Enhancement of the thermal conductivity of films by the use of stable graphene dispersions

B. Iraola, L. Bilbao, I. Obieta, M. A. Mendizabal, I. Bustero

TECNALIA, Mikeletegui, 2, San Sebastián, Spain
Izaskun.bustero@tecnalia.com

Abstract

Graphene is an extraordinary good heat conductor, measurements revealed that graphene's near room temperature thermal conductivity is in the range from 3500-5300 W/mK [1]. The superb thermal conduction property of graphene is beneficial for electronic applications and establishes graphene as an excellent material for thermal management [2]. Thermal Interface Materials (TIMs) are typically made of polymer or silicone matrixes filled with thermally conductive particles. The biggest challenge of polymer-based TIMs is to achieve a low thermal resistance. The effective thermal resistance of a TIM can be decreased by reducing the bond-line thickness (BLT), reducing the contact resistance and increasing its thermal conductivity. This study has been focused on the improvement of the thermal conductivity of polymer and sol-gel coatings deposited on Al substrates by the addition of graphene.

The method selected for fabricating the conductive films on the Al requires the preparation of stable graphene dispersions because the graphene platelets tend to form agglomerates due to their strong van der Waals interactions. Stable graphene dispersions in aqueous media were prepared with the aid of dodecylbenzene sulphonic acid sodium (SDBS) by adjusting the ratio of surfactant, the ultrasonication time and the initial graphene concentration.

Dispersions of XGnP-M-25 graphene nanoplatelets from XG Science with initial concentrations from 0,1, 1 and 10mg/l were sonicated (tip and bath) in the presence of different ratios of SDBS during different time. The resulting dispersion was then centrifuged at 5000rpm during 4 hours to remove any aggregates, and the concentration of the supernatant was measured through absorbance measurements at a wavelength of 660 nm using the reported extinction coefficient for graphene dispersions in surfactant/water solutions α= 1390 (L g^{-1} m^{-1}) [3]. Dispersed SDBS has negligible effects at this wavelength value. All absorbance measurements were measured against a blank of the appropriate SDBS/solvent mixture. The highest final concentration of 0,13mg/mL was achieved at an initial concentration of 10mg/ml and a surfactant ratio 1:1. It was also noted that tip sonication is more efficient as compared to bath sonication.

Different concentrations of the stable graphene suspension were introduced in polymer and sol-gel solution to increase their thermal conductivity. The graphene solutions have been deposited by immersion techniques at different extraction speeds in order to control the film thickness. The thickness of the film at high extraction speed was around 20μm, measured by scaning electron microscopy (SEM). The thermal conductivity was measured at room temperature by a Hot Disk sensor TPS 2500 S. Significant differences in the thermal conductivity values were observed depending on the percentage of graphene incorporated in the coating. Enhancement up to 46% with 1%w of graphene was measured reaching the percolation threshold.

These preliminary results are very promising for the development of new thermally conductive coatings based on graphene that will allow reducing the amount of additive when comparing with currently used conventional.

References

[1] Balandin A.A. et al., Nano Lett. **8,** (2008). 902
[2]Ghosh, S. et al.. Appl. Phys. Lett**. 92**, (2008) 151911
[3] Lotya M, Hernandez Y, King PJ, Smith RJ, Nicolosi V, Karlsson LS, et al. J Am Chem Soc **131(10)** (2009) 3611–20.
[4] Balandin A.A. et al., Nano Letters 12**,** (2008) 861

Figures

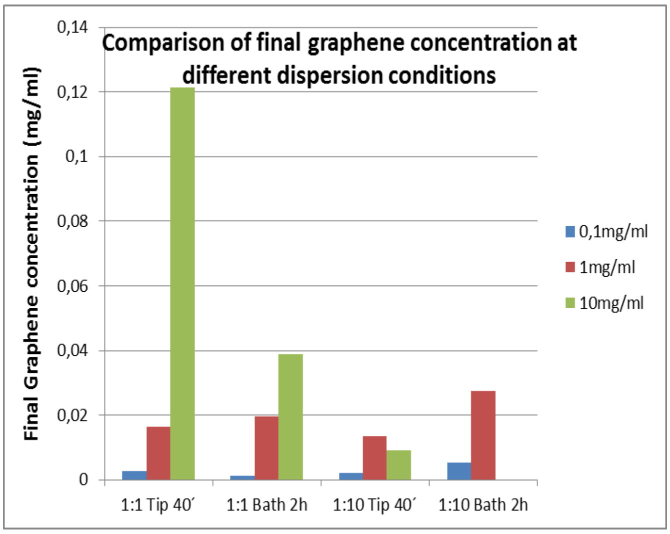

Figure 1. *Comparison of final graphene concentration for different dispersion conditions: initial graphene concentrations, initial concentration:surfactant ratio, tip versus bath sonication, sonication time.*