Supporting Information

Cotton Candy-templated Fabrication of Three-dimensional Ceramic Pathway within Polymer Composite for Enhanced Thermal Conductivity

Yuming Wu †‡∥, Kai Ye †, Zhiduo Liu †‡, Bo Wang †, Chao Yan ‡, Zhongwei Wang §, Cheng-Te Lin †‡∥,* Nan Jiang †‡∥,* and Jinhong Yu †‡∥,*

† Key Laboratory of Marine Materials and Related Technologies, Zhejiang Key Laboratory of Marine Materials and Protective Technologies, Ningbo Institute of Materials Technology and Engineering, Chinese Academy of Sciences, Ningbo 315201, China.
‡ Center of Materials Science and Optoelectronics Engineering, University of Chinese Academy of Sciences, Beijing 100049, China.
∥ School of Chemical Engineering, The University of Queensland, St. Lucia, Queensland 4072, Australia.
‡ School of Materials Science and Engineering, Jiangsu University of Science and Technology, Zhenjiang, 212003, China.
§ College of Materials Science and Engineering, Shandong University of Science and Technology, Qingdao, 266590, China.
*Corresponding author, E-mail: linzhengde@nimte.ac.cn; jiangnan@nimte.ac.cn; yujinhong@nimte.ac.cn.
Fig. S1 Raw materials: (a, b) sucrose for centrifugal spinning and (c) its optical micrograph image. Digital images of commercial alumina powders of (d) micron-sized and (e) submicron-sized respectively. (f) Alumina suspension with different alumina contents shows excellent dispersity, even standing still 12 h.
Fig. S2 (a) SEM image, (b) XRD pattern and (c) particle size distributions of micron-sized alumina powder. (d) SEM image, (e) XRD pattern and (f) particle size distributions of submicron-sized alumina powder.

Fig. S3 Digital images of cotton candy machine and centrifugal spinning process

As shown in Fig S3, the purchased centrifugal spinning device (cotton candy machine) includes three main components: a spinneret which rotates around its axis, a heater and a collector. Once the sucrose added into spinneret is melted and the rotating rate reaches a critical value, centrifugal force overcome the surface tension of the molten sugar which is ejected through a gap in edge of spinneret and stretched fibers with decreased surface area.
Fig. S4 (a) The alumina suspension in steel piston and cylinder system is under high pressure treatment that is implemented by 5985 Universal Testing System (INSTRON, US). The system possesses perfect airtightness. (b) The inside pressure dependent on loading time.

<table>
<thead>
<tr>
<th>Samples</th>
<th>Al₂O₃ wt%</th>
<th>Al₂O₃ vol%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure Epoxy</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Composite 1</td>
<td>24.5</td>
<td>8.8</td>
</tr>
<tr>
<td>Composite 2</td>
<td>35.3</td>
<td>14.0</td>
</tr>
<tr>
<td>Composite 3</td>
<td>54.3</td>
<td>26.1</td>
</tr>
<tr>
<td>Composite 4</td>
<td>65.6</td>
<td>36.2</td>
</tr>
</tbody>
</table>

**Calculation method:**

Density at standard conditions: \( \rho_1 = \rho_{\text{Al}_2\text{O}_3} = 3.97 \text{ g/cm}^3 \) \( \rho_2 = \rho_{\text{Epoxy}} = 1.18 \text{ g/cm}^3 \)

The volume fraction of \( \text{Al}_2\text{O}_3 \) filler is calculated through the equation:

\[
\text{Al}_2\text{O}_3 \text{ vol}\% = \frac{(\text{wt}\%)/\rho_1}{(1-\text{wt}\%)/\rho_2}
\]
**Fig. S5** Comparison of thermal conductivity results in this work with other work.[1-8]

**Fig. S6** (a) Fracture surface SEM image of the CTM composite containing 36.2 vol% alumina. (b) Fracture surface SEM image of the PMM composite containing 36.2 vol% alumina.
As shown in Fig. S7, the breakdown strength of composite decrease with the addition of alumina. The possible reason is that there are many defects in composites, which is caused by unfilled channels between the filler and the matrix.