A novel thermal-barrier composite system was developed by incorporating fusible metal particles in the epoxy matrix system. Using the latent heat of melting, the Sn/In metal particles having melting temperature at 125°C were imbedded in the polymer matrix to suppress the thermal shock and transient temperature variation. The high-density metal particles were successfully dispersed in the polymer matrix without sinking by incorporating inorganic particles of aluminum nitride (AlN) and boron nitride (BN), which desirably facilitated the heat dissipation to give a high thermal conductivity at around 10 W/m-K. Under the repeated melting and cooling cycles, the spherical shape of metal particles and the latent heat of melting were retained demonstrating the reversible thermal-barrier capability of the developed composite system. Under the constant-heating conditions, it was validated that the temperature rise was delayed by the endothermic melting of Sn/In particles. The developed composite system could find various applications since it could minimize damages caused by the repeated thermal fatigue and/or accidental thermal shock. POLYM. ENG. SCI., 52:2435–2442, 2012. © 2012 Society of Plastics Engineers

INTRODUCTION

With the increase in the performance of the electric circuits and electronic control units (ECUs), efficient heat dissipation is considered to be one of the most important issues which need to be dealt with, because the amount of generated heat often becomes overwhelmingly high in such systems. For example, light emitting diode (LED) lights in such application for vehicles and illuminators [1], the heat can be easily accumulated in the electronic circuits due to the point-heat source, which subsequently decreases the illumination efficiency and lifetime of LED devices. Stable performance of LEDs can be achieved by enabling the effective heat dissipation from the circuit system [2–4]. In addition, the highly-integrated and/or high-power electric devices usually generate high dissipation energy, which often overheat the system to give an unrecoverable serious damage to the device. Even under the damage level of overheating, it should be addressed that the repeated thermal variation in such electronic device may well cause thermal fatigue, and resultantly reduce the service life time.

A popular method of ensuring efficient heat dissipation is the adoption of high thermal conductivity fillers in the polymer matrices [5, 6]. Extensive studies have been conducted to improve the thermal conductivity of polymer composite systems by adding various fillers, such as aluminum nitride (AlN), boron nitride (BN), carbon materials, and metal particles [7–18]. For example, the thermal conductivity of AlN- and BN-epoxy composite systems has been reported to reach 1–7 W/m-K [11, 16]. Recently, hybrid multi-modal filler composites composed of both AlN and BN can provide a thermal conductivity at around 4–8 W/m-K [18–20]. Since the thermal conductivity of polymeric composites decreases with increasing temperature, the heat generated from electronic devices is often accumulated causing rapid temperature rise during their operation [16, 21].