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Copper heat sinks versus Aluminum heat sinks – Advantages and Disadvantages

Many designers will turn to copper as an alternative material to improve heat sink performance when an aluminum sink may not provide enough cooling. In some cases this switch is justified, in other cases it may not be. Following are a few rules of thumb for when the extra cost and weight of copper makes sense.

- Pure copper has about 2X the conductivity of extruded aluminum. This added conductivity helps reduce semiconductor temperature in heat spreading and fin efficiency. However, this is useful only when:
 - Air flow speeds are very high (over 800 linear feet per minute)
 - The heat input area, the hot spot on the mounting surface, is small (25% or less) in comparison to the size of the heat sink base.
- When airflow speed is below 400 linear feet per minute and/or the heat input area is a high percentage of the heat sink base area the extra cost of copper may not be justified.
- The cost of an all copper heat sink is typically 3X the cost of an equivalent size (fin count, base thickness, fin height, etc.) aluminum part.
 - This cost increase is based on many factors. Copper cannot be extruded in the same manner as aluminum therefore it must be machined from flat plate with fins or other features brazed in place.
 - Due to density and its abrasive nature machining holes and other details in copper takes significantly longer time and wears tooling at a higher rate.
 - Cost of the base copper material is about the same as aluminum per pound but at 3X the density per cubic inch. This results in a raw material cost of 3X that of aluminum.

In conclusion, copper heat sinks may have an advantage in increasing heat removal and lowering semiconductor temperatures. However, the added cost and custom nature of the part will add complexity to the system that must be considered from both the thermal and the economic sides of a design.