Identifying the root cause of a problem is the first step to finding a solution.
Microtech Company Overview

- Privately owned company located in Plano, Texas founded in 2000
- Customers from broad array of industries
  - Semiconductor IC, Defense/Aerospace and Commercial Products
  - Support for large IDM’s and fabless semiconductor companies
  - Extensive Reverse Engineering capability and litigation support
- Experience with CMOS (28/22/14nm), Bipolar, RF SiGe, GaAs, GaN, SiC, for power, digital and mixed signal process technologies
- ISO 9001:2008 Certified
Microtech Company Overview

- Broad range of failure analysis capabilities with special expertise in complex analog/mixed-signal analysis
- For analog and mixed-signal designs schematic and layout databases can be viewed and electrical analysis performed to correlate with the global isolation findings.
- General focus on fast cycle time and quality of results with detailed reports. Our team takes pride in finding the correct answer.
Criteria Labs

- Partnership with Criteria Labs colocated in Texas
- Assembly and Packaging
- ATE Testing
- Reliability Testing
- Full Qualification, DPA and Failure Analysis Flow
Microtech Company Overview

- Failure Analysis of IC continuity, parametric, and functional failures
- PCB, Electronic Assemblies, Components and IC analysis
- Competitor Evaluation and Construction Analysis
- Reverse Engineering and Circuit Extraction
- Services work such as Decapsulation, Cross-section, etc...
- Backside polishing and preparation of IC’s for analysis
- Qualification and DPA work on consumer IC’s for military applications
Microtech Company Overview

2 UTI Multi trace curve tracers

- Six Bus system
- 441 pin capable
- 625 pin capable
- Switchable supplies
Microtech Company Overview

Sonix UHR-2001 SAM

- 15, 75, 150 MHz transducer
- Detect delamination and voiding in IC’s, PCB’s, MCM’s, etc…
Scanning Acoustic Microscope

Characteristics of Ultrasonic Waves

- Freely propagate through liquids and solids
- Reflect at boundaries of internal flaws and change of material
- Capable of being focused, straight transmission
- Suitable for Real-Time processing
- Harmless to the human body
- Non-destructive to material
Scanning Acoustic Microscope

Case Studies:

Uses:
- Die Delamination
- Die cracks
Microtech Company Overview

G.E. Nanomex Real-time X-ray

- Real time x-ray
- IC and PCB inspection
- Data video recordable

Quality
Honesty
Integrity
Timely
Package X-ray

Case Study: Cold Solder Joint
Microtech Company Overview

Xradia XCT-200 3D X-Ray

- Dedicated 3D X-Ray
- IC and PCB inspection
- <0.7µm 3D Voxel
- Virtual cross-sectioning/delayering
- Full dataset provided to customer with viewing software
Package with 3 stacked dies had wire from bottom die shorting to wire from third die. The initial area was found using thermal imaging.
PCB Module Leakage at Substrate

Leakage localized to defective via on the substrate. Confirmed with 3D x-ray CT. Totally non-destructive method to identify the root cause.

X-ray CT (50x)

3D X-ray CT
Microtech Company Overview

Decapsulation Services
Laser ablation and low temperature acid decapsulation for gold, copper and silver bond wires
Global Isolation Techniques

• **Liquid Crystal** – Thermal Technique based on property to liquid crystal response to polarized light in presence of heat. Need 1mA or more leakage.

• **Lock-In Thermography** – Thermal Technique using thermal imaging camera with lock-in amplifier while pulsing current through failure.

• **Emission Microscopy** – Optical Technique using InGaAs camera to capture light given off from electron-hole recombination. Based on principle that silicon defects result in recombination center. (nA leakage detection)

• **TIVA/OBIRCH** (Thermally Induced Voltage Alteration/Optical Beam Induced Resistance Change) – Laser Scanning technique whereby constant current of voltage source is monitored while rastering laser across IC surface. Based on principle that when a material is heated its resistance changes which results in the constant current/voltage source responding.

• If Global Isolation fails, then you are left with on die probing and circuit analysis
Global Isolation
Liquid Crystal Analysis

- Thermal Sensitivity 25mW
- Uses Polarized Light
- Visualize light diffraction
- Detects Shorts, High IDD
- Can give False information
- Limited spatial resolution
- Good for gross failure
Global Isolation

Lock-in Thermography
Application: Locate Line shorts, ESD damage, EOS Damage, Device latch-ups, PCB shorts and Identify faulty components on PCB’s
Global Isolation

Silicon Carbide Thermography Image

Thermal Image

Overlay with IR Image

Quality
Honesty
Integrity
Timely
Global Isolation

Silicon Carbide Damage
Global Isolation: EMMI/TIVA

Semicaps SPEMS 1350

- InGaAs EMMI Detector
- LSM for TIVA/OBIRCH
- 300mm probe station
Frontside EMMI

- Easy access to die
- No CAD required
- Metal Busses block light from electron/hole recombination
Backside EMMI

- Limited imaging for Navigation
- CAD overlay can be used
- IR image from LSM is usually overlayed.
- Best Sensitivity for low level leakage (nA)
- Sample Preparation can be significant depending on package type
Frontside TIVA Images
Backside TIVA Example

TIVA image

Reflected light image
Global Isolation

RF SiGe TIVA Isolation
Global Isolation

RF SiGe Deprocessing

Quality
Honesty
Integrity
Timely
Global Isolation

Gallium Arsenide Leakage Isolation

FIB Cuts and Pads

EMMI Image

Quality
Honesty
Integrity
Timely
Global Isolation

Gallium Arsenide Leakage Isolation

Pad 1 to GND Curve Trace

SEM Image

FIB Cross Section Shows Voiding

Quality
Honesty
Integrity
Timely
Digitally Enhanced Optical Imaging

Olympus BX51
Automated Stage Microscope

- Full die montages
- Multi focus stacked imaging
Electron Microscope Imaging

JEOL 6500 FESEM
w/ Energy Dispersive Spectroscopy

- Images of 45nm features
- Oxford Inca 450 EDX
Electron Microscope Imaging

FEI Nova Nanosem 450

- Variable Pressure SEM
- 0.5 KeV to 30KeV
- Images of 14 nm features
- Holds 4” dia. samples
EDX for SEM Materials Analysis

Energy Dispersive X-ray

X-ray Emission

Secondary electron emission

Incident Beam Electron

Outer electron jumps to inner shell releasing X-ray emission
EDX Materials ID
Focused Ion Beam
FEI P3X Circuit Edit FIB
FEI Dual Beam FIB
FIB Tool Basics

Like an SEM, but primary beam is $\text{Ga}^+$ (30 - 50 keV)

Use beam to sputter
Image by collecting secondary electrons
GAE Etching into Oxide

Ga$^+$ Ion Beam

XeF$_2$

Anisotropic via etching
Probe Pads for Characterization

IC modification and 6 5x5um FIB probe pads

IC modification with FIB probe pad
IC Modifications

Circuit modification to shift 8 phases of PLL on 6 level 130nm device:
The edit consisted of 16 cuts on met3 and 17 jumpers from met3 to met3.
The 7 diagonal jumpers are 7um x 0.7um. The edit was completed successfully on 3 devices.
Dual Beam FIB Cross-Sections

Cross-section of several vias

Cross-section of a process defect

Cross-section of a via
Deprocessing

Chemical Deprocessing

- Wet and dry (RIE/Plasma) chemical delayering
- Chemical decorations/Stains
Deprocessing

3 Allied HighTech
Multiprep Polishers

- Mechanical Polishing
- Backside Thinning
- Precision Delayering
- Whole die Delayering
Teardowns

Reverse Engineering

- Complete Device Teardown
- TV’s, Phones, Smart Watch
- System and IC level detail
- Electrical Testing
Reverse Engineering

Circuit Extraction

Quality
Honesty
Integrity
Timely
Additional Services

- TEM, EDX and EELS
- Auger Analysis
- FTIR Spectroscopy
- Raman Spectroscopy
- X-ray Photoelectron Spectroscopy (XPS)
- Electrical Benchtop Testing
- Numerous DC and other bench test equipment