YOU IMAGINE.
WE ENABLE.

Medical Electronics Packaging Challenges/ Solutions

iNEMI Medical Electronics Workshop
Santa Clara, CA

Endicott Interconnect
Technologies, Inc.

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Medical Electronics Industry

- Gradual production growth.
- Healthy growth of over 8% for the next few years.
- Recession affected growth slightly. Not to the extent it hurt other industries.

Source:
http://www.ems007.com/pages/zone.cgi?a=60051&artpg=1
EI Market Segments

- Implantables
- Supercomputing
- Imaging
- Home Healthcare

Healthcare Opportunities
EI Goals

• Utilize technologies and skill sets available at EI
  – To create the best solutions for our customers
• When necessary, create specialized solutions to meet the unique needs of the Medical Electronic Device industry
  – Product offerings may or may not be different or unique from standard products
• Offer knowledge and techniques learned from providing solutions to other markets
• Work with our customers to develop cross-market usages
  – i.e. Defense – Medical Electronic Devices
• Technology
  – Applications and product development in Endicott, NY
  – FAE support in Dallas and San Jose
  – Manufacturing capability in Endicott, NY and Shenzhen, China
Benefits of Electronics Miniaturization
Markets: Aerospace, Defense and Medical

MACRO ELECTRONIC ASSEMBLIES
Increased Function & Integration
(Servers, Medical Systems)

MICRO ELECTRONIC ASSEMBLIES
Increased Function / Reduced SWaP
(Implantables, biosensors, guidance sensors, UAV’s, advanced receptors)
Technology Available Today
Printed Wiring Board (PWB) to System-in-Package (SiP) Design
Conversion Strategy

Critical Design Inputs

BOM Analysis

BOM Substitution Recommendations

SiP Physical Layout

Preliminary Design Review

SiP Physical Layout Optimization

Critical Design Review
Building Blocks
SiP Fabrication & Assembly Technology

- **Substrate Technology**
  - Replace bulky, thick PWBs with thin, high density substrates

**CoreEZ™ 2-4-2**

Vias are 4X smaller

**Standard Build-up 3-2-3**
Embedding Resistors and Capacitors

- Remove discrete passive devices and incorporate into the substrate to reduce required surface area
• Bare Semiconductor Die

• Unpackaged die has significantly smaller footprint.

• Flipchip attach results in smallest configuration.
Building Blocks
High Density Electronics Integration
Microelectronics Packaging

Turn Key Solutions for Microsystems

Substrate & Design
- Physical design
- Mechanical layout for SiP (MCM)

Substrate Fabrication
- 50 μm laser drilled vias
- 25/25 μm line width & space

IC Assembly
- Flip chip pitch down to 175 μm
- Wirebond, 60 μm in line, 45 μm staggered

Teradyne Ultra FLEX Module Tester
- Boundary scan
- Full functional module test
PWB to System-in-Package Shrink

- Substrate fabrication and 2-sided assembly
- 3-4-3 CoreEZ® substrate
  - 3 signals, 6 planes, 30 µm L/S
- Components: 5 flip chip bare die, CSP memory, passives, SMT components, PGA connector

27X Reduction in Size!

Original PWB 108 in²

Redesigned SiP 4 in²
PWB to System-in-Package Shrink

Original PWB 24 in²

Redesigned CoreEZ® 1.2 in²

26X Reduction in Size!
Research & Development Collaborations

- **Binghamton University**
  - Membership in IEEC supporting Sensors and Microsystems
  - Characterization of Pb-free solders State of NY HTCC

- **Cornell University**
  - Nanocomposites
  - High Dk nanocomposites for buried passives
  - Flexible electronics / displays

- **Clarkson University**
  - Center for Advanced Materials Processing
  - High speed data rate modeling
  - Electrical performance analysis

- **RPI & SUNY at Albany**
  - Provide packaging solutions for advanced chips, MEMS & sensors
  - NY State COE to HTCC

- **IBM**
  - Polymer Optical Waveguides
  - Advanced Server Packaging
  - Robust Interconnect Technology

- **Georgia Tech**
  - System on Package (SOP)
  - Optical Interconnects Backplanes
  - New materials for packaging

- **GE Global Research**
  - Multichip, Power and Medical Systems Packaging

- **US DC**
  - Center for Advanced Microelectronics Manufacturing

- **UNOVIS**
  - Providing solutions for specialty products / equipment

- **Infotronics**
  - University, Industry & Government
  - Advanced packaging & Interconnect for MOEMS & MEMS

- **University of Nevada**
  - Robust Interconnect Technology
  - Multichip, Power and Medical Systems Packaging

- **University of Texas at Austin**
  - Nanocomposites
  - High Dk nanocomposites for buried passives
  - Flexible electronics / displays

- **Penn State**
  - Center for Advanced Microelectronics Manufacturing

- **Watson Research**
  - IBM
  - Polymer Optical Waveguides
  - Advanced Server Packaging
  - Robust Interconnect Technology
Center for Advanced Microelectronics Manufacturing
Flexible Electronics: material, tool and application space

**Design & Fabrication**

- Glass panel (as a standard)
- PET film
- PI film
- PEN film
- Flexible glass
- Metals (Cu, SS, etc...)
- Others

**Substrates**

**Technology**

- Fine circuitry
  - single & double sided
  - single & multilayer
  - registration & overlay
- Sensors
  - environmental
  - biometric
- Medical
  - catheter technology
  - implantable
  - diagnostic
- Passive displays
- Lighting
- Optical waveguides
- Solar energy conversion
- Active devices
- Active backplanes

**Processing**

- Vacuum deposition
- Photolithography
- Wet/dry processing
- Slot-die coating
- Ink-jet printing
- Aerosol ink-jet printing
Why Roll-to-Roll Manufacturing?

R2R can lead to reductions in cost.

• Engineering Challenges
  – Need to develop R2R equipment to operate at IC industry specifications
    ▪ Existing hurdles:
      – Damage due to handling
      – Particle generation
      – Impurity due to contact
      – Yield management
      – Linear processing

• Financial Opportunities
  – A fully integrated facility
  – Lower capital & labor cost
EI provides customized solutions including assembly services, PCB fabrication and organic semiconductor packaging for a host of applications including:

- Pacemakers
- Implantable cardioverter defibrillators (ICD)
- Ultrasonic catheters
- LED surgical overhead and endoscope lighting
- Digital x-ray
- Patient monitoring systems
- CT scan
- Supercomputing for life science simulation (drug design)
Drivers and Challenges

- Better Diagnostics/lower cost

- Non invasive procedures/faster recovery

- Preventative medicine has never been more important. Medicine that promotes cost savings.

- Coverage Expansion in US Pre-existing Conditions. No annual limits.

- Increased funding for certain imaging equipment.

- Novel sensing technology becoming available.
Drivers and Challenges

- Products require FDA approval, which drives very long lead times.

- Any changes also need FDA approval – "needs to be right the first time"
  Examples: dielectrics, hole size, connection technology, surface finish, etc.

- Each substrate/assembly requires traceability.

- Data need to be kept for 10+ years.
Key Technical Challenges for Medical Device Fabrication
Catheters and Implantable

- Miniaturization: circuit feature sizes and device thickness
- Biocompatibility of materials
- Component attach with high placement accuracy
- Novel assembly processing for bioconformance
- Handling of novel materials through substrate fabrication and assembly processes.
- Test and Reliability
- Cost
Intravascular Ultrasound Catheter Sensor Package

- Flip Chip Ultrasound Transducer for Catheter
- Sensor assembly rolled to 1.175mm diameter
- 5 Flip Chip ASIC, .1mm thick, 31 I/O, 2.5mm x .5mm
  - 22 micron flip chip bumps on 70 micron die pad pitch
- 1 PZT crystal
- 12.5mm by 6.5 mm single layer flex circuit
  - 14 micron wide lines and space copper circuitry
  - 12.5 thick polyimide dielectric
- Prototype to production
  - Over 500,000 modules shipped
Intravascular Ultrasound (IVUS) is a catheter-based system that allows physicians to acquire images of diseased vessels from inside the artery. IVUS provides detailed and accurate measurements of lumen and vessel size, plaque area and volume, and the location of key anatomical landmarks.
Support of 12.5 µm polyimide film during substrate fabrication: use of rigid frame

152.4 mm (6 in)

14 µm line and space
ICD (Implantable Cardioverter Defibrillator) & Pacemaker

- Smaller, less intrusive applications for implantable devices
- High density interconnect substrate
  - 8 layers
  - 1.2” x 0.5” & 1.7” x 1.6”
- October 2008 marked 1st human implant of El pacemaker
Ultrasound Application

Si Package – Medical Imaging:
- CoreEZ® 2-4-2 substrate
- SiP assembly (FCA)
Supercomputing for Life Science Simulation

• EI applied its expertise with interconnect devices to resolve customer’s problems
• Our expertise with functional testing expanded the scope of work
• EI building machine in situ on our campus
• EI hosting supercomputer because of enormous infrastructure demands of this machine.
• EI to provide ongoing project maintenance services
**Technology Highlights**

- Low Loss Multi-mode @ 850 nm wavelength (<5dBm per meter)
- Flexible
- Can be connectorized
- Can be used for board to board and within board optical communications
- Compatible with PCB manufacturing*
- Reliability (Passed Tests)
  - **Damp Heat**: 85°C/85%RH for 2000 hours (GR-1221)
  - **Thermal shock**: 100 cycles from -40°C to +70°C
  - **HAST (Highly Accelerated Stress Test)**: 96 hours @ 130°C / 85% RH / 33psi
  - **Solder Reflow**: 6 cycles at standard SAC solder reflow profile

*Compatible with PCB manufacturing is referenced but not explicitly stated in the text.
New Products and Materials
4 metal layers LCP product

- **PTH’s** 3 – 16 mils
- **Blind vias** 2 – 6 mils

Reliability tests:
- CITC (+220 °C) passed min 40 cycles req. min 10 cycles PTH 3.0 mils – 16.0 mils
- DTC (-55/+125 °C) 1,000 cycles / THB 85/85 / ATC / HAST (JEDEC spec testing) in progress
6-Metal Layer All-LCP
Ultrasound Device – Gastrointestinal

TEST VEHICLE TO PROVE FEASIBILITY FOR LEAD FREE SOLDER ATTACH

13 um L/S

DENSE CIRCUITRY
DOUBLE SIDED FLEX

- 13 um LINES / SPACES
- 6 um THICK Cu, 35 u in GOLD
- 25 um VIAS
- FRONT TO BACK REGISTRATION 0.001"
- SOLDERMASK, FLEXIBLE, 6 um THICK, REGISTRATION +/- 10 um
- TWO ASICS, SEVERAL OTHER COMPONENTS
EI goals for the next 5 years

- 12.5 μm LW/ 12.5 μm LS/ 12.5 μm LT using conventional circuitization processes.
- Develop free standing materials (no glass cloth) for the next generation of organic packaging.
- Show feasibility 4 μm LW / 6-8 μm LS / 6-8 μm LT using state of the art circuitization tools.
- Develop optical interconnect to transfer more information per channel.
- Develop non-traditional processes such as inkjet printing for circuitization.
- R2R processing for PWBs and chip carriers.
- EI will continue to offer Z – 3D interconnect technology to our customers for packaging.