Boron nitride/vapour grown carbon nanofibre/rubbery epoxy-based hybrid composites for thermal interface applications

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Miniaturisation of microelectronics demands efficient thermal interface materials (TIMs), such as thermal pastes or adhesives, to effectively dissipate heat from microprocessors. Boron nitride (BN) is a commonly employed filler in TIMs due to its high thermal conductivity (280 W/m.K) and electrically insulating nature. Carbon nanomaterials such as graphene, carbon nanotubes and vapour grown carbon nanofibres (VGCNF) have been extensively researched for developing better TIMs due to their high thermal conductivity (2000-6000 W/m.K), compared to conventional fillers such as BN and silver. This work is focused on developing an epoxy-based hybrid composite using conventional BN filler and VGCNF, with the main motivation of producing highly thermally conducting but electrically insulating composite TIMs, which is not expected to be possible if VGCNFs alone are used to produce TIM composites. Various compositions of BN/VGCNF/rubbery epoxy hybrid composites were developed by 3-roll milling. BN/VGCNF/rubbery epoxy hybrid composites have lower thermal conductivity than VGCNF/rubbery epoxy at equivalent total filler loading. On the basis of SEM analysis it can be inferred that BN inclusions impart resistance to electrically conducting networks of VGCNFs and reduce the networks' efficiency. Such disruption in the conducting networks reduces the electrical conductivity of the hybrid composites significantly and this could be advantageous for thermal interface applications. The thermal conductivity of the hybrid composites increases with increasing VGCNF content, whereas electrical conductivity decreases with increasing BN content. Compression testing of the composites shows that BN inclusion produces stiffer composites than those produced with VGCNFs at equivalent loading. The interfacial thermal transport performance (ITTP - studied according to ASTM D5470) of BN/VGCNF/rubbery epoxy coating, acting as TIM adhesive, improves with increasing VGCNF content due to the increasing thermal conductivity imparted by VGCNF. However, such thermal contact resistance measurements show that addition of BN is not beneficial for improving ITTP of VGCNF/rubbery epoxy coating.