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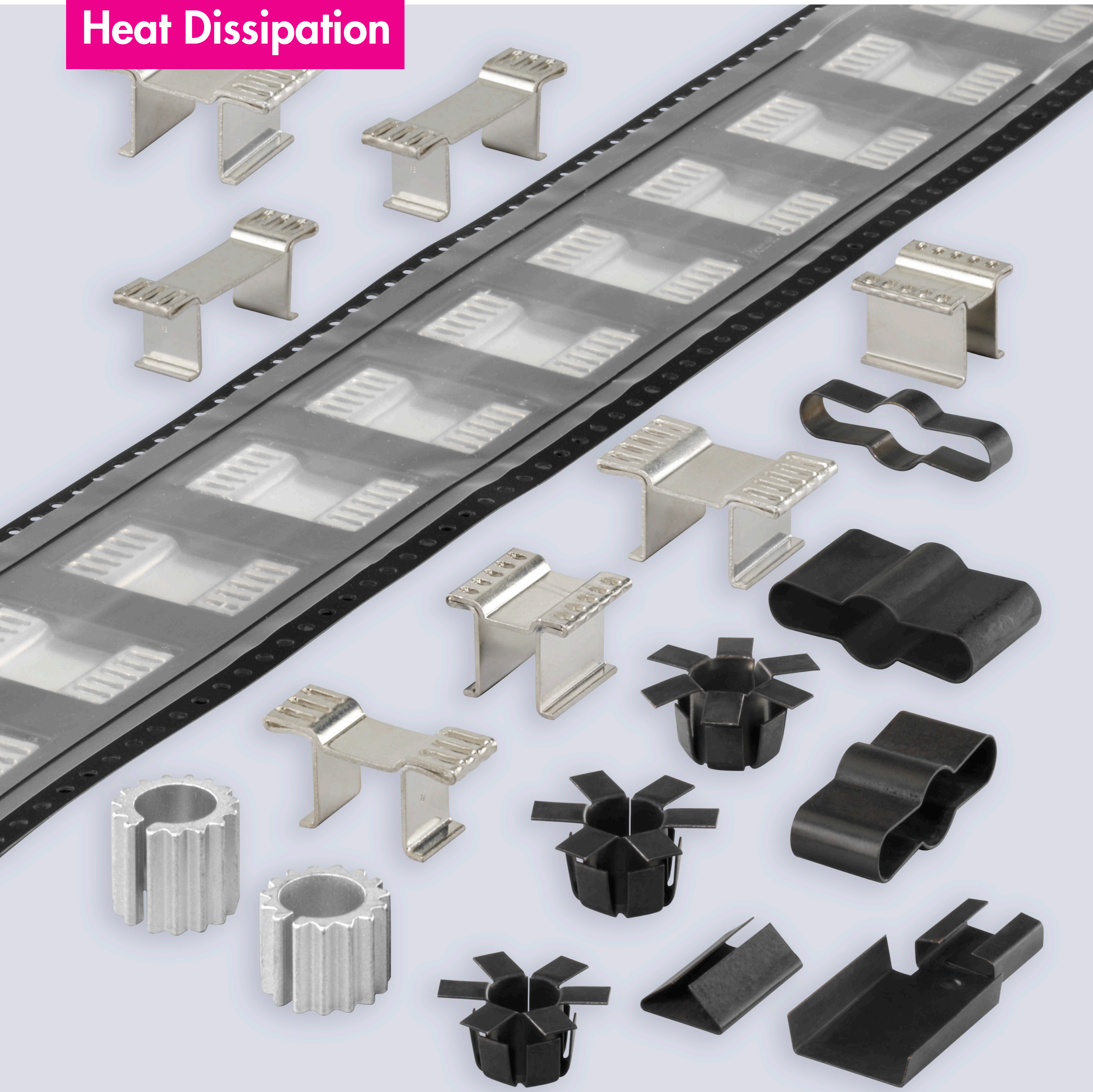
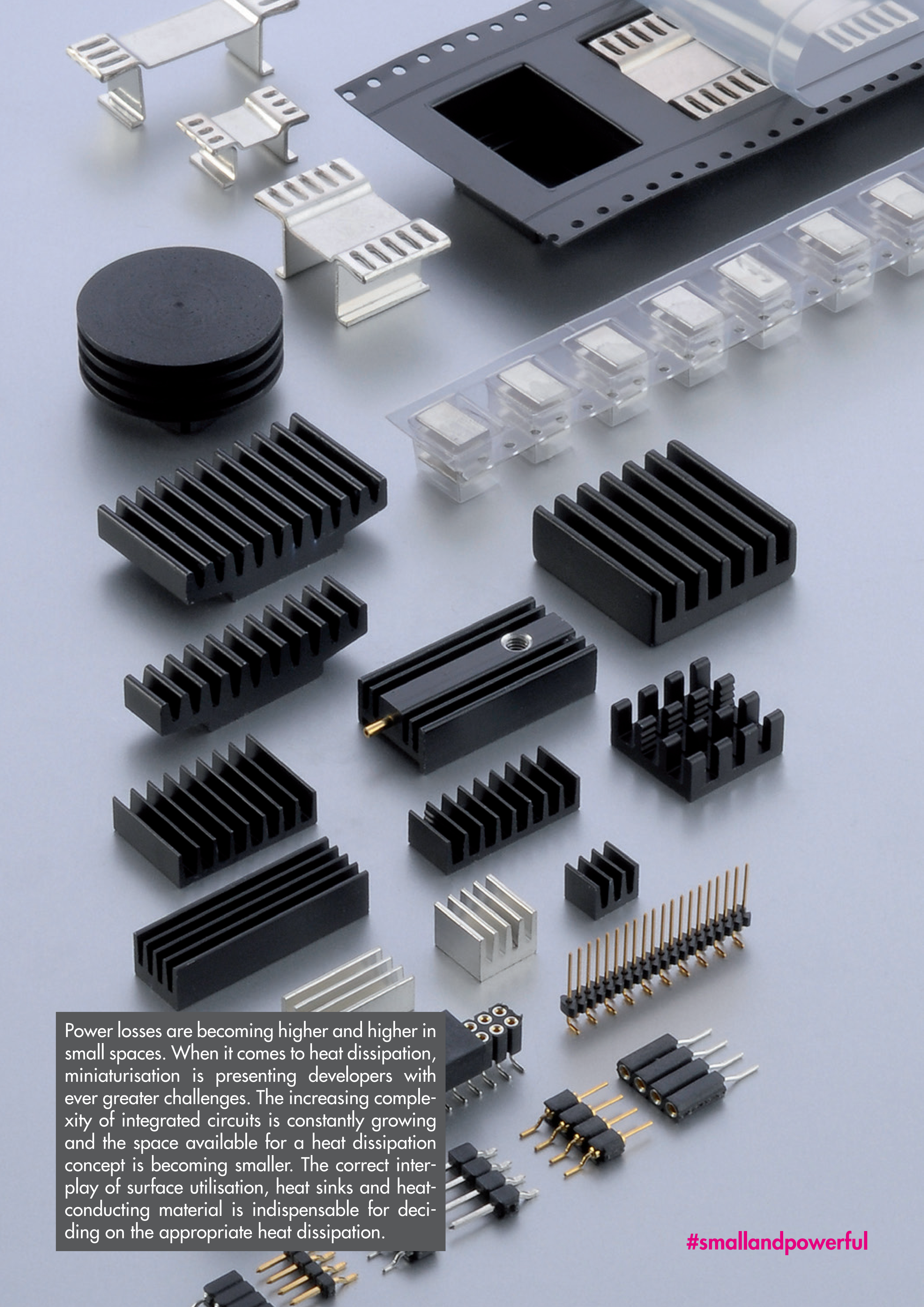
Small-scale Heat Dissipation





Power losses are becoming higher and higher in small spaces. When it comes to heat dissipation, miniaturisation is presenting developers with ever greater challenges. The increasing complexity of integrated circuits is constantly growing and the space available for a heat dissipation concept is becoming smaller. The correct interplay of surface utilisation, heat sinks and heat-conducting material is indispensable for deciding on the appropriate heat dissipation.

#smallandpowerful

Increasing Service Life

Low failure rates and high life cycles are required for electronic devices. These requirements cannot be met without perfectly designed thermal management. The service life of an electronic component is already reduced to about half of the specified value if the temperature exceeds by just 10 °C the junction temperature specified by the manufacturer. For this reason, the power losses occurring in all electronic components must be eliminated as quickly as possible.

Calculation of the Thermal Resistance

The calculation of the thermal resistance can be used to check whether the heat dissipation concept is correctly designed. The aim is to achieve the lowest possible total thermal resistance value, which is calculated from the sum of the individual thermal resistances. The individual thermal resistances include, among others, the internal thermal resistance of the component RthG, the thermal resistance of the heat conducting material RthM and the thermal resistance of the heat sink RthK. The value for the heat sink thermal resistance is specified by the heat sink manufacturer. The value for the thermal conductivity material can be calculated using the following formula:

$$R_{th} = l \; / \; (\lambda \cdot A)$$

R_{th} = thermal resistance [K/W]
l = coating thickness [m]
λ = specific thermal conductivity (material-dependent) [W/mK]
A = heat dissipating surface [m²]

For the thermal resistance of the component the manufacturer specifies top and bottom thermal resistances for SMD (Surface Mounted Device) components. This determines how much heat is dissipated in which direction of the component. The heat that is not dissipated in the direction of the circuit board but in the opposite direction via the case to the environment is indicated by the top thermal resistance. The heat dissipation in the direction of the circuit board is indicated by the bottom thermal resistance.

The most important value here is the thermal resistance junction-soldering point. This refers to the path of heat between the junction where the heat is generated and the point where the component is soldered.

To prevent damage to the component, the circuit board should be included in the design of the thermal management. Multilayer circuit boards are constructed in different layers. Copper layers are embedded in synthetic resin and glass fibre fabric layers as potential and for heat spreading. Thermal vias connect the outer layer, where the heat is generated, to the embedded copper layers. This directs the heat away from the component to areas on the circuit board with space for cooling elements.

Soldered Heat Sinks

Heat sinks soldered directly onto the circuit board increase the surface area through which heat is dissipated to the environment.
Various soldering methods are suitable for soldering the components, among others the reflow but also the wave soldering method.

For the placement of the tinned and thus solderable heat sinks, automatic placement machines can be used as for many other components. For this purpose, heat sink manufacturers offer to pack the heat sinks as tape and reel or in blister belts (Illustration 1). These can then be inserted directly into the automatic assembly machine. Difficulties may arise if the heat sinks must be inserted into the blister belt with the fin side facing upwards in order to guarantee the correct positioning on the circuit board. This can be remedied by loading aids which are mounted on the heat sink and are vacuumed up by automatic assembly machines.

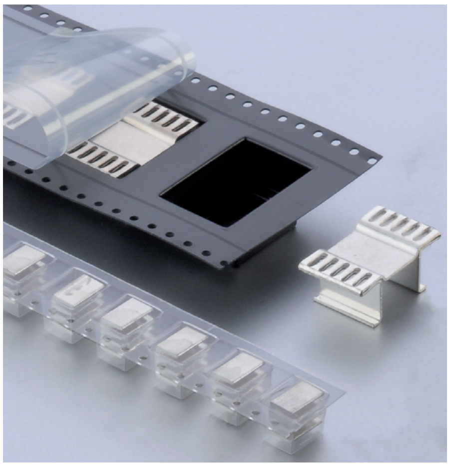


Illustration 1:
Tape & reel

For components where the heat is dissipated via the case, it makes sense to attach the cooling element directly to the component. For this purpose, the components are soldered to the circuit board in advance and the heat sinks are then attached to the component. Various types of heat sinks are available for this purpose. For SMD components, small, extruded heat sinks are often applied directly by means of thermally conductive adhesive.
For THT (Through Hole Technology) components, clip-on heat sinks are a possibility (Illustration 2).

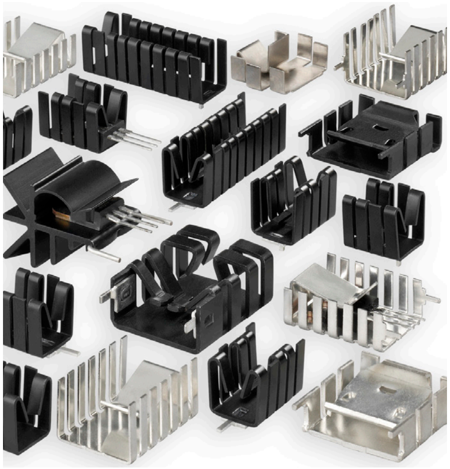


Illustration 2:
Various clip-on heat sinks for THT component technology

Lock-in Retaining Spring for Transistors

If there is a larger space available on the circuit board directly next to the component it is also possible to use heat sinks for snap-in transistor retaining springs. The component is clipped directly onto the heat sink (Illustration 3). For stabilisation, the clip-on heat sinks and the heat sinks for snap-in transistor retaining springs have solder lugs that are also fixed into the circuit board.

Illustration 3:
Lock-in retaining spring for transistors

Thermally Conductive Materials

The component should be connected to the heat sink using one of various available thermally conductive materials (Illustration 4).
Depending on the application, thermally conductive adhesives (up to 7.5 W/mK thermal conductivity), thermally conductive pastes (up to 10 W/mK) or thermally conductive foils (up to 16 W/mK) can be used. High thermal conductivity allows heat to be dissipated quickly to the heat sink and thus to the environment. With a well-selected heat-conducting material, however, it is not only the thermal conductivity but also the layer thickness that must be taken into account.
The following should always apply: As thin as possible, as thick as necessary.

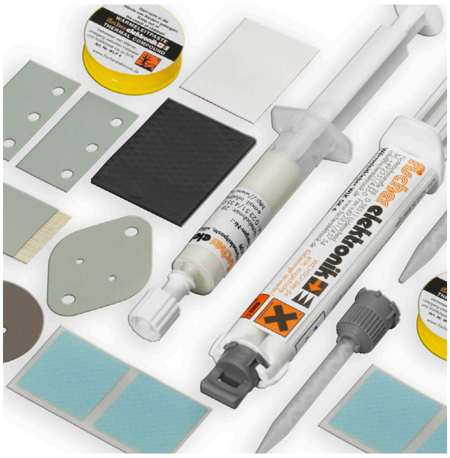


Illustration 4:
Thermally conductive materials

When selecting the thermally conductive material it is important to avoid air inclusions in all cases. With a thermal conductivity of 0.0263 W/mK, air is one of the worst heat-conducting materials. The unevenness and tolerances of the electronic components and the heat sinks cause, among other things, air pockets which must always be filled with thermally conductive material which always has a higher thermal conductivity than air.

Cases with Integrated Cooling Elements

Due to the limited space in some units, it can make sense to integrate the case into the heat dissipation concept. Cooling elements integrated directly into the case structure (Illustration 5) improve heat dissipation as the heat is dissipated to the environment via the natural convection via the integrated fin structure.

Cut-outs in the case can be reduced or even omitted. In certain cases, this can lead to an increase in the IP protection class of the unit.

Illustration 5:
Heat dissipating case

Conclusion

Applicable is, as far as possible, to use all available surfaces for heat dissipation so that the electronic components are not damaged. A long service life is ensured by a correctly coordinated heat dissipation concept.

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