EAG CAPABILITIES OVERVIEW

Engineering Sciences
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OVERVIEW OF EAG LABORATORIES

EAG Laboratories Divisions:

- **Engineering Sciences ("ES")**: Global leader in production and engineering outsourced testing in Electrical, Reliability Stress, and Physical failure analysis services for technology customers
- **Material Sciences ("MS")**: Global leader in micro-analytical surface testing and analysis of materials – started as Charles Evans & Associates in 1978
- **Life Sciences ("LS")**: Global leader focused on technical analyses and registration requirements for the Agrochemical, Industrial Chemical, Pharmaceutical and Animal Health Industries

EAG Laboratories is a differentiated testing and evaluation company which has a common thread across various technology and analytical services that serve different varied markets.

EAG Laboratories serves over 5,500 customers across a broad array of industries including: commercial, industrial, automotive, lighting, aerospace, LEDS, solar, biomed, pharma, chemical, agrochemical, industrial chemical, consumer and technology end markets.

>1,250 highly skilled employees worldwide, including >100 PhD scientists
ENGINEERING SERVICES

- Electrical Product Testing, Characterization and Evaluation with ATE development for volume, pilot, prototype and characterization
- Reliability Stress Testing, Qualification, Monitoring and Burn-in
- ESD and Latch-up Testing
- FIB Circuit Edit and Debug
- Full Failure Analysis Capability
- Materials Analysis
- Printed Circuit Board (PCB) Design and Hardware fabrication

We provide an integrated model that supports semiconductor / microelectronics companies in the total product lifecycle from conception to volume production

- More than 30 years of experience in electronics industry
- Over $100M in capital equipment investment
THE EAG APPROACH

• Engineering expertise
  – Over 20 years of history providing microelectronics services with highly skilled staff
  – Established processes and methodology to identify root cause and deliver consistent high quality results and services

• Large, comprehensive equipment set for increased scalability and flexibility
  – Enables us to pick the right tool set / platform and location for the job
  – Parallel processing of large projects; scalable to handle fluctuations in demand
  – System redundancy to minimize impact
  – Capability to analyse systems down to the component level

• Multidisciplinary approach with all services under one roof
  + Single point of contact   + “Turn-Key” offering Start-Finish

EAG Laboratories solution focus allows us to assemble the right combination of resources to deliver optimized solutions that are timely and cost effective thereby reducing risk
ELECTRONIC TEST & MEASUREMENT (ATE)

• Production/Pilot/Prototype Testing
• Hardware Design / Fabrication
• Test System Rental (On site/Remote Log in)
  – 24/7 access to testing and facilities
  – EAG engineers and expertise available on-site
  – System maintenance and support from in-house staff
• Test Program Development / Test Engineering
• Program transfer to leading OSATs offshore
• Product/Process Characterization
ATE PRODUCTION SERVICES

• Flexible production flow includes:
  – Daily WIP planning
  – Incoming Quality inspection
  – Production test
  – Bake, dry pack, label
  – Outgoing Quality inspection
  – Drop/Direct shipments

• WIP system for visibility
Operating/Storage Life Test
- High-power Operating Life
- High Temperature Operating Life
- Low Temperature Operating Life
- High/Low Temperature Storage

Temperature/Humidity Stress
- Highly Accelerated Stress Test (HAST)
- Temperature Humidity Biased
- Temperature / Humidity
- Temperature and Humidity Cycling

Broad set of equipment
- MCC HPB-5B, 128 I/O, 32M vectors
- INCAL INFINITY, 160 I/O, 16M vectors
- AEHR Max III, 96 I/O, 4M vectors
- INCAL MPU, 48 I/O, 1M vectors
- CRITERIA, 48 I/O, 2M vectors
Temperature Cycling
- Temperature Cycling (Air to Air)
- Powered Temperature Cycling
- Thermal Shock (Liquid to Liquid)

Accelerated Moisture Stress
- Highly Accelerated Stress Test (Biased or Unbiased)
- Autoclave up to 35 psi

Other Stresses
- Package Moisture Sensitivity Characterization
- Preconditioning Flow (MSL 1-6)
- Solder Reflow Simulation
- Gate Leakage Test
ESD & LATCH-UP CAPABILITIES

- Testing up to 2,304 Pins
- Full Characterization Reports
- ESD Human Body Model
- ESD Machine Model
- ESD Charged Device Model
- Latch-up Testing To 256K Vectors
- Temperature Forcing
- Curve Comparisons
- Multiple Systems / Multiple Locations
- Talented ESD Engineering Staff
- Adapter Boards for all platforms
IN-HOUSE PCB DESIGN

- All design work done by EAG engineering staff
- HTOL, THB, HAST, ESD, ATE designs
- Multiple board design/chamber options:
  - MCC
  - Infinity (HX, XP160)
  - Criteria
  - MPU
  - Trio-Tech / Hirayama
  - MK4
- Layout/Schematic capture
- PCB pitches down to 0.3mm
- Performance/Impedance matching
FIB CIRCUIT EDIT

- Design Debug
- Verify Functionality
- Same day prototypes for customers / engineering
- Probe points / Pads
- CAD Navigation / Overlay
- Backside FIB / Sample Prep
- Nanomachining
FAILURE ANALYSIS – EXAMPLES

- Smart meters
- Power adaptors
- Safety latch mechanism
- LED assemblies
- AC/DC converters
- Temperature pressure sensor
- Cochlear implant
- Surgical instrument controller
- Touch panel display
- Fingerprint sensor
- Car steering sensor assembly
Design, Debug, R&D
• New product / design
• Package assembly
• Performance and function

Production
• Wafer sort yield
• IC Final test yield
• Yield improvement

Qualification
• ESD / Latch-up
• Operating Life/HALT/HAST
• Environmental Stress

Applications
• System Level
• PCB Manufacturing Yield
• Field Failures

Broad analysis range from design through production and field returns
FAILURE ANALYSIS - FLOW

Review History / Documentation

Perform non-Destructive steps

Verified?  No

Deconstruction

Localize the failure

Perform Destructive steps

Report

Electrical FA
Steps to characterize the failure and localize to a smaller area on the sample.

Physical FA
Dis-assembly of the sample to get a picture of the failure site / mechanism.
COMPONENT ANALYSIS

- Levels of Service to meet the needs of our customers
  - Analytical Services
    - Individual / Client driven/directed
      - Turnkey FA
        - Level 1 – Package / Die level
        - Level 2 – Electrical Localization
        - Level 3 – Physical root cause
    - Advanced FA
      - System Level
      - Root Cause
  - Capabilities and Techniques
    - Electrical Verification / Test
    - Time Domain Reflectometry
    - X-Ray
    - SAM
    - Decap / De-lid / Sample prep
    - Deprocess / Cross section
    - Backside Analysis
    - Emmi/Light Emission Microscopy
    - XIVA / OBIRCH
    - IR Thermography
    - Dual Beam FIB / SEM / EDS
    - TEM / EDS / EELS
    - Material Analysis / Characterization
Advanced Device and Sample Types

- Imaging/sensors: Read Output Integrated Circuit (ROIC), Pixel Array Detector (PDA), Focal Plane Array (FPA)
- Application Specific Integrated Circuit (ASIC)
- Custom Hybrid Assemblies
- Technology: SiGe, GaAs, InSb, InP, InGaAs, SiC, GaN
- Process nodes: 28nm, 14nm FinFET
- Package: Cu wire bond, Cu pillar, WLCSP, SoC, PoP, MCM, MEMS, 3D, Stacked Devices
Failure Modes and Mechanisms

- Functional, parametric, high leakage, excessive sleep current, Vt shifts, dead pixels
- Intermittent: manufacturing, application or environmental factors
- Fabrication: silicon crystalline, metal puddling, photoresist/masking, misalignment, spacing, particles
- Packaging and assembly: handling, contamination,
Advanced Analytical Techniques

• CAD Navigation / GDS file (layout and coordinates)
• Dual Beam (DB FIB) slice and view
• Deprocessing: advanced technology nodes (Cu, low K)
• FIB Circuit Edit: probe internal nodes, modify circuit
• Advanced fault isolation tools: Photon emission (PEM/LEM/EMMI), IR thermography, Laser Signal Injection Microscopy (OBIRCH/XIVA/TIVA/LIVA).
• Backside Analysis: improved resolution, no metal masking on multi-metal layer device.)
• EDS (spot, line scan, dot mapping)
• TEM
Investigations

- Cu wire bonded PED Qualification: AEC Q006
- Materials analysis: multi-discipline investigation, critical aspect of advanced IC analysis
- DOE: design of experiments (e.g. ESD, Reliability stress, bench test failure replication, latency defects)
- Modules and System or PCBA level
- ESD vs. EOS
- Root Cause identification: containment/corrective actions
WHY WORK WITH EAG?

• **Engineering Expertise** from system level to component level with the latest technologies to address both electrical and materials characterization

• **Customized Solutions** that can be designed to meet your product specific and analytical support needs

• **Large, comprehensive equipment set** across testing and analytical services coupled with ongoing investment to address changing technological trends

• **Strong integrated approach** with Failure Analysis and Debug tied to ATE test, Reliability, ESD and Materials Characterizations to quickly and comprehensively develop solutions