Thermal Solutions

1. Introduction

As electronic devices become increasingly fast with downsizing dimensions, how to transfer and remove heat efficiently, in other words, heat radiation countermeasure, have become important issues for every designer of electronic devices. As materials for such radiator components such as the heat radiation sheet, heat sink and heat-conducting substrate, Nippon Graphite Fiber Corp. and Micron Co., Ltd. (both member companies of the New Materials Divisions Group of Nippon Steel) have been developing and selling highly heat-conductive, pitch-based carbon fibers and spherical alumina micro powder, respectively. At present, they are developing heat radiation parts for thermal solutions to the aggravating problems of heat transfer and radiation by using the above materials. As an example, the development of highly heat-conductive carbon fiber composite materials (carbon fiber reinforced plastics: CFRP) is discussed below.

2. Composition and characteristics

The composition of highly heat-conductive CFRP is shown in **Table 1**.

Pitch-based carbon fiber (heat conductivity: 500 W/mK) - a highly heat-conductive material - is impregnated with epoxy resin in which spherical alumina micro powder has been mixed. Then, it is formed into a CFRP.

Since the pitch-based carbon fiber mentioned above demonstrates high heat conductivity and low thermal expansion along its length, the CFRP derived from it also shows a unique thermal anisotropy (not found in metals) as shown in **Fig. 1**.

In addition, the above pitch-based carbon fiber has a low specific gravity (2.0) while it has higher heat conductivity than metals. Therefore, CFRP produced in this manner is also particularly lightweight. **Table 2** compares the characteristics of highly heat-conductive CFRP

Table 1 Composition of highly thermal conductive CFRP

Thermal conductive filler	Highly thermal conductive carbon fiber	Nippon Graphite Fiber Corp.
	Alumina spherical micro powder	Micron Co. Ltd.
Matrix	Epoxy resin	

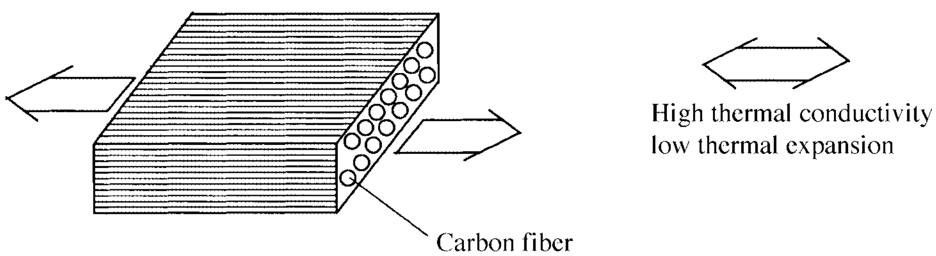

Fig. 1 Anisotropy of highly thermal conductive CFRP

Table 2 Characteristics of highly thermal conductive CFRP and metal

	CFRP	Mg	Al	Cu
Thermal conductivity (W/mk)	300 (*) 1.9 (**)	150	230	390
Specific gravity	1.9	1.8	2.7	9.0
Thermal expansion Coefficient (10^{-6}/K)	−1.2 (*) 49 (**)	27	24	17

(*) longitudinal, (**) transverse

with typical heat-conductive metals.

The heat conductivity of the highly heat-conductive CFRP is 1.3 times that of aluminum - a standard material for heat radiation, whereas the specific gravity of the CFRP is two-thirds that of aluminum. Therefore, much is expected of such CFRP as one element in the thermal solution for electronic devices which pose a couple of difficult problems, namely the increase in power consumption (heat dissipation) and the demand for downsizing, especially in IT and digital home appliances.

3. Application examples

With mobile devices, such as notebook PCs, cellular phones and projectors, a large heat spot occurs locally due to the heat generated by the CPU or other heat source. In such cases, because of a lack of space for heat radiation around the heat source, it has been common practice to use a heat pipe or similar means to transfer the heat to a more suitable place for heat radiation. This method, however, has the following problems.

(1) Metallic parts, such as the heat pipe, cannot be freely made into the desired form. This means that they cannot always be laid out neatly in a limited space.

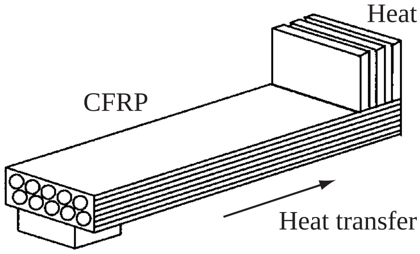

Fig. 2 Application of highly thermal conductive CFRP

(2) Heavy metals with superior heat conductivity, such as copper, cannot be used in view of the demand for smaller, lighter devices.

(3) Along the heat transfer path lie active elements, optical components, etc. which are easily affected by heat. Therefore, layout of the heat pipe, etc. must be planned with special care.

Because of the above problems, the application of CFRP, characterized as it is by a unique anisotropy, high heat conductivity and low density, is being studied in earnest. **Fig. 2** shows an example of CFRP applications under consideration.

4. Future activities

Formerly, it was quite common for “heat radiation design and measure” problems for electronic devices to be addressed and solved only once development of the device neared its final phase. Today, with the progress in digital devices, “heat radiation design and measures” are becoming a really serious problem that significantly influence the basic design from the earliest development stages of any electronic device.

With respect to passenger cars too, the increasing use of electronic devices has made the problem of heat radiation conspicuous. Under these circumstances, the development of new lightweight materials and parts to replace conventional metallic ones is urgently sought.

In the future, assuming our correct recognition of the above needs, we intend to develop new materials and parts which are more than simply replacements for conventional metals or plastics, and to offer them as effective thermal solutions.

For further information, contact
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