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# On application of heat-conductive plastics in LED technology

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**Abstract.** A comparative analysis of the characteristics of heat-conducting plastic was performed. The results of the thermal measurements of two of the same type 3W LED modules installed on heat sink with the same area of heat-dissipating surface made of aluminum and heat-conducting polymer have been presented. It has been shown that the overheating of LED module mounted on the heat-conducting polymer heat sink is 2…3 °C higher than that on the aluminum heat sink (thermal conductivity is 20 times higher). The ranges of applicability of the heat-conducting plastics in LED technology have been determined.

**Keywords:** LED, composite heat sink, thermal conductive plastics.

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## 1. Introduction

Typically, heat removal and dissipation in LED technology is reached with metal (aluminium) thermal heat sinks manufactured by molding or extrusion. In recent years, however, the market has seen new entrants – heat-conductive plastic. Heat-conducting plastic is a polymer composite material, in which for increased conductivity, it is fitted with high heat conductivity filler. The characteristics of some commercially available heat-conducting plastics are shown in Table. The advantages of heat-conducting plastics include: low density, a high stiffness to weight and strength to weight ratios, manufacturability and precise molding under pressure, etc. However, applicability of material of this type in LED technology is still insufficiently investigated.

Thus, the aim of this work is to study applicability of heat-conducting plastics as heat sinks for LED technology.

## 2. Method

The methodology for this paper is based on a comparison of thermal images of experimental samples of LED devices that are completely identical to each other except for the materials used and shape of the heat sinks.

Fig. 1 shows the external view of the experimental equipment. 3W LED aluminum printed circuit boards with a diameter of 50 mm were used in it. The printed circuit board is attached to the heat sink with screws and thermal KPT-8 paste.

In the first case, the heat sink is a piece of ribbed (plate) aluminum. In the second case, the heat sink is a needle filled fragment from heat-conducting plastic [1], provided by LLC "Spetsplast-M" (Russia). Despite the differences in geometry, thermal heat sinks had the same heat-dissipating surface area $S = 0.013$ m$^2$.

Thermal measurements were carried out using the thermal imager FLIR A325 (Sweden). Thermal modeling of cooling heat sinks is done using CAD software SolidWorks.

**Table. Thermal conductivity of several heat-conducting plastics.**

| Trading Brand | Manufacturer | Thermal conductivity, W/(m·K) |
|---|---|---|
| COOLPOLY | Cool Polymers, USA | 1.0–40.0 |
| LATICONTER | Lati Industria Termoplastici, Italy | 1.0–15.0 |
| FORTRON | Ticona, Germany | 1.1–3.0 |
| RTP (99x) | RTP, Imagineering Plastics, USA | 1.0–18.0 |
| TEPLOSTOK | “SPETSPLAST-M”, Russia | 1.0–13.0 |

**Fig. 1.** Experimental samples with heat sinks made of aluminum (left) and composite (right).

## 3. Results

Fig. 2 shows the thermal images of two heat sinks, one of which is made of aluminum alloy, and the second of the heat-conducting plastic. It should be noted that the heat-conducting plastic heat sink design enable to observe more uneven temperature distribution than that in the heat sink based on aluminum alloy.

The analysis of Fig. 2 shows that the overheating of LED circuit board mounted on the heat sink of heat-conducting polymer is approximately $\Delta T = 3$ °C higher than that in the case of the analogous aluminum heat sink, despite the fact that the thermal conductivity of the heat-conducting plastic is 20 times lower.

Obviously, $\Delta T = \Delta T_1 + \Delta T_2$, where $\Delta T_1$ – the contribution due to different geometrical shape of the heat sink (needle/ribbed), $\Delta T_2$ – the contribution due to the heat sink materials of a different thermal conductivity. According to the results of thermal modeling (Fig. 3), the temperature for the needle (pin) design heat sink is 2.1 °C lower than the ridge (plate) design heat sink, i.e. $\Delta T_1 = -2.1$ °C. Thus, $\Delta T_2 = \Delta T - \Delta T_1 = 3$ °C + 2.1 °C = 5.1 °C, i.e. the temperature of heat sinks of the same shape, but made from a thermally conductive plastic and aluminum would differ by approximately 5 °C.

It should be noted that this result is valid only to a low-power LED devices. As the power of LED increases, $\Delta T_2$ increases proportionately. So, in the case of 10W lamp for HCS the temperature difference increases to $\Delta T_2 = 19$ °C (Fig. 4).

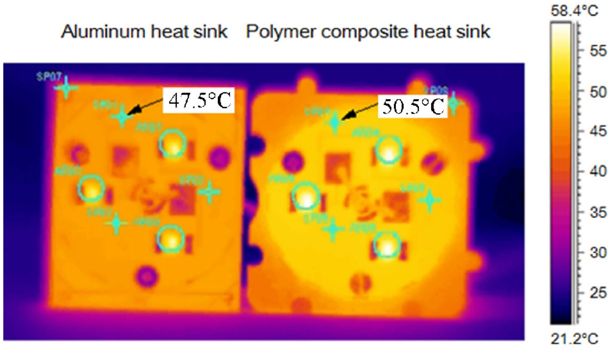

**Fig. 2.** Experimental temperature distribution (running time is 60 min).

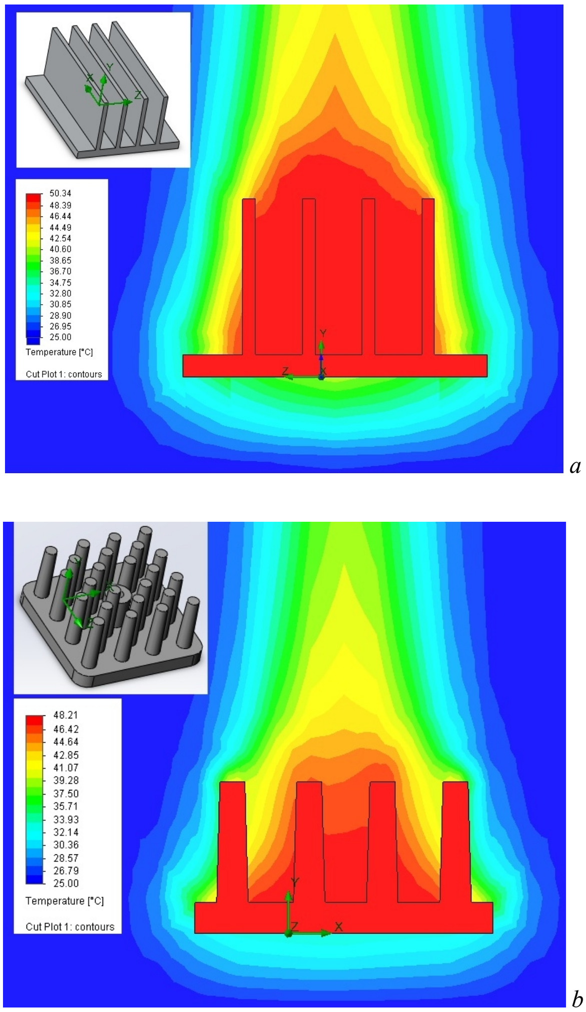

**Fig. 3.** Comparison of cooling efficiency ridge (*a*) and the needle (*b*) aluminum heat sinks that have the same surface area $S = 0.013$ m$^2$.

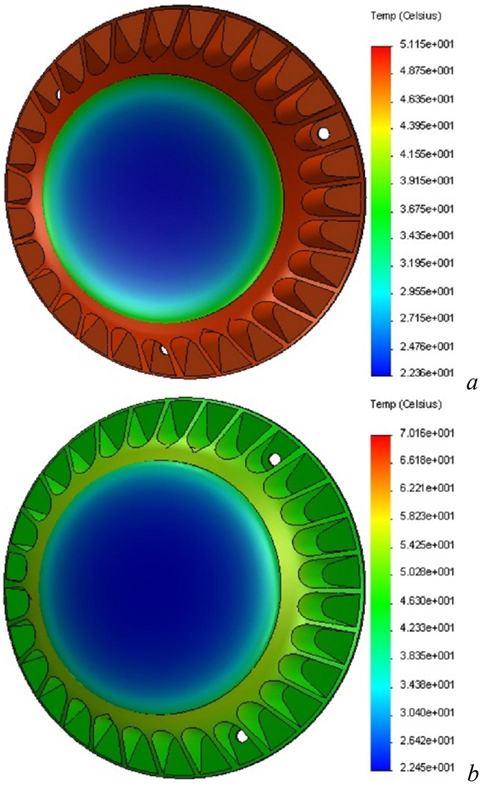

**Fig. 4.** Model of the temperature distribution on the lamp for housing, made of aluminum alloy (*a*) and thermally conductive polymer (*b*).

## 4. Conclusions

1. Thermal conductivity λ of the material is 10 W/(m·K), which is not always enough to transfer all the heat to the cooled surface to be released out of the system.

2. The disadvantage of heat-conductive composites is in the significantly increased resistance to heat flow compared to aluminum, which does not allow using it for heat removal from point sources. Therefore, the possibility of application of a thermally conductive composite material must be checked carefully in each case.

3. The advantages of heat-conductive composites include the possibility to manufacture heat sinks of almost any shape. Also, the transition from the ribbed to the needle design increases the cooling efficiency of the heat sink by 11%.

### *References*

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