Enhanced Thermal Conductivity of silver filled-epoxy resin loaded with Carbon Nanotubes and Graphene

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The development of property-designed conductive adhesives represents an important technological step in the development of smart packaging systems for next generation applications in avionics and power electronics. Silver-filled epoxy resins, such as the EPO TEK H20E (a standard for high speed chip bonding), feature remarkable thermal conductivity (~ 2.5 W/mK) and low electrical resistivity (~ $4x10^{-4}$ ohm-cm) characteristics, thanks to the presence of micrometric metallic particles embedded in the epoxy matrix.

Furthermore, in the last few years, researchers have made many studies in performing multifunctional polymer nanocomposites based on Carbon Nanotubes (CNTs) and graphene sheets due to the extraordinary intrinsic properties of these reinforcement [1,2].

Intense research has been carried out in the recent years to improve the conductivity properties of epoxies. Haddon and coworkers dispersed a GNPs into a epoxy resin, and showed thermal conductivity reaching 6.44 W/mK in resin containing 25 vol% GPs[3]. Song and coworkers reported a good enhanced of thermal conductivity with 10wt% graphene flakes.[4] Here we show that the addition of Graphene nanoplatelets (GNPs) and Carbon Nanotubes (CNTs) allows to improve by a factor ca. 5 the conductivity properties of the EPO TEK H20E reaching optimal values of 11 W/mK and $5x10^{-5}$ ohm-cm for the thermal conductivity and the electrical resistivity, respectively.

Our procedure allows to prepare epoxies capable to host different carbon nanostructures (DWCNTs and Graphene) and exhibit improved conductivity properties even at low fillers loadings, down to 1wt% and 0.01 wt%, for CNT and graphene, without compromising the mechanical and thermodynamic performances. Raman Spectroscopy and Scanning Electron Microscopy provide insight on the crucial role played by the CNTs and graphene in bridging together the silver micro-particles within the epoxy matrix, filling and reinforcing the structure of the nanocomposite material, at the same time.

This work has been supported by the Programma Operativo Nazionale Ricerca e Competitività 2007-2013, PON01_01322 PANREX.

References

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