Multifunctional Nano Silver/Carbon/Epoxy Conductive Adhesive

Xiaojiang Xu, and Hongbo Gu*

School of Chemical Science and Engineering, Tongji University, Shanghai, 200092, P. R. China
*Corresponding author: hongbogu2014@tongji.edu.cn

Keywords: Multifunctional; Epoxy Nanocomposites; Carbon Structure; Nano-Silver; Conductive Adhesive.

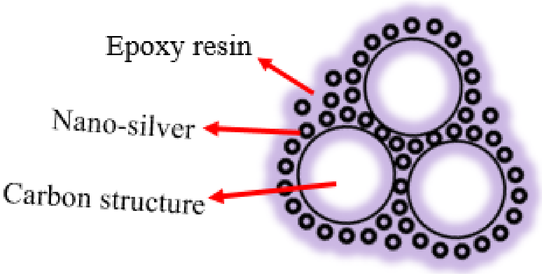
ABSTRACT

Epoxy resin adhesive with the advantages of high bonding performance, low cost and simple bonding process has been widely applied in the automotive industry, electronic device, aerospace and other fields. The traditional epoxy resin conductive adhesive is obtained by addition of the conductive fillers into the epoxy resin. However, it still has many challenges, such as poor dispersibility of conductive fillers in the epoxy matrix, weak interfacial interaction, high electrical conductivity thresholds and so on. With the development of high-tech and nanotechnology, the modification of epoxy resin has also entered a stage of rapid development. The traditional fillers have been unable to meet the current performance requirements, therefore, the conductive adhesive with high-performance and multi-functions is the current hot research topic. It's important to design and develop the new conductive nanocomposites to prepare the conductive epoxy adhesive with low threshold, low resistivity, and high bonding strength.

Conductive adhesive is a combination of adhesive and conductive adhesive, is the semiconductor package, printed circuit board repair, conductive composite bonding and electronic components of the first choice. With the development of miniaturization in the field of electronics and microelectronics, the research of new conductive adhesives has become a hotspot. Conductive adhesives usually consist of prepolymers, curing agents, diluents, toughening agents, etc., while adding conductive filler to achieve its conductivity. The prepolymer contains the active functional group as the main component and provides the molecular skeleton for the cured polymer. The prepolymer is also the main source of bond strength, and the mechanical properties and adhesive properties of the conductive adhesive are mainly determined by the prepolymer. Commonly used prepolymers include epoxy resins, polyurethanes, phenolic resins, and the like. Compared with polyurethane and phenolic resin, epoxy resin has the advantages of high bonding strength, wide adhesion, corrosion resistance, low shrinkage, good stability, high mechanical strength and good workability. Therefore, epoxy resin is the research The most widely used base material. Wherein the epoxy resin is a matrix which produces adhesive properties and mechanical properties, and the conductivity is mainly determined by the conductive filler. So the high conductivity and low filler volume of the conductive adhesive is the main direction of the current research. Common conductive filler silver, copper, carbon materials and composite materials, conductive properties of conductive filler directly determine the performance of conductive adhesive. In general, the content of silver to fill the filler to reach 60 wt% -80 wt%, but the silver is expensive, while in the case of DC electric field and moisture will migrate, thereby reducing its conductivity, affecting the service life; with copper Do the filler content higher than the silver filler, and the air is easy to oxidation of copper oxide is not conductive, and high filler will affect the adhesive adhesive properties and mechanical properties.

In this work, the conductive nanocomposite fillers consisting of C-polydopamine (PDA)/Ag were designed and developed. The carbon sphere with average diameter of 200 nm was synthesized by hydrothermal method combined with high temperature annealing method. Then the polydopamine was

introduced on the surface of carbon sphere through the self-polymerization of dopamine in order to improve the dispersibility of nanofillers within the epoxy matrix and the interfacial interaction between nanofillers and epoxy matrix. After that the nanosilver with diameter of 10 nm-20 nm was fabricated by the in-situ reduction of a silver nitrate and ammonia solution to further increase the conductivity of nanocomposite fillers. The X-ray diffraction (XRD), Fourier Transform infrared spectroscopy (FT-IR), scanning electron microscope (SEM), transmission electron microscopy (TEM), and Raman results confirmed that the C-PDA/Ag nanocomposite fillers were successfully synthesized. Finally, the epoxy adhesive with different loadings of C-PDA/Ag nanofillers were prepared. The peel testing results illustrated that the highest peel strength of 0.281 kN/m was achieved in the epoxy adhesive with 5 wt% loading of C-PDA/Ag nanofillers. The resistivity of epoxy adhesive was increased by almost 8 orders of magnitude after adding C-PDA/Ag nanofillers. The 5 wt% was the threshold for C-PDA/Ag nanofillers in epoxy adhesives.



Schematic for epoxy resin compound conductive adhesive.

REFERENCES

[1] Hui-Wang Cui*, Jin-Ting Jiu, et. Ultra-fast photonic curing of electrically conductive adhesives fabricated from vinyl ester resin and silver micro-flakes for printed electronics. RSC Advances, 2014, 4, 15914

[2] Iosif D. Rosca, Suong V. Hoa*. Method for reducing contact resistivity of carbon nanotube-containing epoxy adhesives for aerospace applications. Composites Science and Technology, 71 (2011) 95–100

[3] Nen-Wen Pua, You-Yu Pengb, et. Application of nitrogen-doped graphene nanosheets in electrically conductive adhesives. Carbon, 67(2014)449-456.

[4] Y. Li et al. Effect of surface modification of fiber post using dopamine polymerization on interfacial adhesion with core resin. Applied Surface Science 274 (2013) 248– 254

[5] Hongbo Gu*, Chao Ma. An overview of multifunctional epoxy nanocomposites. J. Mater. Chem. C, 2016,4, 5890.

[6] Wei Zhang, Yikang Zhou, et. Morphologically Controlled Bioinspired Dopamine-Polypyrrole Nanostructures with Tunable Electrical Properties. Advanced Electronic Materials 2015, 1, 1500205.

[7] Hui-Wang Cui*, Dong-Sheng Li,1 and Qiong Fan1. Using a Functional Epoxy, Micron Silver Flakes, Nano Silver Spheres, and Treated Single-Wall Carbon Nanotubes to Prepare High Performance Electrically Conductive Adhesives. Electronic Materials Letters, Vol. 9, No. 3 (2013), pp. 299-307

[8] Cheng Yang*, Ching Ping Wong, et. Printed electrically conductive composites: conductive filler designs and surface engineering. J. Mater. Chem. C, 2013, 1,4052.

[9] Xinli Hu, Rongrong Qi, et. Preparation and Properties of Dopamine Reduced Graphene Oxide and Its Composites of Epoxy. J. APPL. POLYM. SCI. 2014, DOI: 10.1002/APP.39754.

[10] Wen Zhu, Yuanyuan Wu, et. Facile Synthesis of Mono-Dispersed Polystyrene (PS)/Ag Composite Microspheres via Modified Chemical Reduction. Materials 2013, 6, 5625-5638; doi:10.3390/ma6125625.

[11] Tuo Jia, Long Chena, et. In-situ reduction of Ag nanoparticles on oxygenated mesoporous carbon fabric: Exceptional catalyst for nitroaromatics reduction. Applied Catalysis B: Environmental 182 (2016) 306–315.

[12] Yugang Sun and Younan Xia*. Mechanistic Study on the Replacement Reaction between Silver Nanostructures and Chloroauric Acid in Aqueous Medium. J. AM. CHEM. SOC. 2004, 126, 3892-3901.

[13] Fan Zhang, Gary B. Braun, et. Fabrication of Ag@SiO2@Y2O3:Er Nanostructures for Bioimaging: Tuning of the Up conversion Fluorescence with Silver Nanoparticles. J. AM. CHEM. SOC. 2010, 132, 2850–2851.