



Constructing Interconnected SiC Whisker Networks in Polymer Composites for Thermal Conductivity Improvement

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1. Introduction

Electronic device packaging

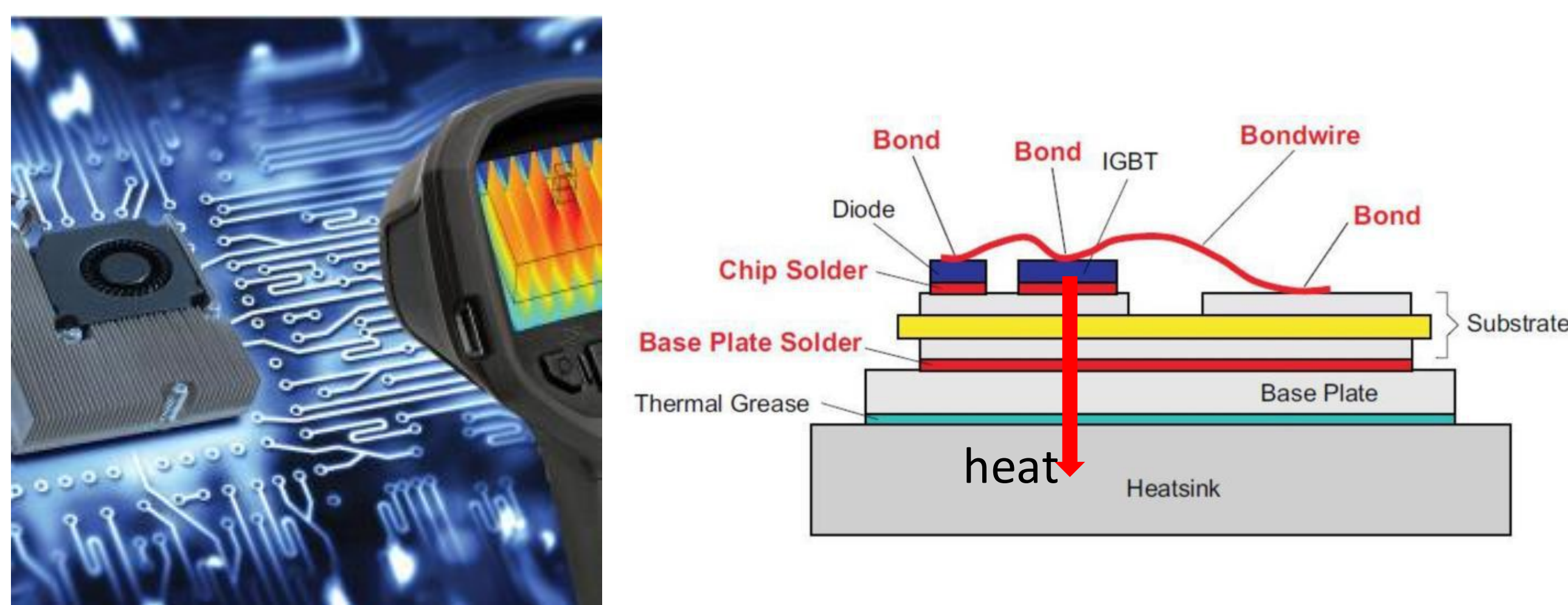


Figure 1. Integrated circuit and structure of the device packaging

With further development of smaller and faster packages of smart electronic products, one of the most vital challenges is how to efficiently remove the heat generated by high power integrated circuits.[1] Composite materials used as packaging materials play a key role in heat dissipation.

Thermally conductive composite materials

Thermally conductive materials are composed of thermally conductive fillers and a polymer matrix. However, the enhancement of thermal conductivity for the polymer composites with randomly dispersed fillers is limited because of the lack of heat transfer pathways.

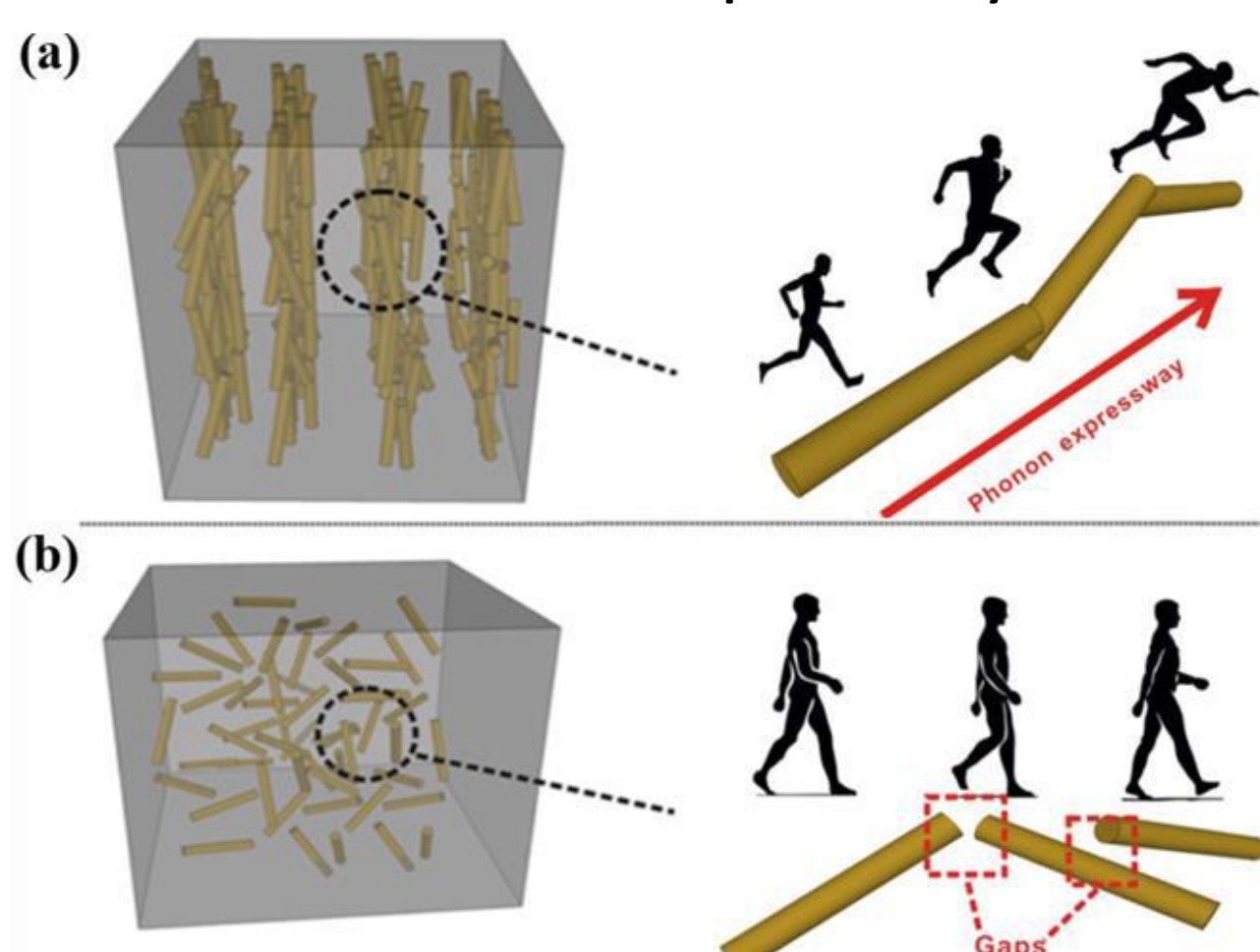


Figure 2. Illustration of thermally conductive paths for composites filled with (a) oriented and (b) randomly dispersed fillers. [2]

Aim

To construct the continuous pathways of fillers as heat transfer pathways in polymer composites to achieve high thermal conductivity

2. Methodology

β -SiC whisker aerogel prepared by freeze casting

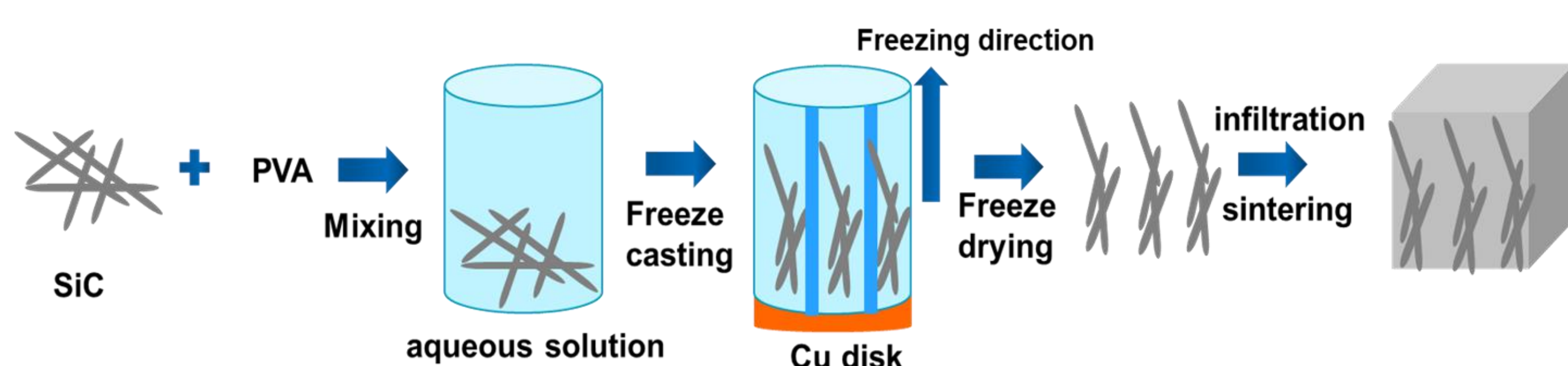


Figure 3. Schematic to the fabrication of SiC aligned composites

The experimental process consists of four steps: (I) preparation of an aqueous slurry containing SiC and PVA; (II) freezing the slurry in liquid nitrogen to form the ice along the temperature gradient; (III) freeze-drying; (IV) sintering the aerogel and polymer infiltration.

Characterization

SEM was applied to observed the microstructure of the samples. The thermal diffusivity was measured using LFA 467 HyperFlash facility.

3. Results and Discussion

Microstructure of SiC aerogel

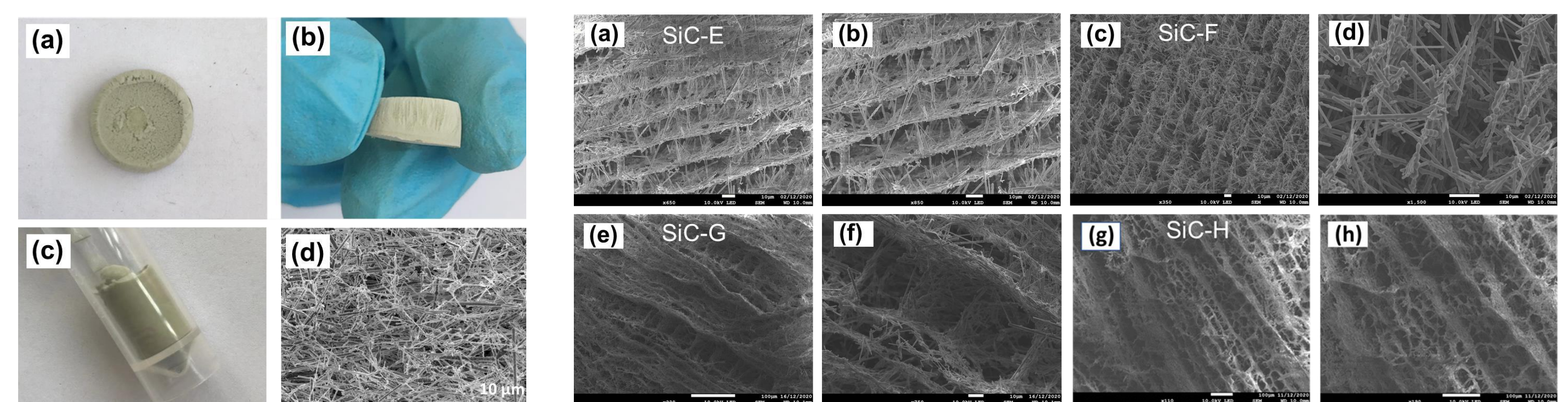


Figure 4. Digital photograph of (a) SiC aligned aerogels; (b) SiC random aerogel; (c) SiC random aerogel; (d) SEM image of the cross-section of SiC random aerogel

Figure 5. SEM images of the cross-section of SiC aligned aerogels with different solid loading. (solid loading: E<F<G<H)

- The aligned SiC along the frozen direction is clearly observed. The sintered SiC aerogels exhibit a structure with a hierarchical architecture formed by the thin SiC whiskers layers.
- The number of bridges between the layers increases with the increasing solid loading. As a result, the interconnected SiC networks form in aerogels.

Thermal diffusivity of SiC composites

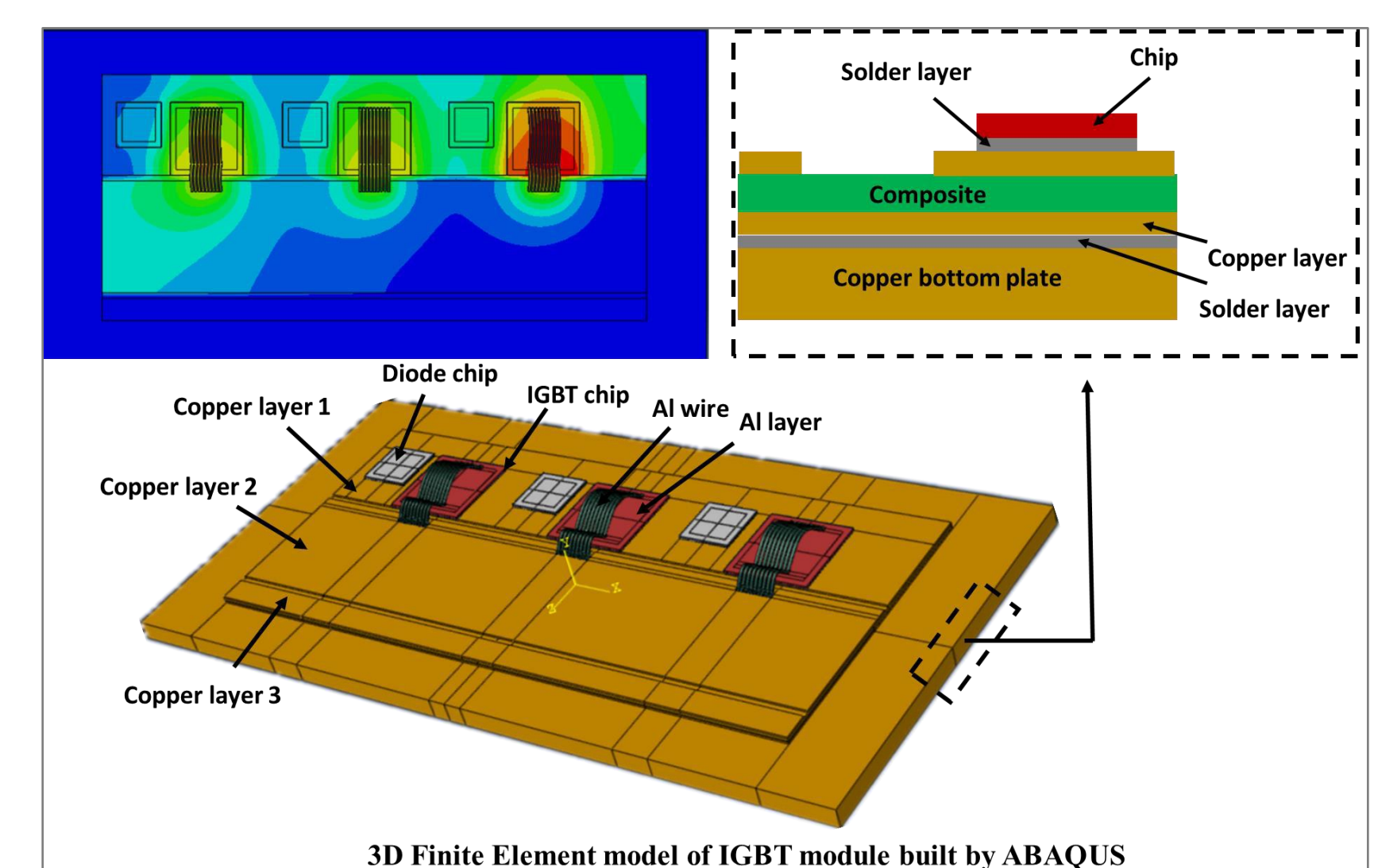
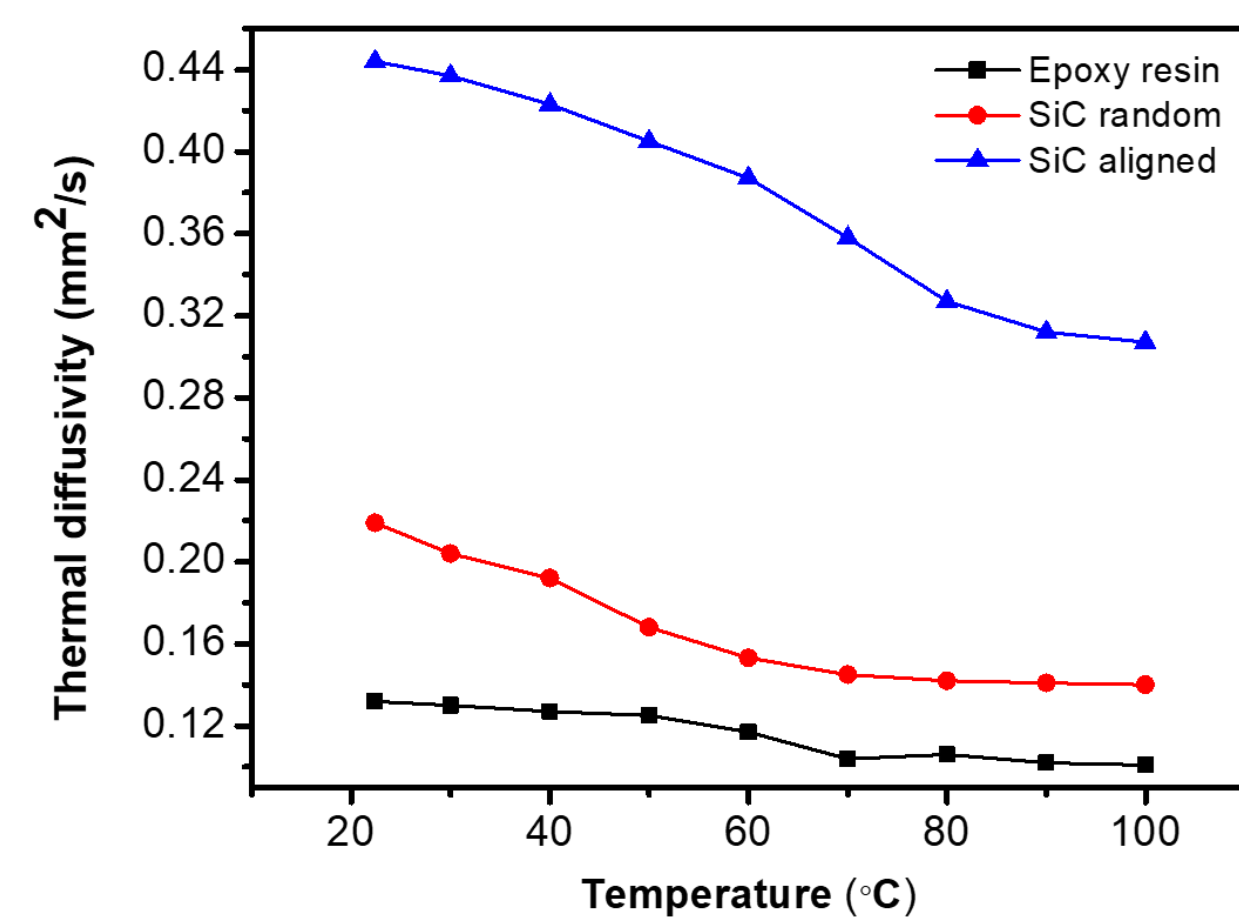


Figure 6. The thermal diffusivity of epoxy resin, SiC random composite and SiC aligned composite.

- The heat transfer capability of SiC composites could be demonstrated in the finite element model of IGBT packaging by electro-thermal simulation.

4. Conclusions

- The SiC aerogels with aligned and interconnected microstructure were successfully prepared by freeze-casting.
- The thermal diffusivity of SiC aligned composite is much higher than the thermal diffusivity of epoxy resin.

5. Future work

- Calculate the thermal conductivity of SiC aligned composites. The relationship between the microstructure of SiC aerogels and the thermal conductivity of SiC composites requires further tests and characterization.
- Test the coefficient of thermal expansion of SiC composites.
- After getting the performance parameters by tests, the function of these novel materials will be simulated in the model of electronic devices built by ABAQUS.

References: [1] Mater. Today 2005, 8, 30-35.
[2] ACS Appl. Mater. Interfaces 2018, 10, 9669-9678.

