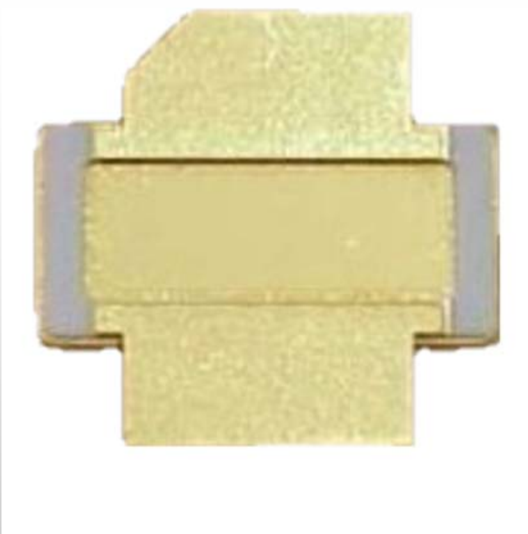
Thermally Enhanced Packaging for RF Power Transistors



IWPC Workshop

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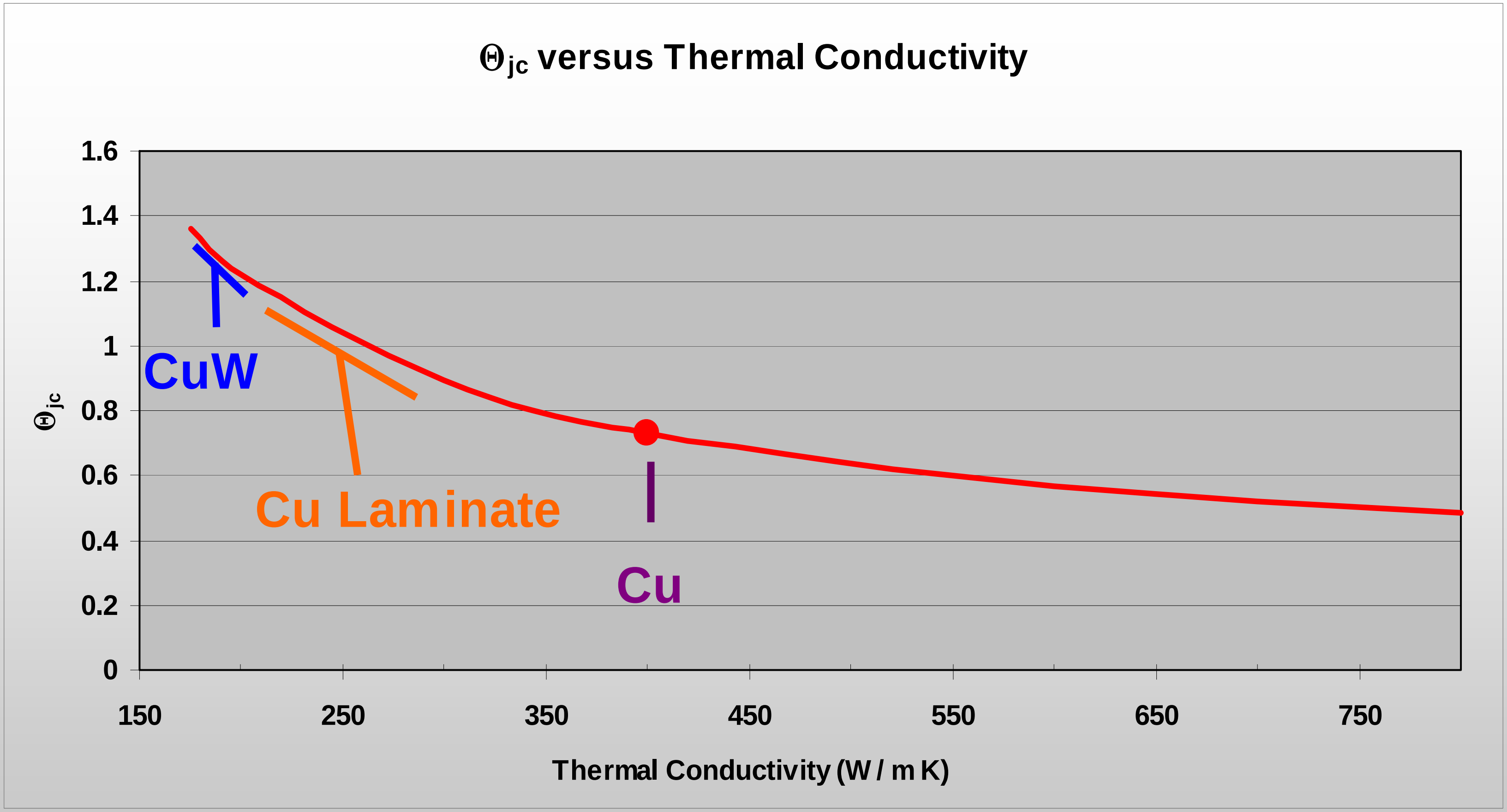
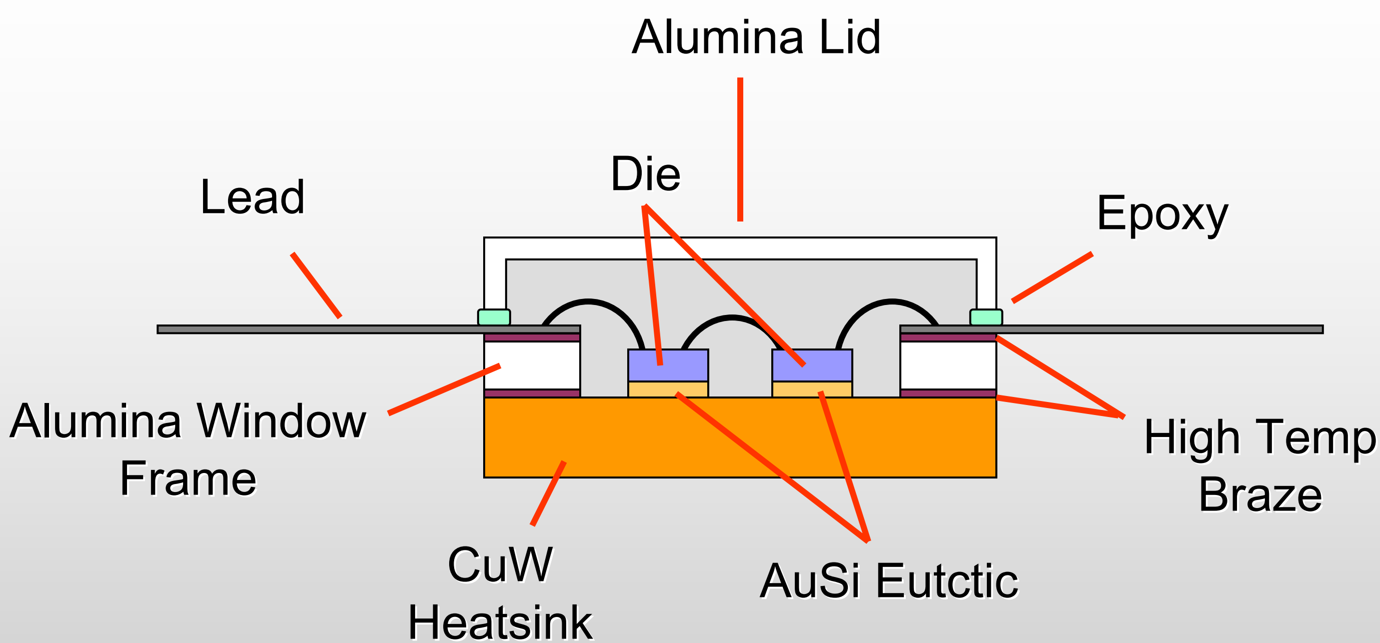
Thermal Performance of Heatsink Materials

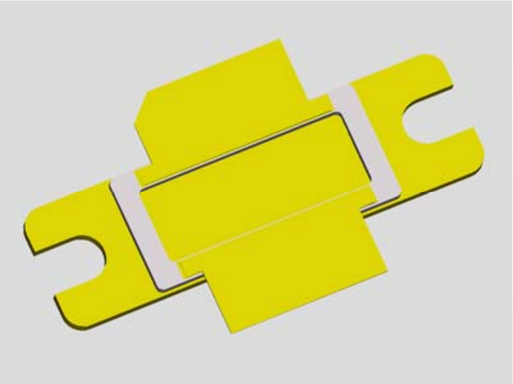


Current Package Construction



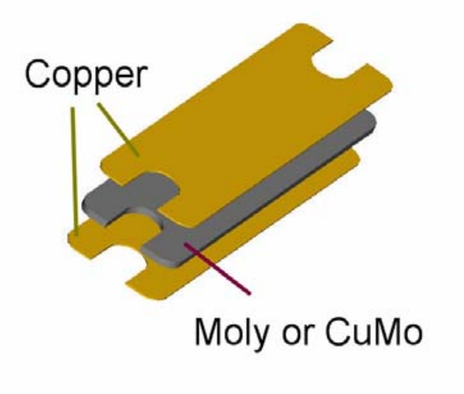
CuW Heatsinks

- High Temp Brazing to Alumina window frame
  - Proven reliability – hermeticity and electrical performance
  - AuSi die attach
- Mature Technology
  - Cost reduction opportunities are limited



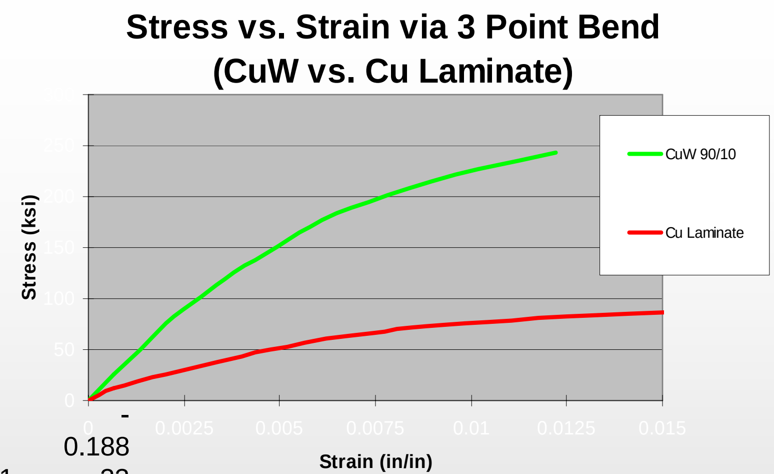
Recent Developments

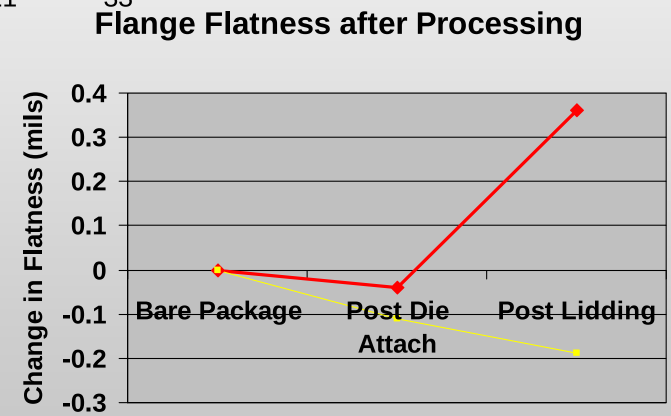
- Cu Laminates
  - Higher Power Devices now entering the Power Amplifier Market
  - High Temp brazing to alumina for large and small outlines – suitable for AuSi die attach
  - "Drop-In" replacement for CuW
  - 17% improvement in θ_{jc}
  - Potential Cost Reduction compared to CuW
    - Clad / Roll / Stamp versus
    Press / Fire / Machine
    - Decreased precious metal content
    - Revisit design requirements at device level in order to achieve cost targets



Cu Laminate Device Level Impact

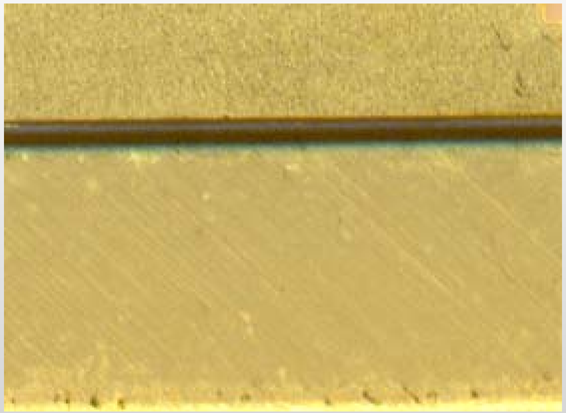
- Flatness – Actual junction temperature is dependent on contact area between package and heatsink
  - CuW is much stiffer than Cu Laminates
  - Die Attach and Lid Seal have more pronounced impact on Cu Laminates than CuW



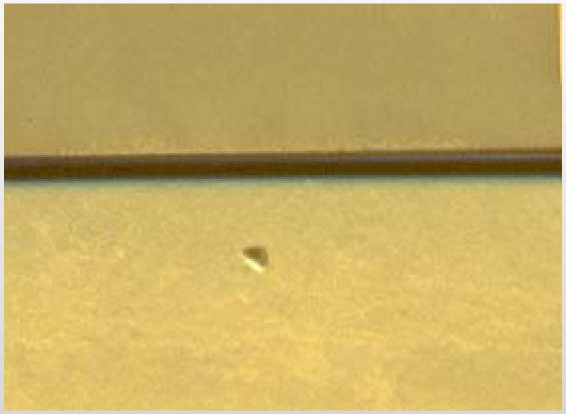


Cu Laminate Device Level Impact

- Surface defects –
  - Depressions in the heatsink raise concerns about voiding beneath the die
  - Actual Surface wetting needs to be tested



CuW surface is machined or ground and is very consistent



Cu Laminate surface is rolled copper and is much more prone to dents and pits

The Next Step – Cu Heatsinks

- Estimated 40% - 50% reduction in θ_{jc} compared to CuW
- Lowest Cost Heatsink Material
  - No precious metal
  - Readily available from multiple sources
- Any materials with thermal performance beyond Cu will be more expensive
  - CuSiC
  - Cu Diamond
  - Cu Graphite

Cu– Package Level Challenges

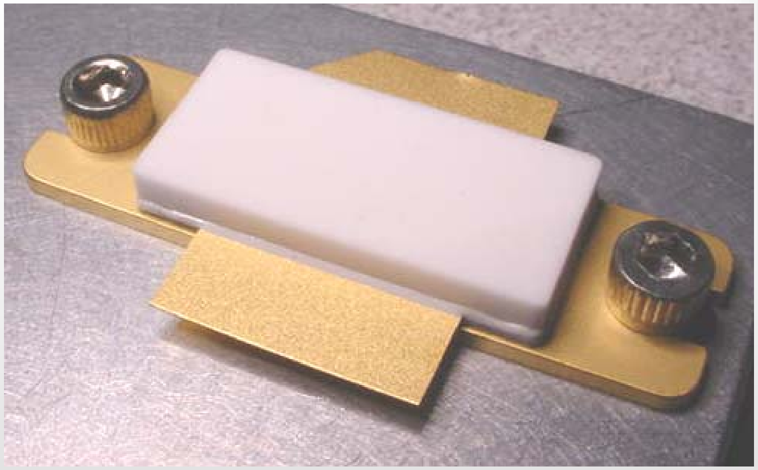
- New window frame material needed
  - Ceramic will crack due to thermal expansion mismatch
  - Plastic and Organic Laminate are an option
- Hermeticity
  - Plastic must withstand die attach process and temp cycling
  - Organic Laminate can be brazed at low temp, suitable for AuSn die attach
- Lid Material
  - Alumina lids will impact the flatness of Cu alloy heatsinks
  - Cost of lid becomes more significant

Cu– Device Level Challenges

- Die must withstand the stresses due to the CTE mismatch with Cu
- New Die Attach methods are needed –AuSn or Silver Epoxy
- Electrical Performance of window frame material will be different than ceramic
- New window frame and lid materials
  - Flatness requirement before / after lidding
  - Reliability Testing Requirements

Cu – Device Level Reliability Testing

- Hermeticity
- Bolt Down Thermal Cycle Testing
- Solder Reflow Thermal Cycle Testing
- Temperature / Humidity / Bias Testing

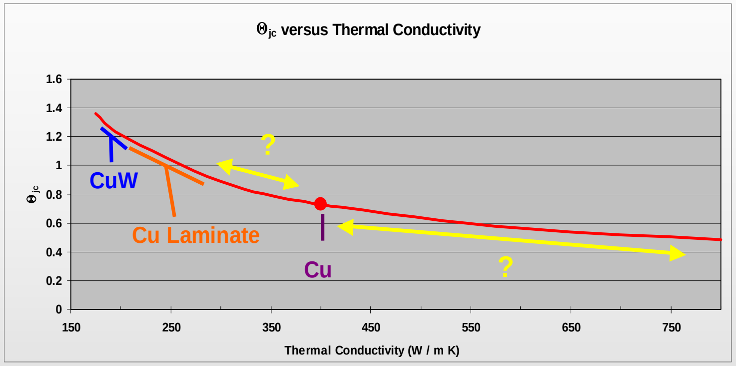


Cu– Power Amplifier Level Challenges

- “Drop-In” Requirement – Thicker Cu is more stable
- Mounting requirements – Bolt-down versus Solder Reflow
- Reliability Testing Requirements
  - New Package and lid material
  - New Die Attach method and/or metallization
  - Cost Benefit versus Risk versus Time to Market

Other Questions for Supply Chain

- With the challenges of Cu, does an intermediate solution make sense at the same cost as CuW?
- Will there ever be a need for more exotic materials beyond Cu?
  - Is the market willing to pay more than Cu?
  - Does it make more sense for newer die technologies with higher power densities (SiC and GaN)?
  - Would it make sense for higher frequency applications?



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