastic modulus , $\eta_L = (E_g / E_m - 1)/(E_g / E_m + 2/3p)$; $\eta_L = (E_g / E_m - 1)/(E_g / E_m + 2)$; The subscript m, g, c, and H represent the matrix. Graphene random distribution and uniaxial composite materials; P and f are respectively the diameters and volume fraction of graphene.

Theoretical studies have shown that children of graphene tooling cc lake, uniform dispersion in the matrix, the arrangement orientation and the reaction product with matrix interface decided to load transfer efficiency of graphene composites.

3. Analysis of mechanical properties of graphene materials

Because of its good mechanical properties, high specific surface area, good conductivity and no chiral structure, graphene has become an important reinforcement of polymer matrix composites, which has attracted great attention in scientific research. Graphene can be well dispersed in various kinds of polymer matrix, a tiny amount of graphene content can bring material performance greatly ascend, this has prompted a series of the birth of graphene reinforced polymer matrix composites. In this chapter, the mechanical properties of graphene composite materials were analyzed by using AGA (Graphene aerogel) as an example, and then other graphene composites were analyzed.

3.1. Comparison of mechanical strength of AGA of different densities

Different density of AGA in graphene layer density must be different, this makes the different density of AGA compression strength is different, with the rights of AGA density, the compression strength and the corresponding rights, this is because the density of the larger AGA in graphene layers between the stronger interaction. In addition, as the density is similar, the AGA that is prepared by directional freezing is also higher in mechanical strength than other methods. In the experiment, the compression strength of the AGA with a density of 6.1mg/cm3 reached 14.1 KPa, indicating that the directional freezing method was able to help increase the mechanical strength of the graphene nostrils.
3.2. Comparison of mechanical compression in different directions of AGA

Test after many tests, AGA in horizontal and vertical direction has a good compression resilience, the first compression can produce irreversible damage to the structure of AGA, lead to the after 10 cycles can't back up to 100%. This is to say that the AGA not only has a structure of anisotropy, but also has good compression resilience in different directions.

3.3. AGA in air compression

In order to better analyze the compression of AGA, we specifically measured the cyclic curve of 10 times the AGA compression with density of 8.3mg/cm³. During the first cycle, when the strain was less than 20%, the stress showed a straight line and increased rapidly, mainly due to the elastic bending and shear deformation of graphene wall holes. And then the stress will continue to increase in a straight line but it's going to slow down obviously, and that's a densification process. Starting from the second circle, the curve is roughly the same shape but with the obvious difference from the first time, it should be three stages of the strain curve. The flexion region of the curved surface of the graphite wall. The elastic stacking of the AGA walls; The densification of graphene cells increases stress.

3.4. Mechanical properties of multiple graphene composites

Like other micro size increase phase, due to the graphene larger specific surface area and high surface energy and is easy to be together, so this has been the difficult in study, how to be more evenly spread graphene in the metal substrate, the general research using the solid dispersion method and two kinds of liquid dispersion method. According to previous research, the solid dispersion method of high production efficiency suitable for the preparation of high content of graphene composites, but easy to destroy the graphene structure in the process of production, the liquid dispersion method can combine surface chemical further improve composite material performance. Graphene is used as a metal composite material to show high efficiency, and the mechanical properties of graphene composites are summarized in table 1. As can be seen from table 1, the intensification efficiency of graphene in aluminum and copper matrix is close to 100, which is much higher than other metal strengthening efficiency. In addition, when the content of graphene increased, the strength of the composite material increased, but the efficiency decreased.

| Matrix | Sample | Strength/MPa | E/GPa | HV/MPa | R         |
|--------|--------|--------------|-------|--------|-----------|
| Al alloy | GNS/Al | 249(tensile) | -     | -      | 62.6      |
|         | GNP/Al | 28±5(tensile) | -     | 850±50 | 22        |
|         | GNPs/Al | 467(tensile) | 72    | -      | 25.5      |
|         | GNP/Al | -            | -     | 930    | 34.6      |
|         | GNFs/Al-Mg-Cu | 454(tensile) | 72    | -      | 25.3      |
|         | RGO/Al | -            | 90.1±301 | (1.59±0.07)×10³ | 17.1 |
|         | GNPs/MG | -           | -     | 660    | 64        |
| Mg alloy | GNPs/Mg-Ti | 230±3(tensile) | -     | -      | 57.1      |
|         | GNPs/Mg-Al-Sn | 269±3(tensile) | -     | -      | 19.4      |
|         | GNPs/Mg-Al | 407±3(compressive) | 7.6±0.5 | -      | 18.4      |
| Ni alloy | Ni-Gr nanopillar | 4.0×10³(tensile) | -     | -      | -         |
| Ti alloy | Ni-Al/GNPs | -           | -     | 6.32×10³ | 11.2      |
|         | GTMC | -            | -     | 700.3  | 2.3       |
|         | Graphene/Cu | 284(yield) | 131   | -      | 45        |
|         | Ni-GPL/Cu | 245(tensile) | -     | -      | 53        |
| Cu alloy | GNS-Ni/Cu | 268(yield) | 132   | -      | 94.2      |
|         | GNP/Cu | 320(yield)   | 103   | -      | 14.2      |
|         | MLG/Cu | 401.3±5.2(tensile) | -     | -      | 8.9       |
|         | Cu-Gr composite | -      | 137   | 2.5×10³ | -         |
|         | GNP/Cu composites | 485(yield)| 103   | -      | 22.8      |
4. Conclusion

Graphene is the thinnest, strongest, conductivity and thermal conductivity of the new nanomaterials found at present, which is both the thinnest material and the strongest material and has a wide market. Graphene has an indelible contribution to the preparation of high quality and controllable composite materials. The analysis of the difference between theoretical calculation and measured results is the basic method to guide the development of graphene composite metal materials. In the development and research of graphene, opportunities and challenges coexist. First of all, the mission of graphene composite materials are developed for industrial applications is to make cheap and distributed good graphene. Secondly, optimizing the computational model and adding other calculation methods to improve the mechanical properties of composites. Finally, due to the structure of graphene, the traditional enhancement theory may not apply to graphene reinforced metal composites, which is subject to further study.

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