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Citation: Chin. Phys. B, 2025, 34 (**7**): 070703. DOI: 10.1088/1674-1056/adca9e
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Enhancement of thermal conductivity in diamond/Al composites through vacuum-pressure thermal diffusion sintering

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(Received 22 January 2025; revised manuscript received 7 April 2025; accepted manuscript online 9 April 2025)

Improving the thermal conductivity (TC) of diamond–metal composites has always been a significant challenge in the field of thermal management. In this paper, diamond/Al composites are systematically studied, and the influence of the holding time (10–120 min) on interface structure and TC is discussed. The results of this research show that long-term thermal diffusion sintering can achieve dense interfacial bonding in diamond/Al composites, enhancing their TC. Diamond/Al composites with 50 vol% of 900 μm diamond attain the highest TC value of 888.73 $W{\cdot}m^{-1}{\cdot}K^{-1}$ under sintering conditions of 650 °C, 50 MPa, and 120 min — nearly 92% of the theoretical value predicted by the Maxwell model. This study establishes that high TC can be achieved through long-term thermal diffusion alone, without the need for complex diamond surface coating or substrate alloying.

Keywords: diamond/Al composites, thermal conductivity, interfacial bonding

PACS: 07.78.+s, 12.38.Qk, 07.30.–t, 02.30.Nw

DOI: 10.1088/1674-1056/adca9e **CSTR:** 32038.14.CPB.adca9e

1. Introduction

With the rapid development of modern electronic technology, electronic devices are continuously evolving towards miniaturization, high power density, and integration. This has led to a significant heat dissipation challenge, which has become a key factor restricting the performance improvement and service life of devices.[1–5] Materials with high thermal conductivity (TC) have emerged as core materials for addressing this issue, attracting considerable attention from both academic and industrial circles. Among the various candidate materials, diamond/aluminum composites have stood out due to the superior intrinsic TC of diamond (approximately 2200 $W{\cdot}m^{-1}{\cdot}K^{-1}$) and the relatively low cost and good machinability of Al.[6–10]

Early research into diamond/Al composites mainly focused on the exploration and optimization of traditional preparation processes. For example, the vacuum hot pressing (VHP) process can improve the TC of composite materials to a certain extent, as key parameters such as sintering temperature, pressure, and time can be adjusted. Tan *et al.*[11] found that the TC of a composite prepared under specific conditions (such as 650 °C/67 MPa/90 min) could reach 567 $W{\cdot}m^{-1}{\cdot}K^{-1}$, more than 90% of the theoretically predicted value, indicating that the sintering temperature and time are crucial to the densification and interface bonding of the composite. However, the high temperatures used in the powder metallurgy sintering method can easily cause aluminum seepage and the formation of harmful phases, which have an adverse effect on TC. At the same time, the pressure needs to be accurately controlled to avoid damage to the diamond particles while ensuring the density of the composite material, but this further limits the use of coarse-grained diamond particles.

With continued research, interface engineering has gradually become a key research direction for improving the properties of diamond/Al composites. By adding alloying elements (such as Cu, Ti, Si, etc.) to the aluminum matrix or metallizing the surface of diamond particles (using Ti, W, Mo, etc.), the interface bonding strength can be effectively enhanced, the interfacial thermal resistance can be reduced, and the TC can be significantly improved.[12–22] In some research studies, the optimized interface treatment allowed the TC of the composite material to exceed 700 $W{\cdot}m^{-1}{\cdot}K^{-1}$. The interaction between the alloying elements and the diamond surface can promote the interface reaction, forming a stable compound or alloy layer and enhancing the phonon transport ability at the interface.[23–26] However, the addition of alloying elements may reduce the TC of the Al matrix, and improper control of the thickness and uniformity of the metallized coating may also introduce new thermal resistance, limiting the further improvement of TC.[27–33]

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Recent studies have shown that thermal diffusion plays a critical role in the optimization of composite properties. Cao *et al.*[34] systematically investigated the effects of thermal diffusion temperature (800–1025 °C) and time (5–60 min) on the growth and TC of the chromium carbide interface in a diamond/Cu–Cr composite material system and found that appropriate extension of thermal diffusion time can promote the optimization of the interface layer structure.[35] The decrease in TC is avoided, and instead, it is increased to about 577 $W{\cdot}m^{-1}{\cdot}K^{-1}$. This is because reasonable thermal diffusion can promote the diffusion and reaction of elements, optimize the interface microstructure, and reduce interface defects and thermal resistance. However, too long a time or too high a temperature during thermal diffusion may lead to the graphitization of diamond particles or excessive interface reaction, which damages the properties of composite materials.[36–38]

Large-grained (500–1000 μm) single-crystal diamond has a unique advantage in improving the TC of composite materials. Compared with small-grained diamond, large-grained diamond can significantly reduce the interfacial area between particles at the same volume fraction and reduce the obstructive effect of interface thermal resistance on heat conduction.[39,40] In 2022, Zhang *et al.*[41] used double-grained (116 μm/980 μm) diamonds and gas pressure infiltration sintering to achieve the highest recorded TC of a diamond/Al composite, 1021 $W{\cdot}m^{-1}{\cdot}K^{-1}$. However, large-particle-size diamond faces many challenges in its preparation process. The traditional sintering process, due to its small specific surface area and insufficient driving force between particles, can easily lead to low-density sintering, pores, and other defects, which seriously affect the TC and mechanical properties of composite materials.[42–47]

In this study, in order to achieve the preparation of diamond/Al composite materials with high TC, a novel strategy combining the long-term thermal diffusion method and the application of large-particle single-crystal diamond is innovatively proposed. The long-term thermal diffusion is helpful for the diffusion of Al atoms to the pores and the diamond crystal surface, improving the compactness of the composite material and enhancing the interface bonding strength and heat conduction ability. Large-grain single-crystal diamond can fundamentally reduce the interfacial thermal resistance and provide a more efficient channel for heat conduction. The synergistic effect of the two is expected to break through the bottleneck of existing technology, allow diamond/Al composite materials to be prepared with higher TC and better performance, meet the urgent demand of modern electronic equipment for efficient thermal management materials, and promote the further development of electronic technology.

2. Experimental details

2.1. Sample preparation

The materials utilized consisted of pure Al powder and synthetic diamond particles. SEM images of these materials are depicted in Fig. 1. Pure Al powder (purity 99.95%, particle size 25 μm, Shanghai Aladdin Bio-Chem Technology Co., Ltd., China) was used as the matrix, and the diamond particles (model: HWD 40, average particle size 900 μm, Henan Huanghe Cyclone Co., Ltd., China) were used as TC reinforcement materials. Fourier transform infrared (FTIR) spectroscopy results for the raw diamond used in this study are shown in Fig. 2. We used a formula to calculate the nitrogen content. The specific calculation formula is as follows:[48]

$$N_{\mathrm{C}}\ (\mathrm{ppm}) = (1.1\alpha_{1130} - 0.2\alpha_{1282}) \times 25 = 25\alpha_{\mathrm{c}}, \tag{1}$$

$$N_{\mathrm{A}}\ (\mathrm{ppm}) = (1.1\alpha_{1282} - 0.2\alpha_{1130}) \times 25 = 25\alpha_{\mathrm{A}}, \tag{2}$$

$$\alpha_{1130} = \frac{\mu(1130\ \mathrm{cm}^{-1})}{\mu(2000\ \mathrm{cm}^{-1})} \times 12.3, \tag{3}$$

$$\alpha_{1282} = \frac{\mu(1282\ \mathrm{cm}^{-1})}{\mu(2000\ \mathrm{cm}^{-1})} \times 12.3. \tag{4}$$

Here, N_{C} and N_{A} represent the nitrogen contents in the form of C centers and A centers, respectively; α_{c} and α_{A} represent the absorption coefficients of the nitrogen contents in the form of C and A color centers, respectively; and α_{1130} and α_{1282} represent the *ab*-adsorption coefficients at the 1130 cm^{-1} and 1282 cm^{-1} peaks, respectively. According to the above equation and the FTIR data, the nitrogen content is estimated to be 264 ppm, so the TC of the raw diamond is about 1336.72 $W{\cdot}m^{-1}{\cdot}K^{-1}$ from the linear relationship between the TC and the nitrogen content.[49]

2.2. Fabrication of diamond/Al composites

First, prior to further processing, the diamond particles underwent a pretreatment procedure and were submerged in aqua regia (H_2SO_4:HNO_3 =3:1 volume ratio) for a period of three hours, with the aim of eliminating metallic contaminants. After the treated diamond was subjected to a drying process, the organic contaminants of the diamond particles were removed using acetone, ethanol, and deionized water for 10 min. The treated diamond was directly mixed with the pure Al powder in a volume ratio of 1:1. Subsequently, the powder mixture was cold-pressed into a powder briquette, loaded into a graphite mold, and pressed into a cylinder with $\Phi = 12.7\ \mathrm{mm} \times 2\ \mathrm{mm}$. The sample was then placed into a vacuum hot-pressing furnace, and a temperature program was set for sintering. The fabrication temperature was 650 °C, and the pressure applied was 50 MPa. After the sintering was complete, the temperature was naturally lowered, and the mold and sample were taken out. Finally, the sample was polished, cleaned, and dried. The fabrication process is illustrated in Fig. 3.

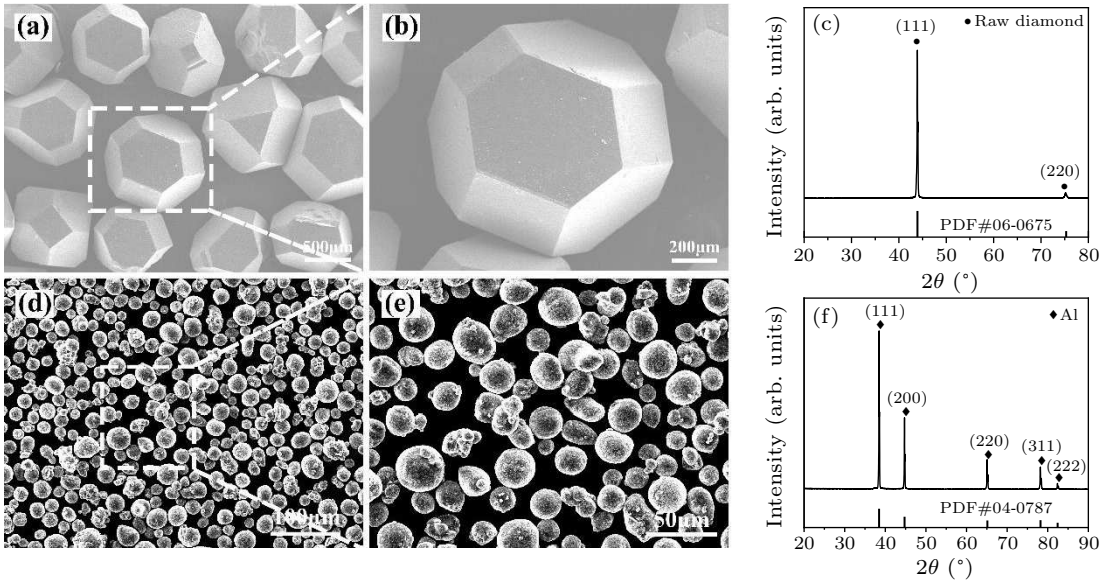


Fig. 1. SEM images of intact diamond crystal (a)–(c) and aluminum powder (d)–(f).

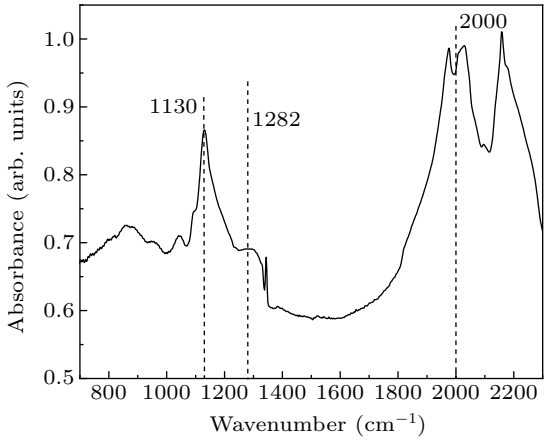


Fig. 2. FTIR spectrum of raw diamond.

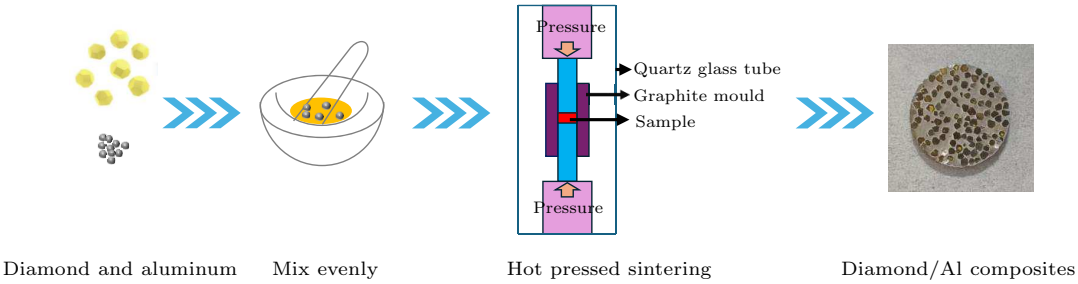


Fig. 3. Flow chart of the diamond/aluminum composite preparation process.

2.3. Sample characterization

The density d of the sample was determined using the Archimedean displacement technique, while the specific heat capacity C_p of the sample was computed by assessing the volumetric fractions of the diamond and Al powder within the formulated specimen. The thermal diffusivity α of the diamond/Al samples ($\Phi = 12.7 \times 3$ mm^3) was measured by a laser TC meter (LFA 467, Netzsch, Germany). Finally, the TC was calculated using the formula $\kappa = \alpha C_p d$. The structures of the composites were characterized through x-ray diffraction (XRD) using Cu $K\alpha$ radiation (SmartLab, Rigaku, Japan). The 3D structure was detected by micro-computed tomography (CT) (Nano Voxel 4000, Tianjin Sanying Precision Instrument Co., Ltd.). The morphology and chemical composition were studied using a scanning electron microscope (SEM) (ZEISS Sigma 300, Germany) equipped with energy-dispersive spectroscopy (EDS) (Oxford Xplore 50). The coefficient of thermal expansion (CTE) (30–250 °C) was measured with a thermal dilatometer (Netzsch TMA 402F3, Germany) using a sample size of $12 \times 4 \times 2$ mm^3.

3. Results and discussion

3.1. Phase constitutions and densification of diamond/Al composites

Figure 4 depicts the XRD patterns of diamond/Al composite samples produced using different sintering times. Only the characteristic peaks of diamond and Al were detected. No characteristic peaks of graphite and aluminum carbide were found in the XRD pattern, indicating that there was no graphitization of diamond during the sintering cycle at 650 °C for 10–120 min. The main reason for this is that the vacuum hot-pressing sintering method is a powder metallurgy solid-phase sintering technology. The sintering temperature used in this work is 650 °C, which is far lower than the temperature of diamond graphitization. Therefore, there is no decisive condition for the formation of aluminum carbide or free carbon. In liquid-phase sintering methods, such as gas-pressure infiltration, the commonly used sintering temperature often exceeds 1000 °C; at this temperature, the diamond surface undergoes graphitization and then reacts with the aluminum matrix to form aluminum carbide.[11,41] The TC of aluminum carbide is about 20–200 $W \cdot m^{-1} \cdot K^{-1}$, and it also easily reacts with water, resulting in poor water resistance and structural instability in diamond/Al composite materials. Therefore, the key factor in the preparation process of diamond/Al composite material is to prevent the formation of aluminum carbide; in this regard, the use of low-temperature sintering at 650 °C (less than the melting temperature of Al) can effectively inhibit the formation of aluminum carbide and maintain the structural stability of the composite material.

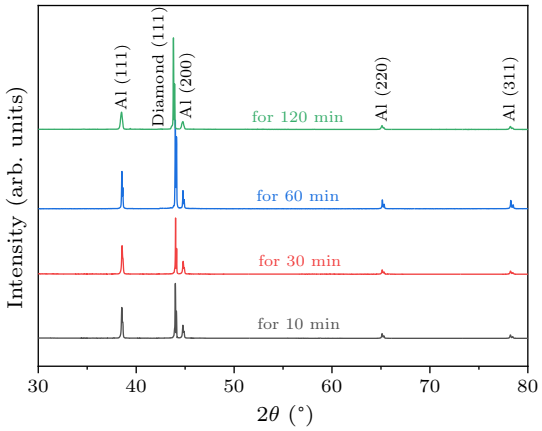


Fig. 4. XRD results for diamond/Al composites sintered at 650 °C/50 MPa for 10 min, 30 min, 60 min, and 120 min.

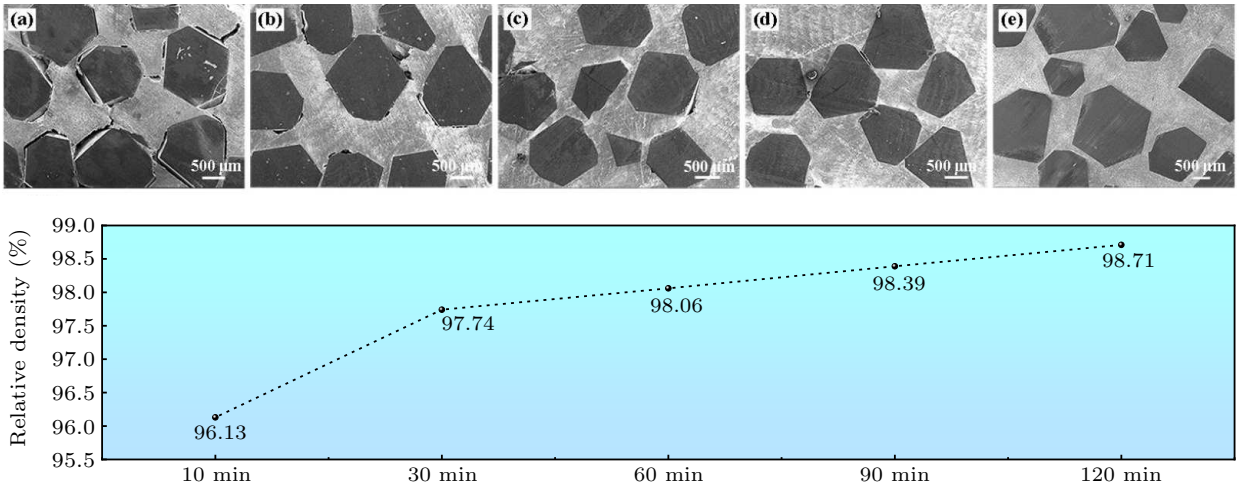


Fig. 5. SEM morphological images (top) and relative densities of diamond/Al composites (bottom) sintered at 650 °C/50 MPa for (a) 10 min, (b) 30 min, (c) 60 min, (d) 90 min, and (e) 120 min.

In order to study the effect of long-term thermal diffusion on the bonding and densification of diamond/Al composites, the sintering temperature used in this work was uniformly set to 650 °C (close to the melting point of Al). The general morphologies and relative densities of diamond/Al composites with 50 vol% diamond sintered at 650 °C/50 MPa for holding time of 10 min, 30 min, 60 min, 90 min, and 120 min are shown in Fig. 5. It is obvious that the structure of the diamond particles in the Al matrix is continuous (without fractures) and that the diamond particles retain a regular polygonal shape throughout various sintering processes, signifying their structural stability. From Fig. 5(a), it can be clearly observed that there are numerous gaps between the diamond particles and the Al matrix. Meanwhile, the relative density of the composites is merely 96.13%. The existence of these gaps between the diamond and the Al matrix can induce high thermal resistance, which significantly impedes the heat conduction efficiency of the composite material. When the prolonged holding time reaches 30 min, the gaps are significantly reduced. When the sintering holding time is further increased to 120 min, these gaps disappear completely. Correspondingly, the relative density of the composites increases to a maximum of 98.71%, approaching full densification. The above results reveal that, in the sintering process of diamond/Al composites, the sintering time plays a crucial role in determining their microstructure and properties.[50–52] A short sintering time fails

to allow sufficient diffusion and bonding between the diamond particles and the Al matrix, resulting in the presence of many gaps. These gaps not only reduce the density of the composites but also act as barriers to heat transfer due to the relatively low TC of air or voids within the gaps. This is because during long-term thermal diffusion, the atoms of the Al matrix have more time to diffuse and fill the gaps around the diamond particles, gradually improving the interfacial bonding and reducing the porosity, which leads to an increase in density. The promotion of Al atom diffusion during long-term sintering is a key factor in optimizing the performance of diamond/Al composites, which provides a theoretical basis for the preparation of high-performance thermal conductive composite materials. When the holding time is further increased, the densities of the composites show a decreasing trend, which is consistent with the trend of the TC of the composites.

In order to more intuitively observe the effect of the holding time on the density of the composites, we added density plots of the composites under different holding times, as shown in Fig. 6.

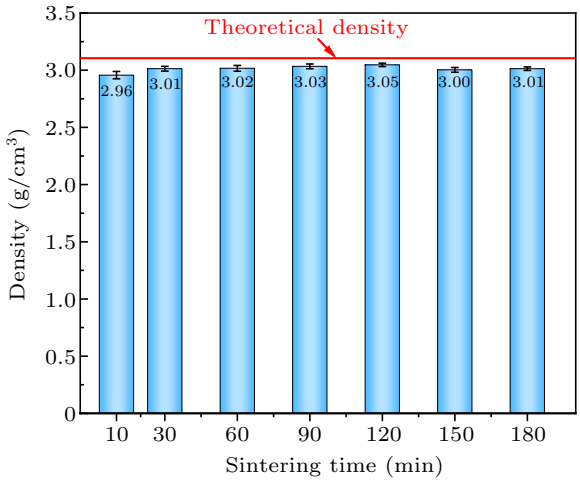


Fig. 6. Densities of composite diamond (50 vol%)/aluminum thermally conductive materials prepared by maintaining the sintering process at 650 °C/50 MPa for different time periods.

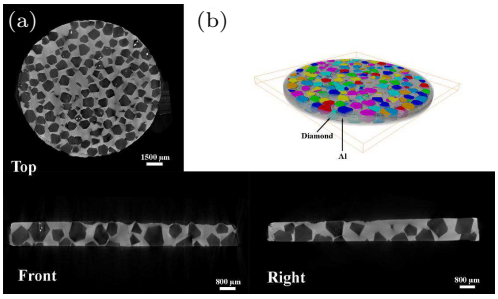


Fig. 7. Three-dimensional x-ray micro-CT characterization of the diamond/Al composite materials sintered at 650 °C/50 MPa for 120 min. (a) Top, front, and right views; (b) three-dimensional distribution of diamond particles.

To detect the distribution of diamond particles in the Al matrix, 3D x-ray micro-CT tests were performed on the prepared diamond/Al composites that were sintered for 120 min, as shown in Fig. 6. Figure 7(a) shows the top view, from which it can be seen that the diamond particles are approximately evenly dispersed in the Al matrix, while the front and right views also show uniform distributions of diamond particles. In Fig. 6(b), the 3D image reveals the uniform distribution of diamond particles in the Al matrix. In this study, we selected a fixed 50 vol% diamond content, so the uniform dispersion of diamond particles helps to improve the TC of diamond/Al composites.

3.2. Microstructure of diamond/Al composite materials

The microstructures of the diamond/Al composites sintered at 650 °C/50 MPa for 120 min are shown in Fig. 8. In Fig. 8(a), it can be seen that the diamond particles showed a relatively uniform size distribution and good dispersion in the Al matrix. This means that the stability of the diamond particles is better maintained during the long sintering process, providing a stable reinforced skeleton for the composite material. In the magnified views (Figs. 8(d) and 8(g)), it is particularly noteworthy that the interface area between the diamond particles and the Al matrix is clear and tight, with no obvious holes or gaps, indicating that a relatively ideal combined state has been formed. This good interface combination can effectively enhance the mechanical properties of the composite material and promote heat conduction.[8,11] The results of elemental mapping based on EDS are shown in Figs. 8(e), 8(f), 8(h), and 8(i), and line scanning results are shown in Fig. 8(k). These further confirm that long-term sintering can promote dense bonding between the diamond crystal surface and the

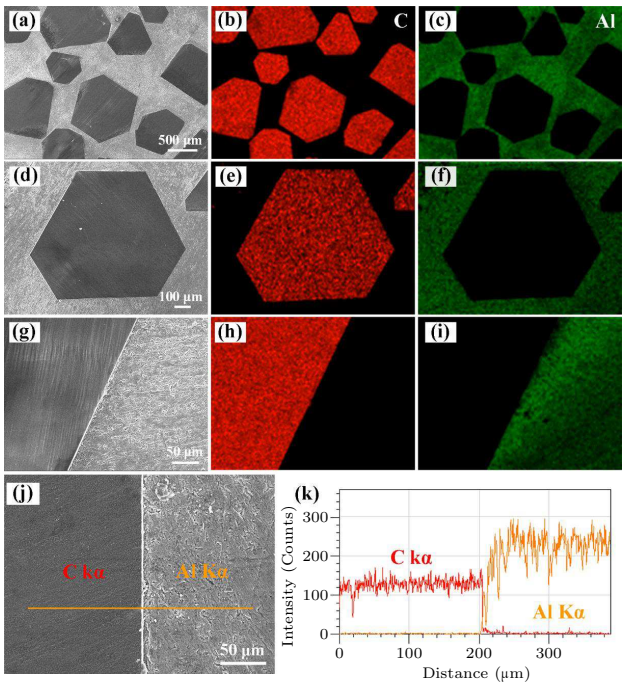


Fig. 8. The morphology and elemental distribution of diamond/Al composites sintered at 650 °C/50 MPa for 120 min. (a)–(c) Diamond/Al; (d)–(e) 70×; (g)–(i): 300×; (j) and (k) show line scan results.

Al matrix, eliminating pores and reducing pore thermal resistance, which is crucial to improving the heat transfer efficiency of diamond/Al composites.[51–53] Compared with the strategy of diamond surface coating and matrix alloying, this highly dense bonding between the diamond and the Al matrix can be achieved only by extending the holding time during sintering, which has certain guiding significance for the sintering of cermet composites and provides an experimental basis for industrial production.

3.3. Effect of sintering time on thermal properties of composites

Figure 9 illustrates the dependence of the TCs of the diamond/Al composites with 50 vol% diamond sintered at 650 °C/50 MPa on sintering time. For the composite sintered for 10 min, the combination of diamond and Al matrix is weak; its TC is only 462.77 $W{\cdot}m^{-1}{\cdot}K^{-1}$, and the effect of diamond on enhancing heat conduction is not obvious. As the sintering time increases, the TCs of the composites increase to a maximum value of 888.73 $W{\cdot}m^{-1}{\cdot}K^{-1}$, an increase of 92%. Currently, this value represents the highest TC ever recorded for diamond/Al composites fabricated by strengthening the Al matrix with single-grain diamond particles. In this study, we innovatively combined a long-time thermal diffusion process with large-size single-crystal diamonds to enhance the composites' densities and interfacial bonding strengths through the deep diffusion of aluminum atoms. At the same time, we made use of large diamond crystals to reduce the interfacial thermal resistance and construct a highly efficient thermal conduction network. The synergistic effect of these factors breaks through the bottleneck of traditional technology, allowing high-TC diamond/aluminum composites to be successfully prepared, which provides a novel solution for the efficient thermal management of modern electronic devices. When the holding time is increased to 150 min and 180 min, the TCs of the composites show a decreasing trend, which is due to the fact that prolonged sintering may lead to excessive grain growth in the aluminum matrix. While grain growth may reduce the number of grain boundaries, it also leads to interfacial stress concentration and microcrack formation, which increases phonon scattering and thus reduces the TC. Images demonstrating this point are shown in Fig. 10.

Figure 10 shows the variation of aluminum matrix grains in bimodal diamond/aluminum composite thermal conductive materials prepared at holding times of 120 min, 150 min, and 180 min, respectively. From the SEM images, we can see that the aluminum matrix grains change as the holding time increases, and this phenomenon also explains the decrease in TC after holding times of more than 120 min. Crystal coarsening, i.e., an increase in aluminum grain size, reduces the number of grain boundaries but also leads to the appearance of local pore defects, increasing the pore thermal resistance.

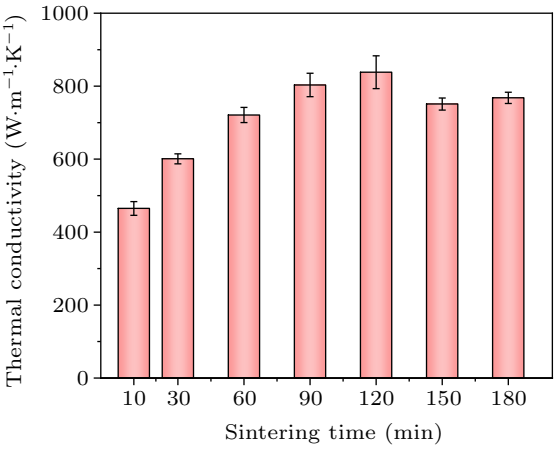


Fig. 9. The dependence of the TCs of diamond/Al composites with 50 vol% diamond sintered at 650 °C/50 MPa on sintering time.

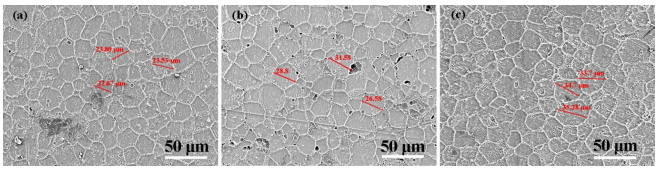


Fig. 10. SEM images of aluminum matrix grain changes in composites produced using holding time of (a) 120 min, (b) 150 min, and (c) 180 min.

To better understand the effect of the interface on the TC of diamond/Al composites, the TCs of diamond/Al composites were calculated using the Maxwell model[54] (the relevant reference values are shown in Table 1)[55]

$$K_c = K_m \times \frac{2-2V_p+(1+2V_p)\frac{K_p}{K_m}}{2+2V_p+(1-2V_p)\frac{K_p}{K_m}}. \tag{5}$$

Here, K_c denotes the TC of the composite material, while K_m signifies the TC of the Al matrix, which is 230 $W{\cdot}m^{-1}{\cdot}K^{-1}$. Furthermore, K_p represents the TC of diamond, which has a value of 1336.72 $W{\cdot}m^{-1}{\cdot}K^{-1}$. Additionally, V_p indicates the volume fraction of diamond, which is 50%. Based on the reference data, the calculated theoretical TC for a composite containing 50 vol% diamond and Al is 967.81 $W{\cdot}m^{-1}{\cdot}K^{-1}$. The value of 888.73 $W{\cdot}m^{-1}{\cdot}K^{-1}$ obtained from the experimental results reached 91.83% of the theoretical value. Tan's team prepared diamond/Al composites with a maximum TC of 567 $W{\cdot}m^{-1}{\cdot}K^{-1}$ using 55 vol% diamond particles at a size of 200 μm under sintering conditions of 67 MPa for 90 min.[11] In our study, we used large-particle (900 μm) diamond particles; compared with 200 μm diamond particles, the contact interface area between the diamond particles and the aluminum matrix is reduced by 4.5 times. When the contact interface area is reduced by using large-grained diamond particles, the thermal resistance of the interface is reduced accordingly. When the heat flow passes through the composite material, the resistance encountered is reduced, which is

more conducive to heat transfer; i.e., heat conduction is promoted. In diamond/Al composites, phonons are scattered at the interface. Smaller particles result in a larger interface area, which increases the probability of phonon scattering at the interface. When the contact interface area is reduced, the chance of phonon scattering at the interface is reduced. Phonons can more smoothly transfer energy between the diamond and the Al matrix, just like reducing "obstacles" in the road, so that heat can be more efficiently transferred from one phase (such as the aluminum matrix) to the other phase (diamond), thereby promoting heat conduction.[41–45] Thus, the preparation of diamond/Al composites with high TC has been realized through the use of long-term VHP and coarse-grained diamond, which proves that VHP sintering is an effective preparation method.

Table 1. Material parameters of the Maxwell model.

Material	Density (kg/cm^3)	TC ($W{\cdot}m^{-1}{\cdot}K^{-1}$)	Specific heat ($J{\cdot}kg^{-1}{\cdot}K^{-1}$)	Phonon velocity (m/s)
Diamond	3520	1200–2200	512	13924
Aluminum	2700	237	895	3620

Figure 11 compares the TC properties of diamond/Al composites prepared by liquid infiltration, spark plasma sintering (SPS), and VHP. Previous studies have mainly enhanced the bond between the diamond and the matrix by diamond surface coating treatments or matrix alloying. Che *et al.* observed that when the thickness of the Ti coating layer decreased from 500 nm to 200 nm, the TC of the diamond/Al composite increased from 520 $W{\cdot}m^{-1}{\cdot}K^{-1}$ to 650 $W{\cdot}m^{-1}{\cdot}K^{-1}$.[12,61] Diamond surface coating can improve the TC of diamond/Al composites to a certain extent, but not all coating materials can enhance the TC.[21,38,56] Li *et al.* used ZrC-coated diamond particles via gas pressure infiltration to prepare diamond/Al composites. However, the TC decreased from 709 $W{\cdot}m^{-1}{\cdot}K^{-1}$ to 572 $W{\cdot}m^{-1}{\cdot}K^{-1}$ due to ZrC's low TC.[47] Jia *et al.* focused on the preparation of Al/diamond composites using direct current (DC)-assisted fast hot-pressing (FHP) sintering. By optimizing the sintering parameters to 560 °C, 80 MPa, and 10 min, they achieved a TC of 527.8 $W{\cdot}m^{-1}{\cdot}K^{-1}$ for the Al-50 vol% uncoated diamond composite.[60] Mizuuchi *et al.* alloyed the Al matrix by adding 5 wt% of silicon to achieve a TC of 552 $W{\cdot}m^{-1}{\cdot}K^{-1}$ in a 50 vol% diamond/Al composite.[57] In addition, the process of alloying the Al matrix and metallizing the diamond surface led to a significant increase in the complexity and cost of the fabrication procedure. In comparison to methods such as SPS and pressure infiltration, the equipment and manufacturing process of VHP sintering are relatively uncomplicated. Using an appropriate selection of precursor materials and optimization of the sintering process allows the TC parameters of diamond/Al composites to be effectively modulated.

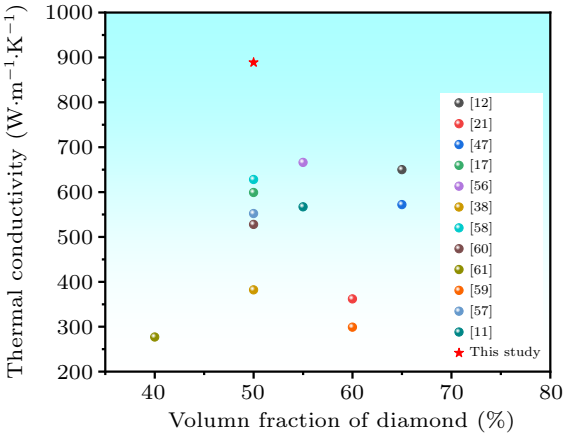


Fig. 11. Comparison between the studied composite and other composites.

3.4. Coefficient of thermal expansion

In this work, the thermal expansion coefficient of the diamond/Al composite in the range of 25–200 °C was measured, as shown in Fig. 10. It was found that the thermal expansion coefficient could be adjusted by varying the holding time, and the lowest thermal expansion coefficient was 9.43×10^{-6} K^{-1} at 25 °C. When the temperature rose to 200 °C, the thermal expansion coefficient increased to 13.2×10^{-6} K^{-1}. Compared with the thermal expansion coefficient of pure Al (23.1×10^{-6} K^{-1}), the thermal expansion coefficient of the composite material is significantly lower, which is mainly due to the low thermal expansion coefficient of diamond, namely, 1.2×10^{-6} K^{-1}.[62] At the same time, this also proves that there is a strong bonding interface between the diamond and the Al matrix in the diamond/Al composites. Overall, the diamond/Al composite produced in this study demonstrates great potential for applications requiring materials with both low thermal expansion and high thermal conductivity.

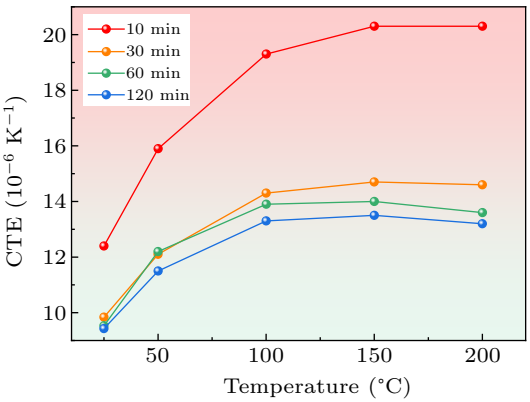


Fig. 12. Thermal expansion coefficients of diamond/Al composites sintered at 650 °C/50 MPa for 10 min, 30 min, 60 min, and 120 min.

4. Conclusion

Diamond/Al composites were fabricated through vacuum-pressure thermal diffusion sintering, and a high TC was obtained by optimizing the sintering time and selecting coarse-grained diamond particles. The results revealed

that the TC of the composite with a 50 vol% diamond content at a particle size of 900 μm reached a TC value of 888.72 $W \cdot m^{-1} \cdot K^{-1}$ when sintered at 650 °C/50 MPa for 120 min. The high-density bonding of the diamond and the Al matrix was achieved by long-term thermal diffusion sintering. By controlling the sintering time, atomic diffusion, and filling mechanism, we were able to achieve controllable bonding between the diamond interface and the Al matrix. Consequently, a high TC could be obtained. Hence, VHP has been proven to be an optimal processing method for the fabrication of diamond/Al composites characterized by exceptional TC.

Acknowledgments

Project supported by the National Natural Science Foundation of China (Grant Nos. 12274372 and 12274373) and the Major Science and Technology Projects of Henan Province (Grant No. 231100230300).

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