Connection / Interconnects in Packaging

Benson Chan
Endicott Interconnect Technologies
Topics to be covered

- What is a connector
  - Connector Theory
  - Types (Pin in hole, compliant pin, surface mount, LGA)
- Where are they used
  - Connect board to card, card to card, card to device, power vs signal
- Examples – photos of connectors from tear downs.
- Performance requirements
  - Main frame class – high speed connection, impedance matched, high cost, high reliability (Harcon never had a field fail, LGA – Cinch vs Tyco)
  - PC class - low cost, performance, ease of use, ease of manufacturer
- Reliability –Time zero vs. latent fails
- High Speed
- Optical
Connector Theory

- Contact Stress
- Contact Geometry
- Mechanical Retention
- Fretting
Basic Connector Theory

Cylinder On Flat

Flat On Flat
Basic Connector Theory

Sphere on Flat

Crossed Cylinders
Where Used
Fretting Corrosion

Contact

New Oxide Film

Micromotion

Oxide Film

Broken Oxide Film

Micromotion

Contact

Oxide Film

Open contact after N cycles
Inter-disciplinary Field

- **Mechanical Engineering**
  - Stress analysis
  - Mechanical Design
  - Plastics – Injection Molding
  - Process assembly
  - Reliability

- **Materials Engineering**
  - New Alloys
  - Plating
  - Organic materials

- **Electrical Engineering**
  - Signal Integrity
  - Systems level understanding
Small to Large

- Cell Phones, consumer electronics, PCs
  - High volumes, Standardized, Low Cost, Lower reliability, Life 1 to 2 years

- PC Servers, Mid Range Systems
  - Medium to High volumes (common parts), Medium Cost, Increased reliability, Higher speeds for custom functions, Life 3 to 5 years

- High End Servers (Main Frames)
  - Low Volumes, Higher costs, High reliability, Higher performance every 2 to 3 years, Life > 7 years
HP PDA
Flex and Mezzanine types
Hard Drive Connectors
Casio Watch
Cell Phones
Anatomy of a Connector

- EMI Gasket
- Threaded Inserts
- D-shell
- Housing
- Signal Terminals Upper and Lower
- Ground Terminals
Cable Assembly
Progressive Stamping
Method of Attach

- Wave solder for Pin in Hole (PIH)
- Surface mount – solder paste
  - High temperature plastics
  - Dimensional Stability
- Compliant pin
  - Pin loading, PTH Integrity
- Compressive Loading (LGA)
  - Retention Mechanisms, Fragility of contacts
- Electrically Conductive Adhesives
Compliant Pin

- Solderless connection
- Press Fit Structure
  - Eye of the Needle
  - C-Press
  - Split Pin
Winchester C-Press
FCI Eye of Needle
Winchester Eye of Needle
LGA Connectors

- Growing field
- Tighter pitches 1.27, 1.00 and 0.8mm
- Higher I/O count (32mm to 93mm)
  - 7439 contacts on one interposer
- Non Standard Retention Mechanisms
Typically, LGA applications use a compression system similar to this:

- **Heat Sink**
- **CPU**
- **Cinch iQ LGA Socket**
- **PCB**
- **Bolster Plate**
LGA Structure

- Substrate w/ pads
- Circuit Board
- Stiffener Plate
- LGA Interposer
- Spring Plate with Actuation Screw
LGA Components

Module w/ interposer

Board w/ Gold pads
Simulator Board

65 modules
1077 contacts
Simulator Board
LGA Module

Copper / Nickel / Gold metallurgy for high reliability
Tyco MPI

“Metal Particle Interconnect” – Silver flakes dispersed within an elastomeric matrix. Non conductive at zero load condition
Tyco LGA

Compression Mount Shorting V Socket

- Unmated System
  - Au Pad
  - Package
  - LGA Socket
  - PCB
- Mated System
  - Top Plate/Heatsink
  - Package
  - LGA Socket
  - Backer Plate
  - PCB

Not to Scale
IBM C-Beam

Palladium dendrites plated on to tips of a buckling beam contact
Amphenol cLGA
Cinch Cin-Apse
Stable Contact Resistance

Button Contact Characteristics

![Graph showing button contact characteristics with force and resistance variables.](image)
Cinch iQ

.6 nanohenry inductance
LGA Flex Application
Intel Socket T 775

<3.7nH Loop inductance

<1pF pin to pin
What Can Go Wrong

- Contact Alignment
- Button Damage
- Handling
- Intrinsic Modes
Surface Planarity

Worse with Organic Carriers!
Load Uniformity
Button Damage
Reliability

- Measured in parts per million per power on hour
- Server class usually in 0.001 ppm/kpoh
- Low to medium <1 – 10 ppm/kpoh
- Intrinsic Failures
July 24, 2000

The RS/6000 SP supercomputer employs the same technology as IBM's ASCI white system, which is used by the U.S. Department of Energy to simulate nuclear testing. ASCI White contains more than 8,100 microprocessors and is capable of processing 12.3 trillion calculations per second -- thirty thousand times faster than an average personal computer.

Over 1,000,000 LGA contacts in the full system!!
LGA CONNECTOR BENCHMARK TEST

DURABILITY
- 5 CYCLES
- LLGR

THERMAL CYCLING
- 0C/70C
- 48 CYCLES
- 0C/70C
- 10 CYCLES TOTAL
- LLGR

TEMP LIFE
- 100C
- 500 HOURS
- LLGR

MFG
- 10 DAYS
- MATED
- LLGR

DISTURBANCE
- 0C/70C
- 24 CYCLES
- LLGR

CROSS MATING
- LLGR

DISTURBANCE
- LLGR

SPLIT SAMPLES

DUST
- 2X MATED
- 5 YR EQ
- LLGR

DUST
- 2X UNMATED
- 1 WK EQ
- 2X UNMATED
- 1 MO EQ
- 2X UNMATED
- 6 MO EQ
- LLGR

POSSIBLE FAILURE MECHANISMS
- CYCLIC STRESS
- FRETTING WEAR
- STRESS RELAXATION
- CORROSION
- CHEMICAL CONTAMINATION
- PARTICULATE CONTAMINATION

- IBM L3 SOCKET TEST VEHICLES USED FOR BENCHMARK TEST
- prototypE LEVEL SAMPLES ARE ACCEPTABLE FOR HAMMER TEST
- SAMPLES TO BE ASSEMBLED UNDER CONTROLLED CONDITIONS
- SAMPLES SIZE: 4 TEST SAMPLES AT LOW LOAD / 4 TEST SAMPLES AT HIGH LOAD
- COMPARISON CRITERIA: STATISTICAL ANALYSIS OF MAXIMUM DELTA R DATA USING JOHNSON DISTRIBUTION
- OTHER NOTES: TEST CARD ONLY EXPOSED DURING UNMATED MFG AND UNMATED DUST
- DUST TESTING PERFORMED PER IBM P17 SPECIFICATION
## Test Sequence:
### Design Objective 108-1676

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*Tyco Electronics AMP*
Plating Problems
Porosity Testing
High Speed

- Support Speeds up to 10Gbs
- Differential Pairs or Single Ended
Infiniband Connector System

Diagram showing the Infiniband Connector System with labeled parts:
- Connector housing
- High-speed connections
- PCB Plug-in card
- Paddle-guard
- Power and Low-speed signals
High Speed Backplane Connector

Erni ERmetZD

Teradyne GBX

FCI AirMax VS
High Speed Backplane

50 cm link running at 6.25Gbs
Interconnect Trends

Interconnect Opportunities

![Graph showing interconnect trends with years from 2000 to 2010 and technology opportunity axes. The graph compares electrical interconnects and optical interconnects.]
Optical Cables

- Single mode and Multimode
- Single fiber and Fiber arrays
- Polished face
- Strain relief
- Parameters: Insertion Loss, Attenuation, min bend radius, Face angle
- Expensive
Optical fiber is constructed of two dissimilar glass elements applied in concentric circles. A light-carrying core is surrounded by a cladding layer (different index of refraction), which caused the light to reflect back into the core. This continual internal reflection propagates the signal down the length of fiber.
As light travels down a fiber, the different rays of light travel different pathways within the core. Since each pathway has a different length, the time of arrival of each ray will be a function of the distance traveled. Hence the initial pulse is spread out over time. Modal dispersion is more prevalent in multimode fibers where larger core diameters and shorter wavelengths offer more pathways for the light to travel. Singlemode fiber, with smaller diameters and longer wavelengths, is less susceptible to modal dispersion. Use of graded index fiber in multimode fiber can minimize the affects of modal dispersion by changing the speed at which the various pathways transport the light.
Single Fiber

Duplex LC
ST - Multimode
SC - Multimode
FC – Single mode
MU – Single Mode
E2000 Multimode
Fiber Arrays

MTP test from Mipox
Multilayer Arrays

XMP from Xanoptix