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Thermal Management at the Component and Board Level

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Thermal Management Need

- Electronic systems are shrinking
  - Reduced component spacing
  - Reduced surface area for radiant cooling
- Power requirements are increasing
  - Driving components to the edge of their capabilities
  - Main component rating is component operating temperature
- Metal prices increasing
  - Proximity to heat sinks saves costs
- Best managed in the design phase

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Board Level Thermal Management Options

Direct Bonded Copper (DBC)

- Copper layer directly bonded to a ceramic substrate
- Provides high thermal conductivity

Active Metal Brazed (AMB)

- Ceramic substrates bonded to metal base
- High reliability especially under high thermal stress environments

Insulated Metal Substrate (IMS)

- Metal layer separated by dielectric layer
- Balance between thermal management and mechanical support

Hybrid Circuits

- Highly conductive substrates with circuits printed via screen print or photolitography
- Provides path for cooling to all components on the board

All options are very expensive per same surface area of FR-4

Component Level Options - Thermal Gap Fillers & Pastes

- Benefits
  - Thermal conductivity 1-10 W/m·K
  - Conforms to highly intricate topographies
  - Compatible with manual or automated dispensing
  - Electrically isolating
- Challenges
  - Many are two-component systems that need to be cured
  - Wide application hard to control
  - Can degrade over time
  - Difficult to rework components later

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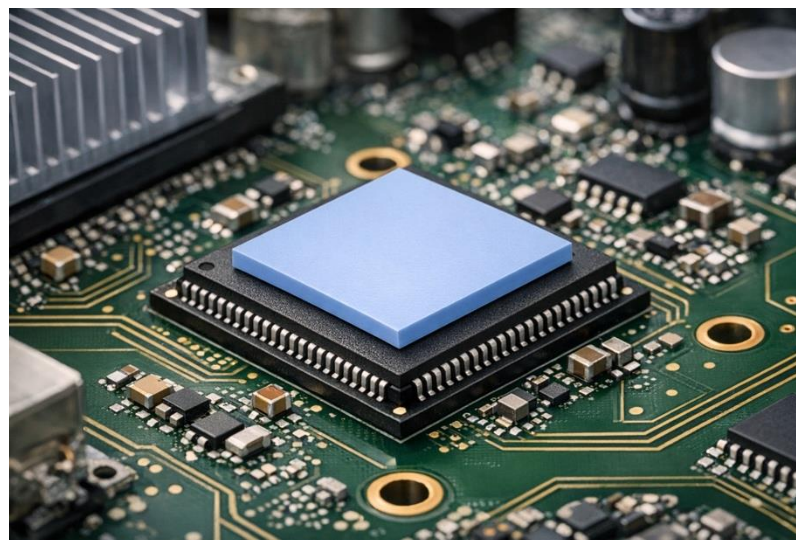
Component Level Options - Thermal Pads

- Benefits
  - Thermal conductivity 1-20 W/m·K
  - Electrically isolating
  - Flexible/compressible materials
  - Provide physical cushioning
  - Can cover multiple items at once if they are all the same thickness
- Challenges
  - Require constant compression that puts mechanical strain on components
  - Heat transfer rates low for common materials



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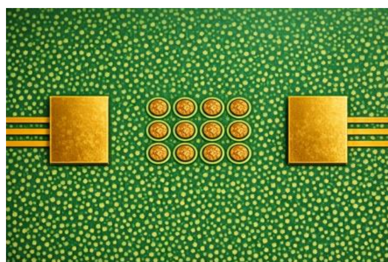
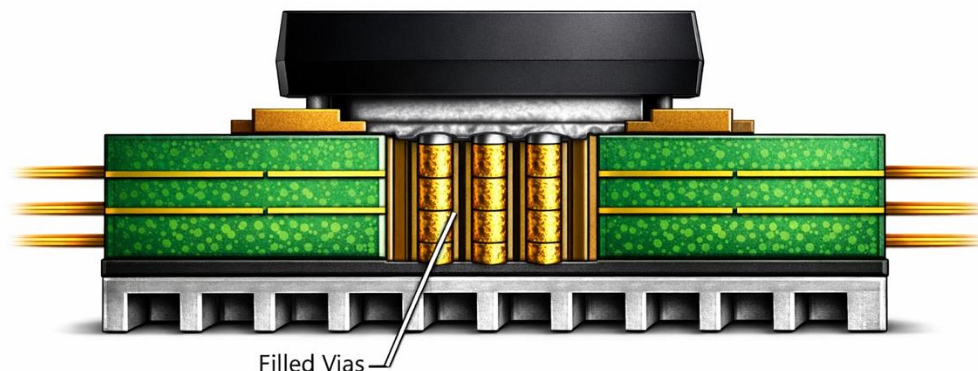
Component Level Options - Metal-filled Vias

- Benefits
  - Thermal conductivity 15-60 W/m·K (paste limited)
  - Plated holes in the PCB connect different layers of the board
  - Enhance thermal conductivity through the board
  - Ground plane or other heat sink is on the opposite side of the board
  - Via use is widely known
- Challenges
  - Increase manufacturing complexity and cost
  - Relies on thermal grease for electrical isolation that can degrade over time





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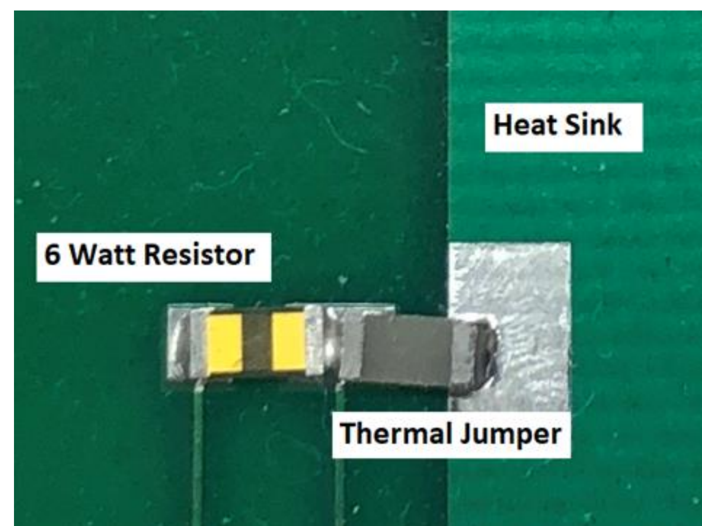
Component Level Options - Thermal Spreaders/Heat Pipes/Thermal Jumpers

- Benefits
  - Thermal conductivity 170 – 1,700 W/m·K depending on material
  - Easy to use - some formats are similar to surface mount chips
  - Varying materials from Aluminum Nitride, Beryllium Oxide, Diamond
  - Targeted heat transfer
  - Electrically isolating without additional materials
  - More cost effective than expensive board options
  - Standard SMD options conducive to standard board assembly process
  - No degradation of pastes or laminations
  - Electrical isolation very high
  - Enhance long-term system reliability



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Thermal Spreaders/Heat Pipes/Thermal Jumpers – Other Considerations for Applications

- Balancing temperature between components
  - Prevent localized gradients
  - Support thermal coupling - components behavior similar at similar temperatures
  - Electrically isolated temperature measurement
- Low capacitance
  - Key requirement for RF applications where conventional thermal pads may disturb impedance
- Reducing overall board temperature
  - Surrounding components also benefit from reduced localized hot spots
- Route heat away from components buried in multilayer stacks
- Reduce thermal cycling stress in power dense modules

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