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CNT Suspension in Thermally Conductive Photocurable Resin via Supercritical Fluid Technology

Yi-Chen Weng[1], Ling-Hsuan Chen[1], Ying-Chih Liao[2]
[1]Department of Chemical Engineering, National Taiwan University
No. 1, Section 4, Roosevelt Rd, Da'an District, Taipei City, Taiwan
r11524067@ntu.edu.tw; r08524051@ntu.edu.tw
[2]Advanced Research Center of Green Materials Science & Technology, College of Engineering, National Taiwan University
No. 1, Section 4, Roosevelt Rd, Da'an District, Taipei City, Taiwan
liaoy@ntu.edu.tw

Extended Abstract

In recent years, because of the miniaturization and integration of electronics, heat dissipation has become a critical issue of electronic components, and the research on thermally conductive components has also drawn lots of attention. In order to facilitate the prototype design on thermally conductive components, 3D printing technology has been used due to its accuracy and efficiency, which reduces the consumption and the production time. Among different types of 3D printing technology, photocuring 3D printing was used in this study because of the rapid printing speed, high precision, smooth surface of printing objects, etc [1]. In the application of heat dissipation devices, photocurable resin with good thermal conductivity is essential for better performance. Thus, conductive fillers were incorporated into our photocurable resin to improve its thermal conductivity. However, fillers are prone to aggregate and settle in the resin, reducing the stability of the resin. Poorly dispersed fillers could not improve the thermal conductivity of resin efficiently. In addition, a higher proportion of fillers results in decreased resin fluidity [2] and a profound light-shielding effect that disturbs the printing process and reduces the printing quality [3]. Therefore, in order to improve the suspension of fillers, a chemical dispersion method was used along with supercritical fluid stirring technology in this study. With proper pressure and temperature conditions of supercritical fluid, the resin can thus effectively diffuse between the fillers and improve the dispersion of the fillers [4].

In this study, methyl methacrylate (MMA) was used as the monomer of the photocurable resin. Carbon nanotube (CNT) was used as a filler to improve the thermal conductivity of the resin, because of its excellent thermal conductivity and high aspect ratio [5]. Dispersant and polyurethane acrylate (PUA) oligomer were then added to the resin to improve the stability of the resin. CNT was prevented from aggregating and settling which was caused by its inner-tube van der Waals force, thereby improving the printing quality. Moreover, supercritical carbon dioxide (SCCO2) fluid was used as a solvent during the stirring process. Under proper pressure and temperature conditions, CNT suspension was improved as well as the printing quality. The printed objects also showed enhanced thermal conductivity and thermal diffusivity. In addition, to further improve the thermal properties of the resin, diamond powders were also added in this study which could further improve the viscoelasticity of the resin. Finally, through the photocuring 3D printing process with formulated thermally conductive resin, heat sinks with the complex structures were quickly and precisely fabricated and showed high efficiency. In summary, a photocurable resin with high thermal conductivity is developed via supercritical fluid technology and demonstrates good feasibility and practicability for prototyping thermal elements through photocuring 3D printing.

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