Proceedings of the 3rd World Congress on Recent Advances in Nanotechnology (RAN'18)
Budapest, Hungary – April 10 - 12, 2018
Paper No. ICNNFC 127
DOI: 10.11159/icnnfc18.127

The Effect of Interfacial Affinity on Thermal Conducting Performance of Liquid Crystalline Composites

Dong-Gue Kang, Yu-Jin Choi, Won-Jin Yoon, Geuk-Cheon Bang, Kwang-Un Jeong
Department of Polymer-Nano Science and Technology, Chonbuk National University
Jeonju 54896, Republic of Korea
dgkang@jbnu.ac.kr; choiyujin@jbnu.ac.kr; wjyoon@jbnu.ac.kr; rmrcjs93@jbnu.ac.kr; kujeong@jbnu.ac.kr

Extended Abstract

Because the electronic devices use a great amount of energy, the harmful heat accumulation rises proportionally to the power density [1]. In this respect, there has been an upsurge in demand for an advanced heat dissipating material to prevent the destructive heat problems [1]. Conventional thermal conducting composites have been made of epoxy thermosets with thermal conductive fillers [2]. In spite of the high loading of thermal conducting additives, most composites display poor thermal conductive performance due to the appearance of phonon scattering at the interface between the epoxy matrix and the filler [2]. Moreover, high filler incorporations also trigger processing challenges for complicated geometries due to the high viscosity [2]. Therefore, an effective development of innovative heat transfer materials for advanced devices needs a profounder understanding of the interfacial relationship between matrix and additive so that acceptable thermal conducting property can be accomplished even at small amount of filler loading [3]. Motivated by the requirement for a thermal conducting organic matrix, polymerizable liquid crystalline (LC) monomers, LC-ene and LC-thiol, were synthesized [4]. The synthesized LC network was served as a polymeric matrix for heat releasing composites packed with expanded graphite (EG) or hexagonal boron nitride (BN) [5]. As predictable, thermal conductive property of both composites were enhanced by increasing the additives [5]. Comparison of theoretical model with experimental measurement of thermal conductivity of LC-EG and LC-BN composites, it was recognized that LC-EG composite showed better thermal conductive performance than LC-BN composite at same filler amount although the thermal conductivity value of BN itself is higher than EG [5]. Spectroscopic analysis combined with surface energy calculation discovered that the LC matrix presented a decent interfacial affinity with EG due to the strong $\pi-\pi$ interaction between EG and LC so that the phonon scattering at the interface between polymeric medium and additive was significantly suppressed [5]. In contrast, BN is able to interact with LC through van der Waals interaction only, and thus the LC-BN composite has relatively poor thermal conductive property [5]. Based on the result, we concluded that the suitable chemical or physical adjustment at the interface between the organic medium and thermal conducting additive is crucial for enhancing the thermal conductivity of composites [5]. This work was supported by the BK21 plus, BRL2015042417, and Mid-Career Researcher Program (2016R1A2B2011041) of Republic of Korea.

References

[1] R. S. Prasher, J.-Y. Chang, I. Sauciuc, S. Narasimhan, D. Chau, G. Chrysler, A. Myers, S. Prstic, C. Hu, "Nano and micro technology-based next-generation package-level cooling solutions," *Intel Technol. J.*, vol. 9, no. 4, pp. 285-296, 2005.

[2] Z. Han, A. Fina, "Thermal conductivity of carbon nanotubes and their polymer nanocomposites: a review," *Prog. Polym. Sci.*, vol. 36, no. 7, pp. 914-944, 2011.

[3] C.-W. Nan, R. Birringer, D. R. Clarke, H. Gleiter, "Effective thermal conductivity of particulate composites with interfacial thermal resistance," *J. Appl. Phys.*, vol. 81, no. 10, pp. 6692-6699, 1997.

[4] D.-G. Kang, M. Park, D.-Y. Kim, M. Goh, N. Kim, K.-U. Jeong, "Heat transfer organic materials: robust polymer films with the outstanding thermal conductivity fabricated by the photopolymerization of uniaxially oriented reactive discogens," *ACS Appl. Mater. Interfaces*, vol. 8, no. 44, pp. 30492-3050, 2016.

[5] D.-G. Kang, N. Kim, M. Park, C. Nah, J. S. Kim, C.-R. Lee, Y. Kim, C. B. Kim, M. Goh, K.-U. Jeong, "Interfacial engineering for the synergistic enhancement of thermal conductivity of discotic liquid crystal composites," *ACS Appl. Mater. Interfaces*, vol. 10, pp. 3155-3159, 2018. DOI: 10.1021/acsami.7b16921.