Thermal Load Board Development Services

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TEA

Topics

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- TLB Requirements
- TLB Design Considerations
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  - Simulation Heat Source Alternatives
  - Directing Heat Flow
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Major Electronic System Industry Issues

- How can electronic system development costs be reduced?
- How can electronic system operational and reliability performance be improved?
- How can the time-to-market be reduced?

Major Electronic System Industry Issues

The usual answer to these questions is –

USE SIMULATION SOFTWARE.

However, use of simulation software without validation usually leads to problems.

This leads to the need for a new thermal management design tool –

The **Thermal Load Board**

Thermal Load Board Definition

- A “form and fit” replacement that thermally simulates the application printed circuit assembly (PCA)
- It can be inserted into the system enclosure and be powered up to simulate actual heat source loading.
- Its circuitry is relatively simple and does not require complex power sources
- It can be used for steady state and transient thermal investigations
- It can be developed long before the final chip(s) are available and/or the electronic circuitry design is done

TLB Requirements

- **It must match the application PCA in X, Y, & Z dimensions**
- **Heat source placement and size should closely match that of actual heat sources**
- **It must have the same mounting holes, component cutouts, etc.**
- **TLB pcb should have the same equivalent copper content**
- **Complexity determined by the thermal management design objective**

TLB Design Considerations

1. The X-Y dimensions
2. The Z dimension
3. The component heat generation
4. Heat transfer into the printed circuit board
5. Heat transfer into the potential thermal management solution
6. Heat simulation dynamic range

TLB Design Considerations

X, Y, Z Dimensions

- TLB pcb must match dimensions and be capable of same system mounting configuration as application PCA
- Heat Sources must match X & Y dimensions of PCA heat generation sources to approximate the same heat flux density
- Heat Source must match Z dimension if mating to a thermal management solution
- Heat Sources must be in the same spatial location as the PCA heat generators

TLB Design Considerations

Heat Source Simulation Alternatives

- Metal Film Chip Resistors
  - Available in multiple sizes
  - Relatively inexpensive
  - Limited power dissipation capability
  - Most of power goes into the board if mounted directly to board
- Metal foil heaters
  - Useful alternatives but are more difficult to implement
  - X-Y dimensions are limited
  - Z dimensions are usually very small
  - Power density issues
  - Purchase availability
- Rectifier Diodes
  - PN or Schottky junction type in a surface mount package
  - Best driven by a current source
  - Heat transfer & dynamic range issues are similar to those for the chip resistors

TLB Design Considerations

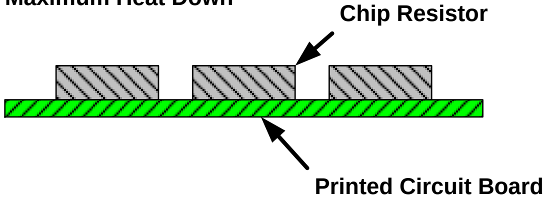
Heat Source Simulation Alternatives continued

- MOSFET and Bipolar Transistors
  - Can generate large amounts heat in a small package and
  - Can be attached to a pcb copper pad to maximize power into the board
  - Can be mounted upside down on pcb to minimize power into the board
  - Electrical circuitry for driving these 3-terminal devices is complex
- TTVs (Thermal Test Vehicles)
  - Thermal test chips (TTCs) mounted in packages.
  - TTVs do not always exist and are usually difficult to get.
  - Usually supplied by chip manufacturers but now also available from TEA on standard or custom-developed product basis

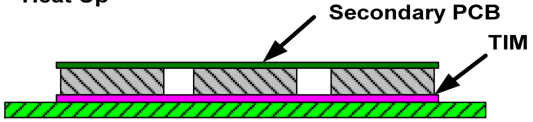
TLB Design Considerations

Directing Heat Flow

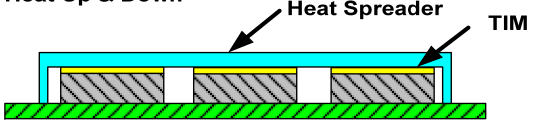
Maximum Heat Down



Heat Up

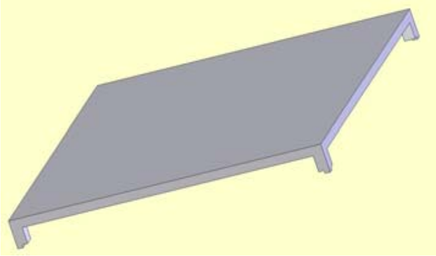


Heat Up & Down

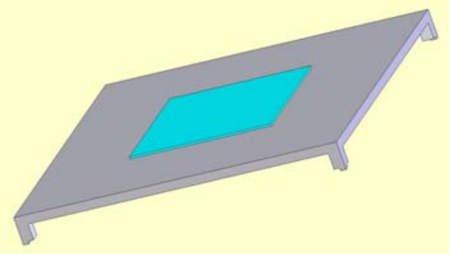


Maximum Heat Up

Heat Spreader



Heat Spreader with pedestal

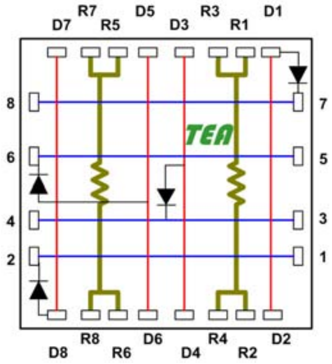


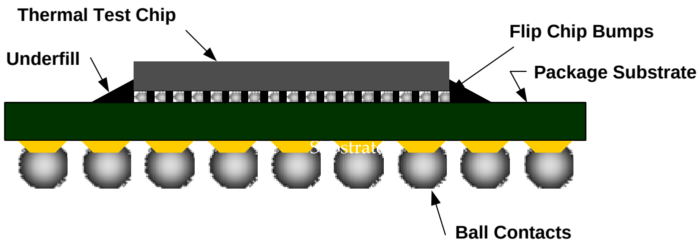
Pedestal simulates lip Chip bare die or metal direct attach pad.

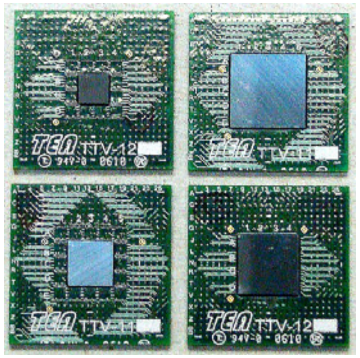
TLB Design Considerations

Directing Heat Flow (continued)

Packaged Thermal Test Chip ➔ TTV







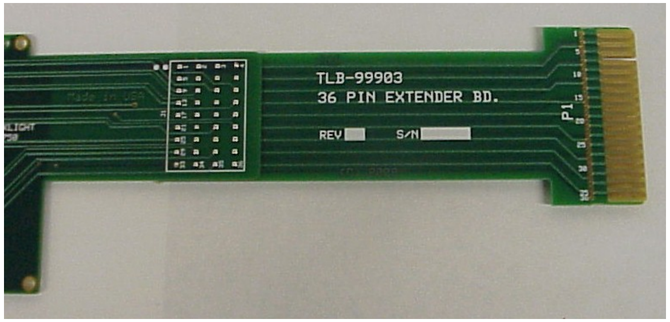
TLB Design Considerations

Copper Content

- Most system-level PCAs have multi-layer (4 to >16) internal copper planes
- TLBs with large number of internal copper planes are expensive and not usually necessary
- Construct a TLB top, bottom and 2 internal plane copper equivalent to PCA's layer coverage and copper thickness
- Include specific thermal vias as required

TLB Design Considerations

Electrical Connection



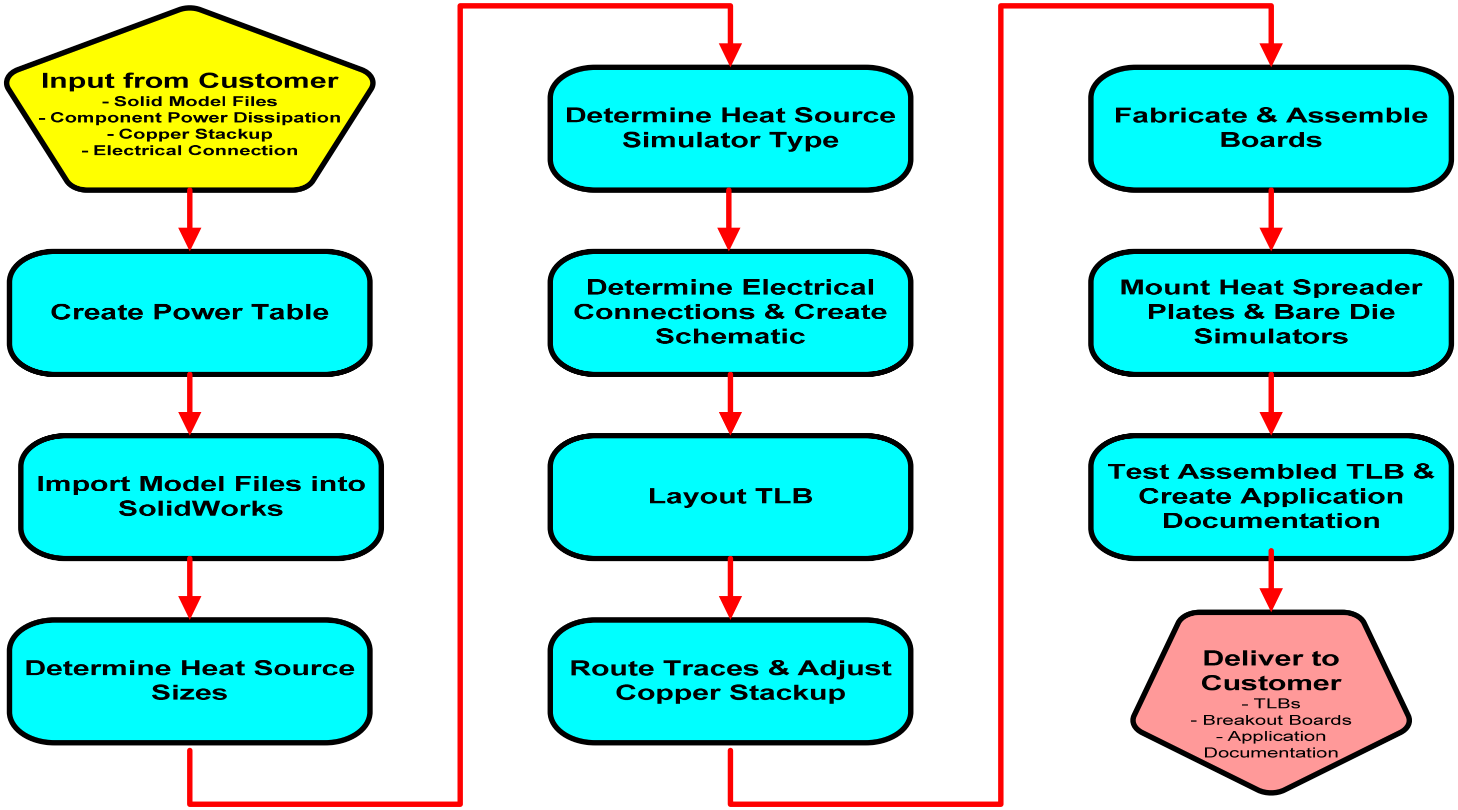
- Flying Leads
  - Soldered to the TLB on one end and bare or connector on other end
  - High Power
- Edge Finger
  - Double sided, multi-finger to mate with connector
  - Medium Power
- Socket
  - Boxed Header with ribbon cable
  - Low Power

TLB Design Considerations

Measurement Issues

- **Kelvin connection for power measurement**
  - Important for hi-power dissipations
- **Junction Temperature Measurement**
  - Possible with TTVs or application ICs
- **Board Temperature Measurement**
  - Usually thermistor in SMT chip form for pcb mounting
  - Thermocouple for IC or component measurement
- **Air Flow Measurement**
  - Possible for low-lying flow measurement

TLB Development Procedure



Input from Customer
- Solid Model Files
- Component Power Dissipation
- Copper Stackup
- Electrical Connection

Create Power Table

Import Model Files into SolidWorks

Determine Heat Source Sizes

Determine Heat Source Simulator Type

Determine Electrical Connections & Create Schematic

Layout TLB

Route Traces & Adjust Copper Stackup

Fabricate & Assemble Boards

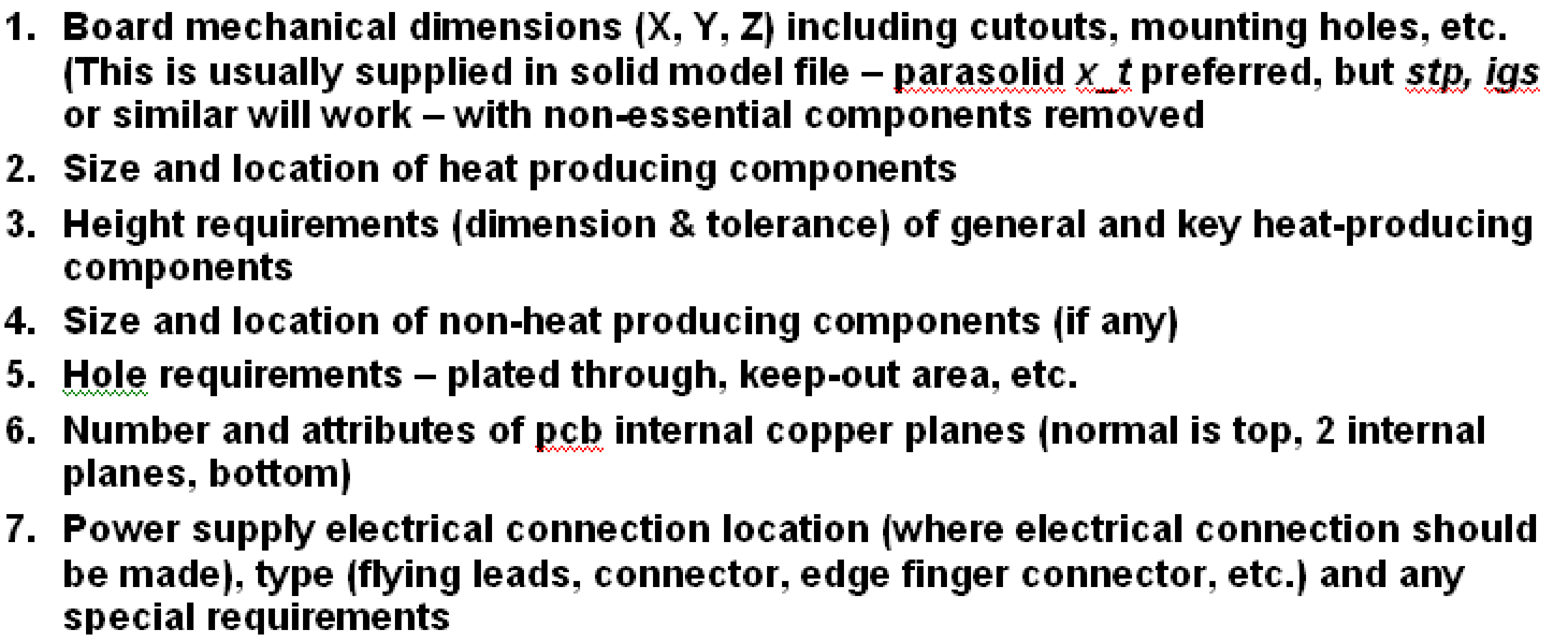
Mount Heat Spreader Plates & Bare Die Simulators

Test Assembled TLB & Create Application Documentation

Deliver to Customer
- TLBs
- Breakout Boards
- Application Documentation

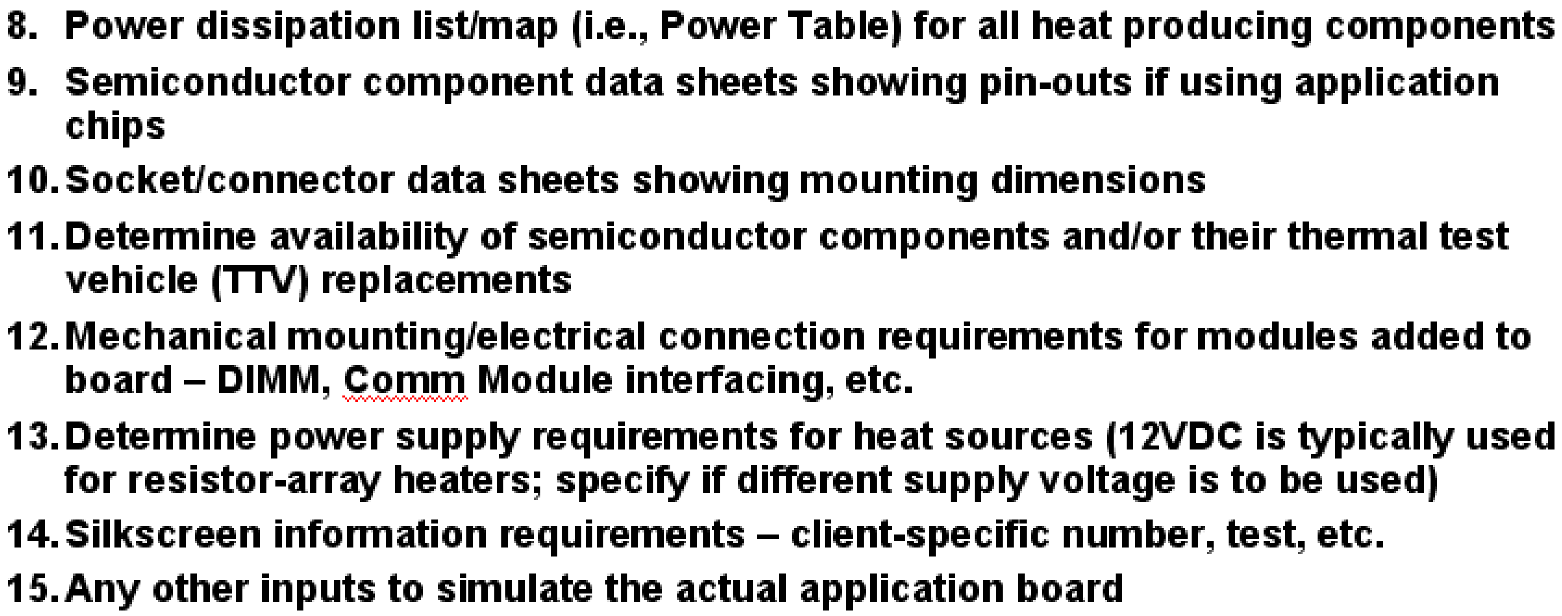
Customer-supplied Input

The first two items below are required in order to initiate a formal quotation for TLB Development Services. Additional information maybe required depending on specific TLB requirements.



1. Board mechanical dimensions (X, Y, Z) including cutouts, mounting holes, etc. (This is usually supplied in solid model file – parasolid *x_t* preferred, but *stp, igs* or similar will work – with non-essential components removed
2. Size and location of heat producing components
3. Height requirements (dimension & tolerance) of general and key heat-producing components
4. Size and location of non-heat producing components (if any)
5. Hole requirements – plated through, keep-out area, etc.
6. Number and attributes of pcb internal copper planes (normal is top, 2 internal planes, bottom)
7. Power supply electrical connection location (where electrical connection should be made), type (flying leads, connector, edge finger connector, etc.) and any special requirements

Customer-supplied Input



8. Power dissipation list/map (i.e., Power Table) for all heat producing components
9. Semiconductor component data sheets showing pin-outs if using application chips
10. Socket/connector data sheets showing mounting dimensions
11. Determine availability of semiconductor components and/or their thermal test vehicle (TTV) replacements
12. Mechanical mounting/electrical connection requirements for modules added to board – DIMM, Comm Module interfacing, etc.
13. Determine power supply requirements for heat sources (12VDC is typically used for resistor-array heaters; specify if different supply voltage is to be used)
14. Silkscreen information requirements – client-specific number, test, etc.
15. Any other inputs to simulate the actual application board

TLB Development Schedule

The schedule information provided below is based on typical times for TLB design, fabrication, and assembly. Actual times will vary with specific TLB projects and are also dependent on customer review/approval cycles.

1) Complete the electrical and mechanical design ==> roughly 1 wk to 2 wks
2) Complete the layout of all boards ==> roughly 0.5 to 1 week
3) Fabricate all the boards ==> roughly 1 to 1.5 weeks
4) Order all components (concurrent with board fabrication)
5) Design and fabricate all mechanical pieces (concurrent with board fabrication)
6) Assemble all boards == roughly 1.5 to 2.5 weeks
7) Apply mechanical pieces and test ==> 0.5 to 1 week.

Total ==> 5 weeks to 8 weeks

Total elapsed time starts after receipt of order, electrical and mechanical information. Shorter time is possible for less complex TLB requirements and if expedite costs are acceptable.

TLB Development Cost Info

The information presented below is for budgetary purposes only. A formal quotation will be submitted in response to a request accompanied with the first two items shown in the Customer-supplied Input list.

The TLB Development Project cost is dependent on the following:

- **Number and Type of Heat Source Simulators required**
- **Number of boards required – main board, daughter boards, breakout boards, etc.**
- **Size and complexity of each board**
- **Delivery requirements**

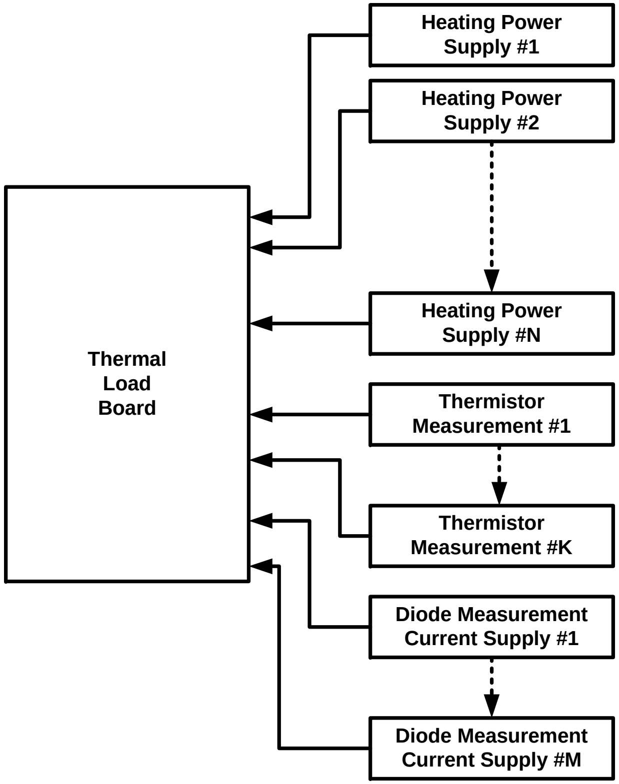
Typically, deliverables are:

- **2 sets of boards consisting of main board, daughter boards, breakout boards, etc.**
- **2 sets of application documentation**
- **1 set of supplemental information as required**

The TLB Development Project cost ranges from $12,000 to $45,000

Due to the custom development nature of TLB projects, a customer deposit is required with order placement to initiate project work.

TLB Application Issues



TLB Application requires standard laboratory equipment.

The number and capability of power supplies are dependent on the number & type of heat sources and the level of fine-grain control required.

Thermistors mounted on TLB can be read either with individual meters or with a scanning meter

If TTVs with integral diode temperature sensors are mounted on the TLB, then low current sources (typically 1mA) are reuired for each diode sensor.

Thermal transient measurements can be made either manually or using controllable power supplies.

About TEA

- TEA provides a broad range of products and services for the thermal design and measurement requirements of the electronics industry
- Founded in 1999 by Bernie Siegal, a world recognized leader in the field of semiconductor thermal measurements and measurement equipment
- Mr. Siegal was a key participant, including principal author, in the development of many of the thermal measurement standards that currently are in wide use within the electronics industry
- TEA has served over 100 customers located throughout the world with products and services

Customer List

A partial list of Thermal Load Board customers includes:

- **Apple**
- **Ericsson**
- **Facebook**
- **Google**
- **Huawei**
- **Intel**

Reference Information

The TEA website (*www.thermengr.com*) has a comprehensive collection of technical information for site visitors wanting to learn the details of semiconductor measurements and thermal management design tools.

- ***www.thermengr.net/html/tech_briefs.html*** **contains short technical briefs on specific measurement and device subjects**
- ***www.thermengr.net/html/standards_status.html*** **provides a listing of, and access to, thermal measurement standards from JEDEC, US Military, and SEMI**
- ***www.thermengr.net/html/hot_links.html*** **lists technical papers, handbooks, and material data files related to semiconductor thermal measurements**

Summary

- **Electronic system development cost, operational and reliability performance, “green” considerations, and time-to-market requirements require greater thermal management design efficiencies.**
- **Increased use of simulation software for electronic system thermal modeling is a “must” for time-efficient and cost-efficient product development.**
- **Reliance on un-validated software models can be dangerous as thermal issues continue to grow in importance.**
- **TLB is a tool for confirming model predication and reducing design uncertainty.**
- **TLB can be designed, fabricated & put into use quickly & at moderate expense.**
- **The TLB’s low turnaround time and fabrication cost offers the potential of modeling and validating several different mechanical configurations while the electronic circuit and chip design is under development.**
- **TEA has considerable experience in providing complete “turn-key” TLB solutions to meet demanding requirements at a reasonable cost.**