

Burn-in & Test Socket Workshop 2000

Session 1

Introduction to Socketing











BURN-IN & TEST SOCKET WORKSHOP

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Presentations

"Thermal Management & The Parameters That Affect Heat Dissipation During Burn-in"

Erik Orwoll Wells-CTI

"A Typical Manufacturing Burn-in Process"

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"Interface Considerations For High Performance Contactors In Automated Test Environments"

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Thermal Management & The Parameters That Affect Heat Dissipation During Burn-in

Feb 2000 Bits Workshop

Presented by Erik Orwoll Engineering Manager WELLS-CTI



PURPOSE OF HEAT SINKS

•As processor speed and I/O density increase, dies dissipate more heat, which can cause thermal failure.

•Heat Sinks maximize the surface area in contact with the cooling air and create a conductive path, which reduces die temperature.

•Heat Sinks can be fabricated from any thermally conductive material - Most commonly aluminum, but conductive polymers can be used.

•Aluminum Heat Sinks are often extruded. Extrusions are low cost and dimensionally accurate.

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INTERFACE TEMPERATURE PROFILE





AIRFLOW TEMPERATURE GRADIENT





HEAT SINK FINS







Enhanced Thermal Version Requires

- •Maximized Heat Sink Surface Area
- •Maximum Air Flow
- •Solid Thermal Interface



HEAT SINK CONFIGURATIONS





HEAT SINK EXAMPLES





THERMAL INTERFACES

- •Physical interface at junctions Figure 1
- •Mating surfaces are not perfectly flat in the real world.
- •Rough surface condition reduces the thermal efficiency across the boundary.
- •Thermal Tape or Thermal Grease fills in the irregularities and can improve thermal transfer. (Heat is conducted across the film instead of convected across the voids)





THERMAL INTERFACE MATERIALS

Thermal Interface Parameters:

- •Compliance
- •Thickness (Increases Thermal Resistance)
- •Wear/Durability of Material
- •Residue (Silicone based)
- Thermal Conductivity
- •Application & Attachment Method (Adhesive, etc)
- •Cost



CONTACT PRESSURE

•Heat Sink Contact Pressure improves thermal performance (especially when using thermal interface material).

•Damage to the die can occur if too much pressure is applied.

•The chip manufacturer should supply a die pressure specification (max value allowed).



OVEN PARAMETERS

•Air flow - Quantified by Feet per minute, etc.

•Flow path must be unrestricted to maximize efficiency. Orient sockets to maximize air flow.

- •Oven Temperature May need to be modified to achieve desired die operating temperature.
- •Air temperature varies as it flows across the burnin board. Thermal uniformity can not be assumed.
- •High Temp areas within the oven may require greater thermal management in those locations (Figure 2).

TEMPERATURE GRADIENT BURN-IN ENVIRONMENT (FIGURE 2)

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MEASURING PERFORMANCE THERMOCOUPLE PLACEMENT



Thermocouple usage and placement is critical



DESIGN INPUTS / PARAMETERS

Parameters needed:

- •Power usage as a function of time. (Peak & steady state power output)
- •Current die temperatures during burn-in
- •Specification for Max die temp allowed
- •Oven temperature & gradient across board
- •Air flow
- •Flow geometry in oven/Flow geometry of socket
- •Die pressure applied
- •Power Consumption Variability Throughout Board (Individual processor speeds are inconsistent)



COMPROMISES / TRADE-OFFS

•Board spacing can be increased to enhance airflow (at the cost of throughput)

- •Modify Oven Temperature to meet die temperature spec
- •Change board layout / density
- •Change socket to thermally conductive resin
- •Increase die pressure



THERMAL TERMINOLOGY

•Conduction - Heat transfer that occurs across a medium

•Convection - Heat transfer between a surface and a moving fluid when they are at different temperatures

•Radiation - Surfaces of finite temperature emit energy in the form of electromagnetic waves

•Temperature Vs. Heat - Heat is a measurement of thermal energy,

•Junction Temp - Temperature at the junction point of two materials

•Thermal Load - Power input to a system or device

•Thermal Efficiency - Rate at which heat is removed compared to another method

•Heat Loss / Heat Dissipation - Energy removed from the system through conduction, convection, or radiation

•Energy Vs. Power - Power is Energy per unit of time. Energy (joules), Power (watts)

•Heat Transfer Rate - Thermal transfer across a medium (measured in watts)

•Heat Transfer Coefficient - Efficiency of given material to transfer heat energy

•Laminar Vs. Turbulent Flow - Laminar Fluid Flow paths are parallel to one another, turbulent flow paths are not

A Typical Manufacturing Burn-in Process



By Kaneasan Advanced Micro Devices Penang, Malaysia Feb' 28-2000

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What is Burn-in ?

Burn-in is a process of stressing semiconductors to weed out potentially weak circuits. It is a stress situation in which time, temperature and electrical input signals and voltage are applied to semiconductors to accelerate aging.

Why Semiconductors need burn-in?

- To screen out the infant mortality or early lifetime failure.
 To cause product with high probability failure to fail before it reach end user.
 - To have quality and reliability products

Types of Burn-in

Static Burn-in - Applied Voltage and Temperature.
 Dynamic Burn-in- Applied Voltage , Signal and Temperature

Failure Mechanism Related to Burn-In

Product Defects



Silicon, Oxide & Manufacturing Defects Dielectric Breakdown Ionic Contamination

Handling Defects



Electrical Over Stress (EOS) Electro Static Discharge (ESD) Visual Mechanical Defects



Common Burn-in Circuit Documentation Rules

- **Documentation Rules should consider the following**
- Burn-in Board Design Concept (Dedicated or Universal)
- Test Condition
- Power Supply Current
- Schematic / Table
- Burn-in Components Values
- Voltages / Current Values
- Input Drive Conditions / Clocks / Signals
- Device Orientation
- Switching Noise
- Power -Up and Power Down Sequences
- Power Stable Condition
- Burn-In Temperature and Duration



Burn-in Driver

Manual Programming or Through Computer Control

Burn-in Oven

Supporting Hardware Computer or Manual monitoring

Power Supplies, Bench Tester, Socket Continuity Tester and Test Probe, Multimeter, Scope

Burn-in Board

Universal Burn-in Board

- Is the most flexible and cost-effective.
- Restrictions are that the device packages be the same size and pin count, Vcc and Ground pins remain constant.

Dedicated Burn-in Board

- Accommodate only a specific type of device.
- Signals and voltages present on the input edge connector to specific pins on the sockets.

Burn-in Driver board

 To generate signal (wave form) for dynamic burn-in.

 It can be configured to require burn-in circuit by manual using hard wires or by computer.

Computer provide an option to select the signal frequency for specific driver zone.

Burn-in Oven

Can be configured through computer or manual control.

The typical monitoring parameters during burn-in process are Power supply voltages and currents

- Voltages and signals at board level.
- Oven Temperature
- Individual Thermal Control

Supporting Burn-in Hardware Needed to:-

Monitoring and Measurement.
 Trouble shooting.
 Individual device temperature control
 Thermal solution

Example of Burn-in Hardware Set-Up



Driver Board with Program Header

PCB connection between driver and burn-in board

Burn-in Board

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Manufacturing Burn-in Reject Modes and Causes

1) Electrical Reject Modes

Leakage Failure
Open Failure
Short Failure
Functional Failure

2) <u>Visual Mechanical Reject Modes</u>

Broken Lead, Bent lead & Coplanarity

Continue.....

1) Possible Cause For Electrical Rejects

Bad burn-in sockets (sockets with damage pin)
Bad components (Resistor and Capacitor)
Integrity of signal and voltage (Electrical Noise and Spike control)
Bias and Signal applying procedure

2) Possible Cause For Visual Mechanical Rejects

Loading and unloading process
 Rework tools, method and material

Enhancement on Burn-In Hardware's

1. Consideration to enhance Burn-In Oven

Shortcomings

- Electrical Noise and Spike. Cause by poor grounding and unstable power supply
- No indication for Bias and Signal loss during burn-in due to power supply shut down.

Recommendation

- Install power conditional on oven and ensure good grounding
 Replace mechanical switches with relay type on oven.
- Installed alarm module to indicate the power supply shut-down

Applying wrong power-up and down sequence through manual handling and fast Vcc voltage ramping- up

Install power supply sequencer

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Example of Hardware Modification

Unmodified Oven

Modified Oven





Before Modification B/I System Without SSR Control and Sequencer After Modification B/I System With SSR Control and Sequencer. This to minimize the electrical noise and spike and also to automated the power supplies ON and OFF mode.

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2. Consideration For Enhanced Burn-In Board Design

A good burn-in board design should able to :-

Minimize electrical noise with good route of traces using multi layers design.

Minimize Board warpage with proper support Example- Rail and Guides.

Useable for manual and automation loading and unloading process for high UPH.
Continue.....

Universal board design concept to use for same package of product. Mainly for cost avoidance

Socket and Print Circuit Board(PCB) Material selection must be in compliance to ESD prevention.

Selection of correct version of socket for better signal and voltage integrity.

Modified Driver Boards



Before Modification Driver Card Without Program Header <u>After Modification</u>



Driver board with program header. This is to allowed for circuit conversion at driver board level. To minimize the signal integrity problem at burn-in board level

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3. Systematic Hardware Maintenance Program

- Regular Preventive Maintenance for Burn-in Hardware (Oven , Power supplies and Drivers Boards)
- Regular Calibration for Test Condition.
 (Temperature and Voltage).

Regular Burn-in Board Socket integrity verification and components measurement on burn-in boards.

Looking Beyond 2000

Future Burn-In Process Should Venture Into Computer Based Monitoring

The Benefits Would Be :-

For Efficient Burn-In and Reduce Burn-in Hours

Data Tracebility During Burn-In.

Fast and Easy Burn-In Circuits Convention.

Provide Flexibility For Various Burn-in Test Condition Bias and Signal To Be Set-Up At Board Level In Same Oven.

Reduce and Minimize Manual Burn-in Boards Preventive Maintenance.

- Socket Test Probe
- Socket Tester
- Resources

Issues which can be addressed and Eliminated by Computer based Burn-In.

 Loss in capacity while boards schedule for 100% sockets verification.
 Need to maintain extra burn-in boards.
 Bad socket only detected during 100 % socket testing.
 High cost to fabricate various test probes
 Socket damage during probing.



As for Burn-in board and Driver board design the future trend is :-

To be designed with device read out capability to monitor the socket integrity while burn-in.

The Benefits Would Be:-

Cost avoidance on burn-in board PM hardware maintenance
Early detection on socket failure during burn-in.
Less burn-in compensation hours
More efficient burn-in.

Using Total Quality Management (TQM) To Monitor Burn-in Performance

Objective

- Acceptance and Reasonable Cost, Lots On Time Delivery Measurement
- Problem Solving and Continuous Improvement
 In process Audit for Oven Setup and Burn-in Test Condition
- Electrical and Visual Rejects Within Allowable Percentage
 Control System and Process Specification Compliance
 Help to Reduce Burn-in Hours

Review Process

Quarterly review on lot rejection rate

Goal Setting and continuos improvement project.

Interface Considerations for High Performance Contactors in Automated Test Environments

Dan Maccoux Product Engineering & Support Manager Pamela Lohr Applications Engineer Johnstech International February 27-29, 1999



BURN-IN & TEST SOCKET WORKSHOP

Test System Interfaces

- Test floor and production managers must consider the entire test system and the interface
 - To ensure more production time and greater MTBF
 - To ensure that Overall Equipment Effectiveness (OEE) goals are met through easily maintainable test systems
 - To ensure higher first pass yields



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Agenda

- Package Considerations
- Contactor Considerations
- Test System Considerations
 - Tester Considerations
 - Handler Considerations
 - Docking Considerations



Package Considerations (Geometry)

- Critical dimensions that affect contactor design
 - Lead Pitch
 - Lead Group Width (directly from samples)
 - Lead Thickness
 - Lead Width
 - Lead Foot

- Lead Height
- Singulation Marks (Dambar)
- Body Size (including mold flash)
- Overall Device Thickness
- Outer Lead Width

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Dimension Evaluations





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Dimension Evaluations

Critical dimensions for contactor design





Package Considerations (Industry Package Ranges)

- Test contactor manufacturers may have difficulty ensuring performance when designing to Industry Package Ranges
 - Small geometry provides for:
 - Improved Electrical Performance
 - Self Cleaning Wipe
 - Long Production Life



Package Considerations

- Larger geometry introduces problems such as
 - Decrease in Electrical Performance
 - Reduced Wipe (Self Cleaning)
 - Shorter Production Life (increased maintenance)
- Insufficient wipe results in failure to break through lead frame coating oxides
 - Causes poor signal integrity and contact resistance varies
- Excessive wipe results in excessive lead frame coating debris
 - Increases maintenance

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Contactor Considerations

- Contactor housing design requirements may vary
 - Based on handler/change kit requirements or configuration
 - Based on device performance requirements
- Alignment plates for automated applications must be considered
 - They provide fine X-Y alignment for handler nest or work press
 - Some automated handlers utilize alignment plates and some do not



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Test System Considerations

- The Test System components must work in concert to meet customer goals; therefore, the test contactor manufacturer must have detailed information on all components
 - Tester Requirements
 - Load Board Requirements
 - Handler Requirements
 - Work Press Requirements
 - Docking Requirements



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Overall Interface Requirements



Tester Considerations

- Tester make and model can dictate size constraints for the test contactor
- Testers are selected based on:
 - The device type (memory, mixed signal, digital)
 - The functions to be tested (DC, AC, Functional)
 - The number of devices tested simultaneously



Load Board Considerations

- Load board design is a critical factor for test contactor manufacturers and their customers
 - Mechanical Interface to Contactor
 - Must be manufactured with all features specified on the data sheet



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- There are significant variations among handlers
 - Horizontal Test Plane
 - Vertical Test Plane
 - 45 Degree Test Plane

- Test Sites
 - Single Site
 - Dual Site
 - Tri-site
 - Quad Site
 - Multiple (8,16,32,64, plus others)



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- There are also many factors that affect handling accuracy
 - Mold Parting Lines on Device Body
 - Flash (Causes Debris)
 - Singulation Tabs (Dambar)
- All these also affect contactor life and performance



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- As the industry moves toward smaller, finer pitched devices, engineers working on handling interfaces are faced with a multitude of issues
 - Smaller devices are more difficult to move
 - Smaller devices are more difficult to locate
 - Smaller devices are more fragile
 - Smaller devices are more difficult to contact



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- Device tooling tolerances play a significant role in the success of an interface
 - Tolerances may not be in direct proportion to package size, lead count, and lead pitch
 - For example, 0.001" variation on a 16-lead SOIC device is totally unacceptable for an 8lead TSSOP
 - Smaller devices provide less surface area to maintain X,Y control



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- Industry Package Range specifications are too wide
- Handler manufacturers are driven to design device kits to accept the full tolerance range
 - This saves the customer money, but in the long run, may affect OEE and first pass yields
 - Accuracy is sacrificed, as it is difficult to contact the device



- As device geometry gets smaller, the area to contact on the device is reduced
- As we get closer to the load board for improved electrical performance, the geometry in which to place contact elements steadily shrinks



- The kit design is dependent upon package dimensions
 - Body Length
 - Body Width
 - Body Thickness
 - Lead Profile (Trim & Form)



- To ensure that test contactor designs will assist with higher first pass yields and OEE, customers must provide the following handler information:
 - Handler Make and Model Numbers
 - Device Kit Manufacturer
 - Device Kit Part Number
 - Second or Third Party Kit Component Suppliers
 - Existing Device Kit Info, (if one is on-site or on order)



- Nest or Work Press Mechanical Drawings
 - Alignment Plate Design
 - Information on the Existing Nest, if Applicable
 - Information on Special Features Required in the Housing
- Drawings (<u>Required</u> for Contactor Design)
 - Sequence of Events While Handling or Aligning
- Handler Theory of Operation



- In addition to specific information on the handler and kits, customers must consider, and share with the contactor manufacturer, information on the following issues:
 - How the handler aligns parts
 - How leadbacking is done
 - What surface is being used for overtravel control



- Test contactor manufacturers must know the requirements of the X/Y device control in the work press or nest
 - Based on device pitch
 - 0.08 mm (0.003") for device pitches of >0.50 mm
 - 0.05 mm (0.002") for device pitches of 0.50 mm
 - Work press or nest presentation/control
 - Nest or work press must provide overtravel stop
 - Control contact deflection
 - Maintain interface reliability



Allowable Device Movement





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- The nest or work press must provide full lead support at point of contact
 - Prevents device lead damage
- Upon actuation, the nest or work press must be coplanar to the contactor within 0.05 mm (0.002")





- For direct plunge, the <u>nest</u> should align to a controlled feature on the contactor (such as the alignment plate)
- For drop and plunge, the <u>device</u> should align to a controlled feature on the contactor (such as the alignment plate)



Docking Considerations

- Docking is as important to the test contactor manufacturer as it is to the handler manufacturer when considering OEE; information is required in the areas of:
 - Hard Docking (locked or keyed)
 - Mechanical Alignment of the Contactor to Handler Backplane
 - Provides repeatable, precise X, Y, and Z alignment
 - Accurate Coplanar Contactor Positioning to Handler Nest or Work Press


Conclusion

- In high performance contacting, the test contactor cannot be considered a "stand alone" component
- Although the test contactor may be among the smallest and least expensive items in the test system, it is critical to the overall success of the system in meeting customer goals for:
 - OEE
 - Higher First Pass Yields



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