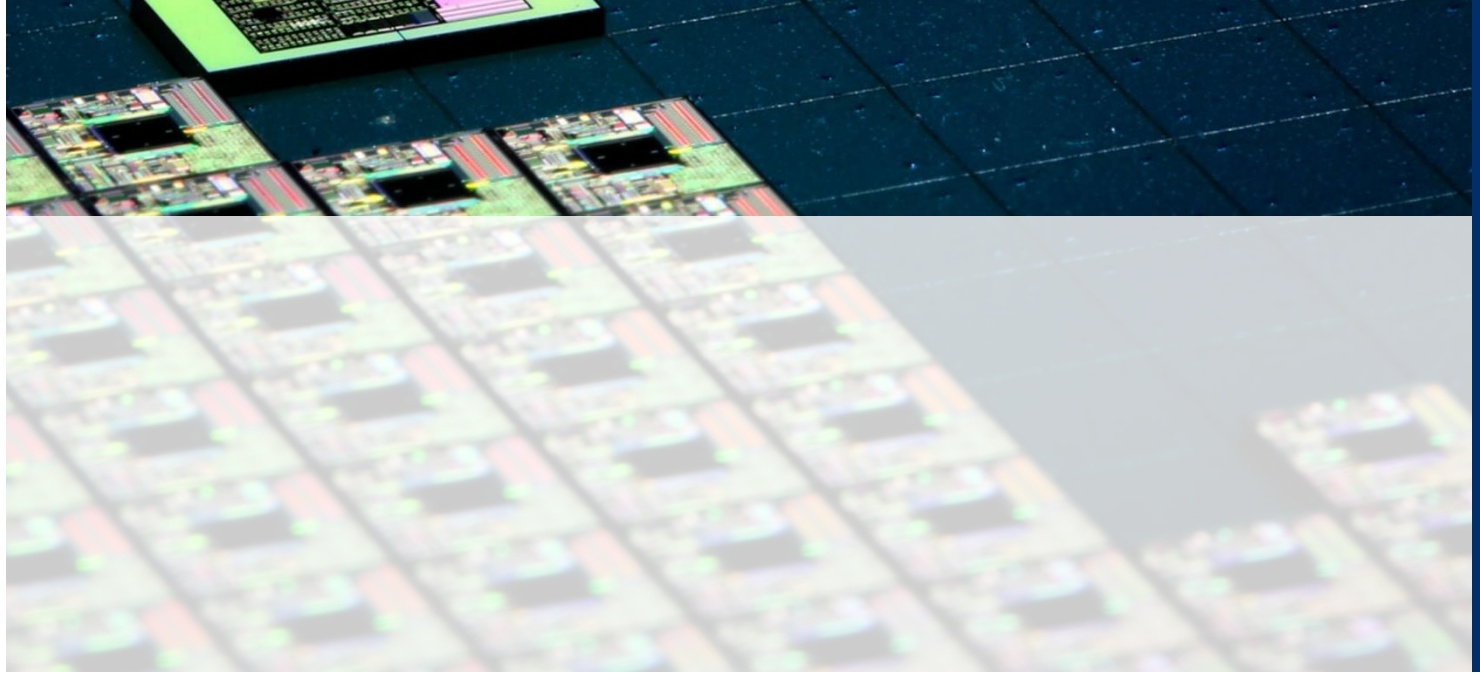


Universal Instruments
A Delta Group Company

advanced process lab

ADVANCED PROCESS LAB (APL) OVERVIEW

BUILD. SMARTER.

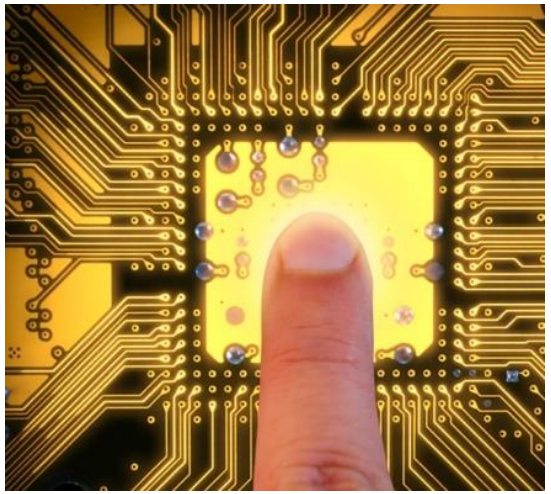
ADVANCED PROCESS LAB (APL)

Founded in 1987, the Advanced Process Laboratory (APL) was created as a customer-focused resource dedicated to understanding the materials and processes used in electronics assembly

- Root cause failure analysis, materials evaluation and reliability testing
- Detailed findings uniquely presented in the context of the assembly process and materials
- ***Comprehend and efficiently resolve production failures***

- Low to mid-volume assembly services
- Prototyping and process development
- ***Reduce time-to-market and cost of NPI for challenging new products***

AREA CONSORTIUM **A**dvanced **R**esearch in **E**lectronics **A**ssembly



A long-standing partnership with industry-leading companies; fast-paced, timely research on leading-edge materials and manufacturing processes

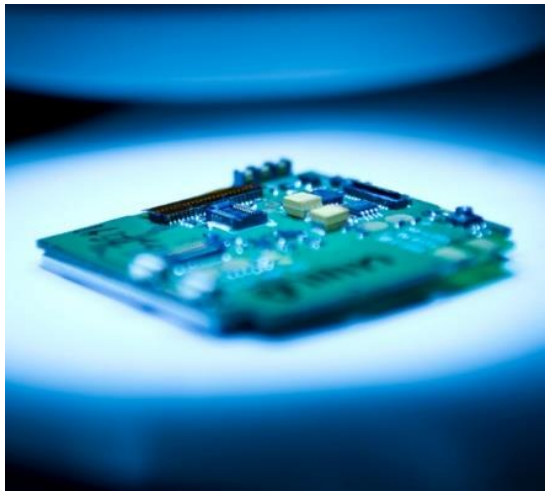
- Member-driven research executed by APL professional research staff
- Members include electronics industry leaders across multiple markets
- Vertically integrated research capability (design, manufacturing, reliability, & analysis)
- Focused on materials, reliability, and process research
- ***Maximize R&D investment and reduce development time and costs***

Academic partnerships: *Over 250 Masters and PhD. Students graduated through our program since 1992*

YOUR COMPANY LOGO HERE

JOIN THE TECHNOLOGY LEADERS

ANALYTICAL SERVICES



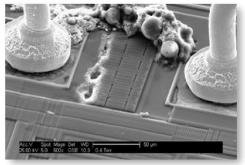
Exclusive expertise and specialized analytical tools to identify and address production and field failures

- ***The primary advantage the APL offers over other analytical laboratories is the ability to interpret and explain data in the context of the assembly process and specific material set***
- Leveraging knowledge from years of process, materials, and reliability research
- Root cause failure analysis
  - Comprehend and efficiently resolve failure modes
  - Comprehensive analytical methods
  - Detailed technical reports to support findings

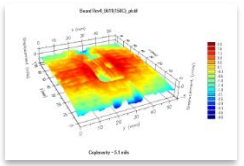
ANALYTICAL SERVICES

Thermal Shock Sample Loading

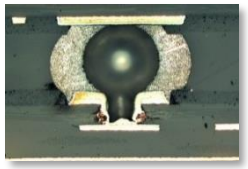
Etched, thermal-cycled, lead-free solder



EOS failed die

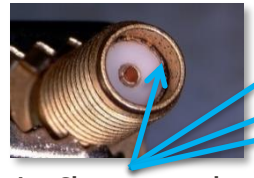


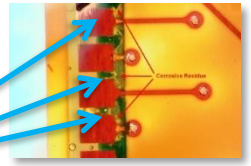
Level 2 – BGA warpage evaluation



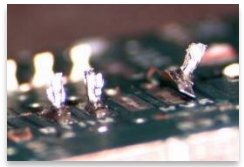
Level 3 – microvia non-conformance

- Package quality: solderability, plating, design
- Mechanical testing: drop, shock, vibration
- Environmental testing
- Circuit board quality: design, fabrication, hole wall
- IPC-A-610 inspection
- IPC-A-600/IPC-6012/IPC-6013 inspection (PCB fab)
- Solder paste/flux testing & qualification
- Ion chromatography, ion contamination
- Contamination/residue analysis
- Thermal analysis: DSC, TGA, DMA, TMA
- Acoustic microscopy and infrared spectroscopy

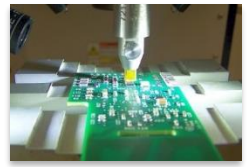




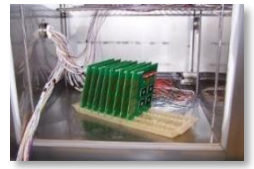
Ion Chromatography used to identify contaminants



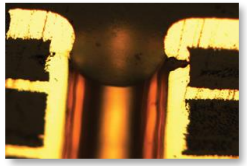
Mechanical Pull/Shear Testing Sample



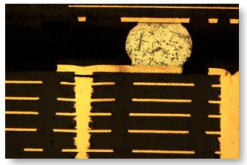
Mechanical Pull/Shear Testing Tooling



THB-SIR Testing Chamber Configuration



Dry film lock-in void



PTH barrel crack

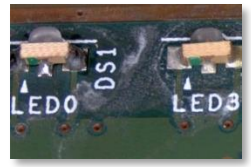
- From silicon-level to product-level analysis
- Level 0 – Silicon-level
- Level 1 – Package(component)-level
- Level 2 – Assembly-level (solder/pick-and-place/reflow)
- Level 3 – Product-level
- Level 4 – Reliability
- Field failures root cause determination
- Post-assembly process recommendations based upon our extensive manufacturing experience
- EOS (electrical overstress)/ESD (electrostatic discharge) die failures
- Component chemical and mechanical decapsulation

Supplier Quality Testing

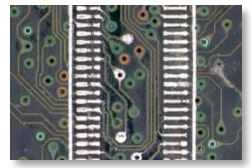
Failure Analysis Services

Reliability/ Endurance Testing

- ESS testing recommendations
- Liquid to liquid
- Air to air
- Temperature/humidity/bias testing
- CAF testing
- SiR testing
- Resistance monitoring
- Electrochemical migration
- Drop shock testing
- Vibration testing
- Dye penetration testing
- Thermal cycling/shock testing (“time zero” prediction)
- Mechanical pull/shear testing



Ion Contamination testing for remnant solder flux



Ion Contamination testing for SM assembly cleanliness

Advanced Technology Assembly Services - ATAS

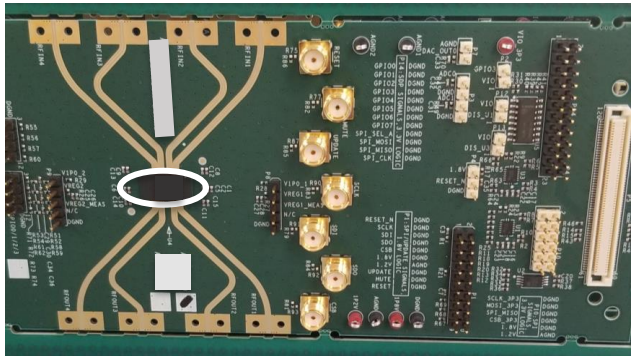
We can provide solutions for all types of assembly challenges:

Traditional Assembly

- Process automation
- New assembly materials & processes
- Solve assembly problems
- Evaluate alternative solutions
- Migration to flip chip or other technologies
- NPI

Advanced Packaging

- 2.5, 3D & WLFOP
- Pitch and package shrink
- Reliable assembly of large I/O devices
- Re-workable Under fills
- Heterogenous integration
- FHE –Flexible Hybrid Electronics



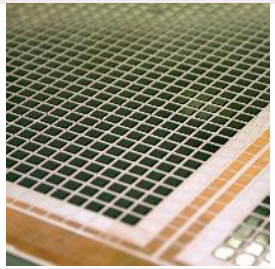
ADVANCED TECHNOLOGY ASSEMBLY SERVICES

Providing solutions for the following types of assembly challenges:

TRADITIONAL ASSEMBLY

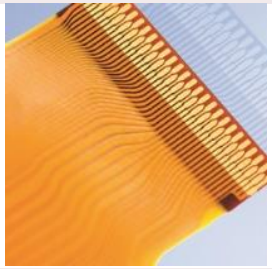
- Process automation
- New assembly materials & processes
- Solve assembly problems
- Evaluate alternative solutions
- Migration to flip chip
- Dispensing solutions
- Enablers of future technologies

ADVANCED PACKAGING



- 2.5, 3D & fan-out packaging
- Pitch and package shrink
- Reliable assembly of large I/O devices
- Re-workable underfills
- Integrated passive device solutions
- Fan-out Wafer-Level Packaging (FOWLP)
- Chip on Wafer on Substrate (CoWoS)
- Flip chip on flex / FHE
- Chip on chip

EMERGING TECHNOLOGIES



- Smaller & lighter weight solutions
- Power management/ TIM testing
- Large Form Factor BGA >100mm
- Material evaluation
- Reliability testing
- Flip Chip on Flex
- Conductive attach & adhesion
- Low temperature soldering
- Environmental testing and protection of packaging

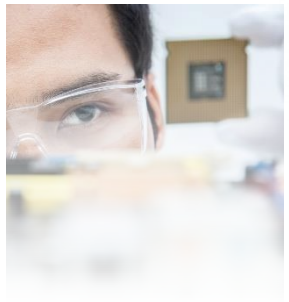
ADVANCED TECHNOLOGY ASSEMBLY SERVICES

Electronics assembly/manufacturing, prototyping and process development services for challenging products

- Assembly Services
  - Optimized assembly solutions for new and existing products
  - Low to mid-volume production – usually associated with NPI
  - State-of-the-art production lines to build a full range of complex products
- Prototyping and Process Development
  - Process development for new and existing products; Formal report and recommendations
  - Expertise for complex assembly, emerging technologies and advanced packaging
  - Review of application assembly processes, materials, components and current yields
  - Design for Manufacture (DfM) and Design for Reliability (DfR)
  - Process transfer, on-site integration, training
- Reliability testing
  - Thermal cycling and thermal shock
  - Drop shock, temp/humidity testing

ADVANCED TECHNOLOGY ASSEMBLY SERVICES

Comprehensive technical support throughout the complete product life cycle



- Process and Materials Research and Development

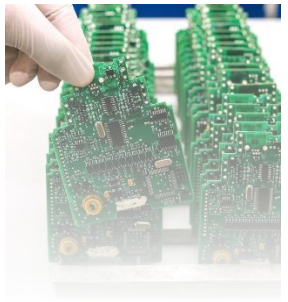
- Product Layout and Design
- Process Design
- Applications Review

- Process Development
- Process Solutions
- Prototyping on Manufacturing Equipment

- Process and Equipment Optimization
- Design for Manufacturability
- Reliability Testing
- Qualification

- New Product Introductions
- Prototyping
- Volume Production
- SMT/PCBA Assembly, Including Chip-on-Substrate

- Failure Analysis
- New Product Introduction and Support
- Knowledge Transfer



APL ON-SITE EQUIPMENT

PROCESS TOOLS


DEK Horizon 01iX Printer


DEK Galaxy Printer


Asymtek Axiom X-1020 Dispense System


Universal Pick and Place Machine


Advantis Pick and Place Machine

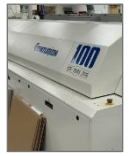

Vitronics Soltec XPM3 Convection Reflow Oven


DEK Europa


MPM Momentum BTB

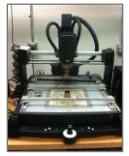

MPM Accela

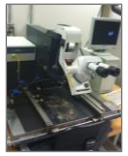

Electrovert As-50 Aquastorm


Vitronics Centurion Reflow Oven


Pyramax Reflow Oven


FuzionSC Pick and Place Machine


Okinternational APR-5000-XL Rework system


Air-Vac DRS25 Rework Station

INSPECTION TOOLS


FKN Systek


Philips Scanning Electron Microscope w/EDS


Wetting Balance Tester


Metcal Optical Inspection System


Machine Shop


Wet Lab


Coordinate Measurement Machine


Dage XD7600 X-Ray System


Kohyoung Zenith Inspection System


Kohyoung Aspire2 Inspection System


Akrometrics TherMoire PS200


Leica Optical Microscope


Keyance Digital Microscope

CHAMBERS


ESPEC Temperature and Humidity Cycling Chamber


Thermotron Temperature and Humidity Cycling Chamber


Envirotronics Temperature and Humidity Cycling Chamber


Thermotron F110 Thermal Cycling Chamber


Thermotron F82 Thermal Cycling Chamber


Thermotron HPS-16 Thermal Cycling Chamber


Tenney JR Temperature Cycling Chamber


ESPEC


Tenney TS5-5


Tenney TS5-5 with Chart Recorder


Ransco Thermal Shock Chamber


Lunaire Box Ovens

Cascade TEK Box Ovens

MECHANICAL TESTING EQUIPMENT & ANALYTICAL TOOLS

Instron Tensile Tester

Dage-4000Plus

Tukon Microhardness Tester

Lansmont Drop/Shock Table

DX-120 Ion Chromatography

Pyris 1 Differential Scanning Calorimetry (DSC)

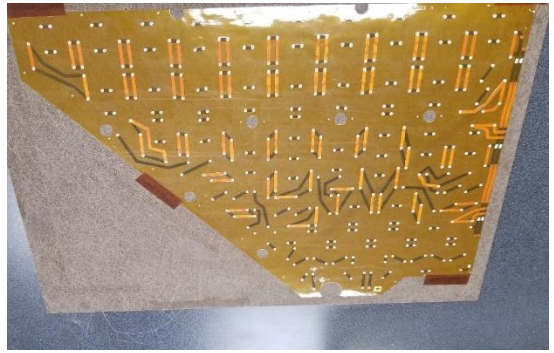
Spectrum 1 Fourier Transform-Infrared Spectrometry (FT-IR)

Pyris 1 Thermogravimetric Analyzer (TGA)

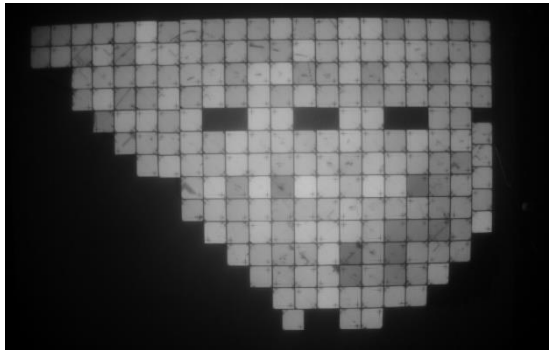
DMA 7e Dynamic Mechanical Analyzer

CASE STUDY – SOLAR ARRAY ASSEMBLY

- **Challenge**
  - Develop a cost effective solution using non standard materials on conventional equipment used in electronics assembly.
- **Solution**
  - APL designed and developed the assembly solution, including pallet, materials, equipment technology, and process.
- **Benefit**
  - Lower cost and higher efficiency than current Solar panels using traditional photovoltaic materials
- **Value**
  - Product is currently in production in APL
  - High-volume manufacturing solution
  - Technology:
    - Adhesive printing, silicone dispensing
    - Fine pitch placement accuracy +/- 25µm or better



Bare Flex

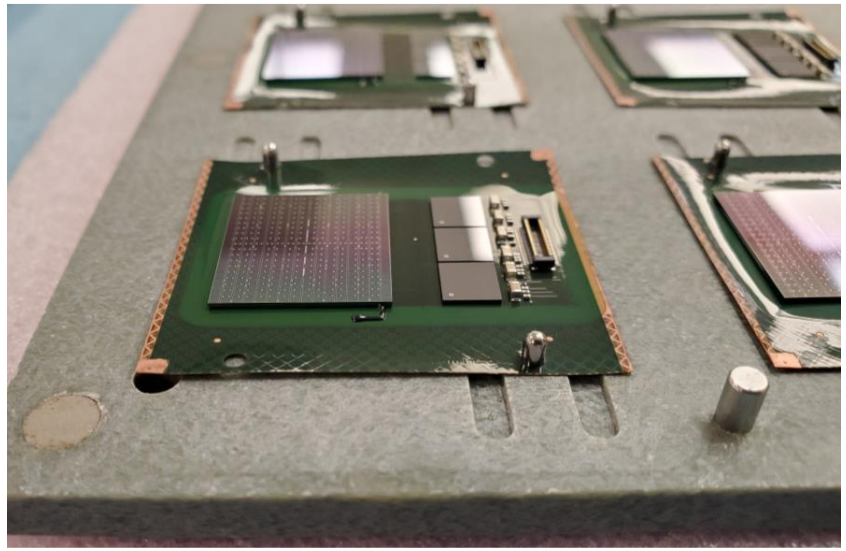


Electrical Test

Universal Instruments
A Delta Group Company

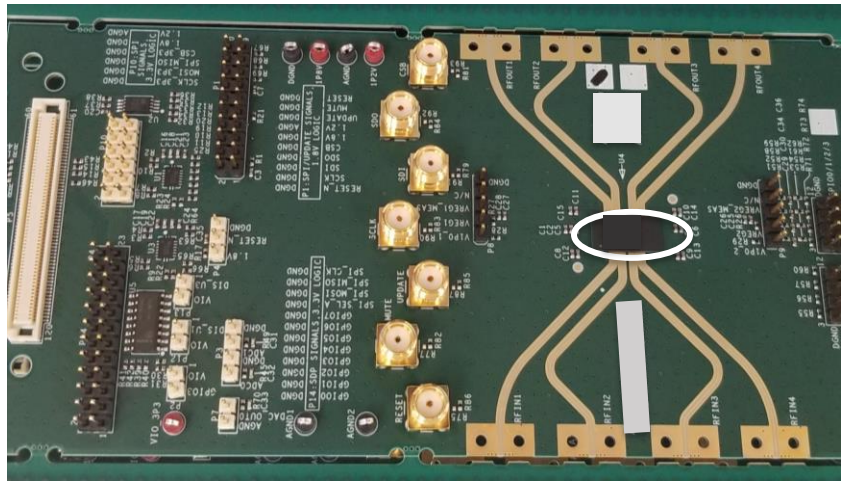
CASE STUDY – MRI DETECTOR FLEX ASSEMBLIES

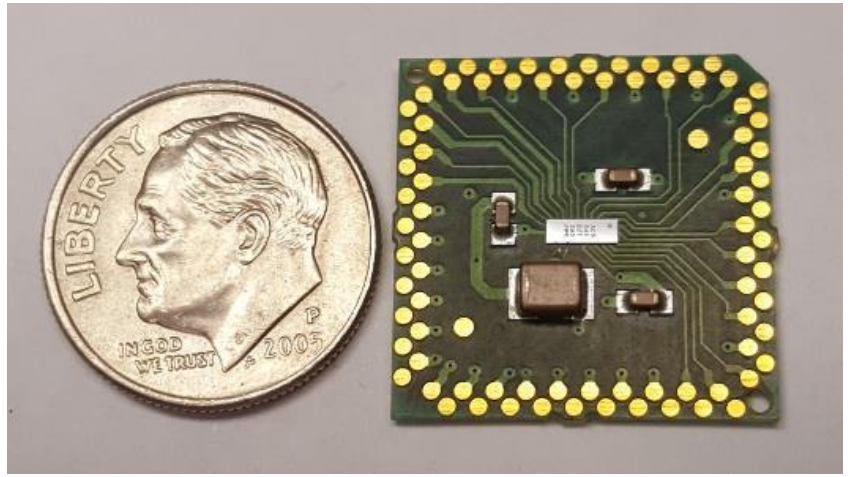
- **Challenge**
  - Customer needed a reliable, low-cost mfg process for an MRI Detector assembly requiring fine pitch placement accuracy +/-.025mm or better
  - Assembly included multiple fine-pitch flip chip ASIC devices, a silicon detector, a micro-connector and small passive devices on a flex substrate
- **Solution**
  - APL designed and developed the entire product, including pallet, materials, equipment technology, and process
  - Bare circuit inspection, screen printing with APL-designed stencil, print inspection & verification, adhesive dispense & inspection, high-speed passive placement, precision placement of multiple die, a silicon detector and micro-connector followed by inspection, reflow, wash and bake, underfill and cure followed by test and final inspection
- **Benefit**
  - Highly manufacturable product using a standard SMT process
- **Value**
  - Low-cost, state-of-the-art assembly currently in production in the APL; 4-6K per month



CASE STUDY – SEMICONDUCTOR QUALIFICATION TEST COUPONS

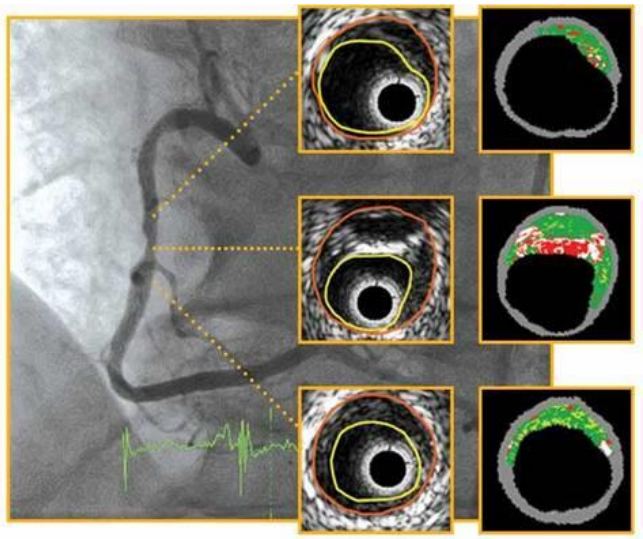
- **Challenge**
  - Productions runs vary from 1 piece to 8K pieces over multiple lots of die, WS or NC flux
  - Copper pillar, .35mm pitch
  - Placement accuracy +/-.025mm or better
  - 01005/0201/0603, .5mm SMT connector
  - Full turnkey kitting
- **Solution**
  - Fuzion Platform performing SM and through-hole placements
  - Hand soldering station and N2 reflow
- **Benefit**
  - Repeatable process with single or double-sided capability
- **Value**
  - Low-volume production on demand

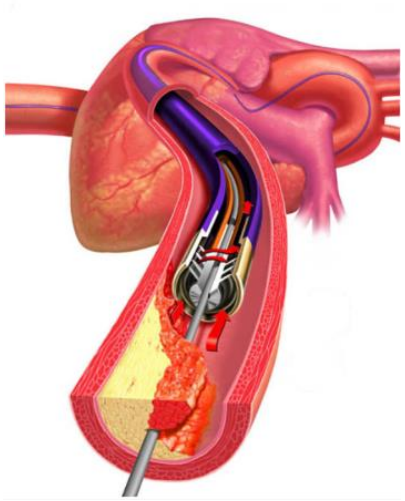




CASE STUDY – FLIP CHIP MEDICAL APPLICATION

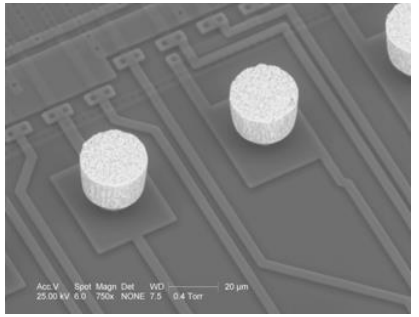
- **IVUS Catheter**
  - Provides an ultrasound image from inside a coronary artery
  - Used to diagnose and assess vascular and structural heart disease
- **The Assembly**
  - Flexible PI substrate, 12µm thick
  - PZT (receiver/transmitter)
  - Multiple flip chip die, underfilled
  - 22 µm tall bumps on 75 µm pitch
  - At the time, the application included the finest pitch, soldered interconnect flip chips in volume production anywhere in the world



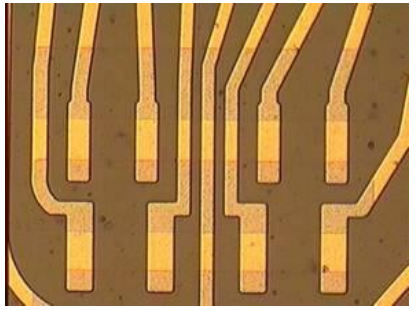


CASE STUDY – FLIP CHIP MEDICAL APPLICATION

- **Challenge**
  - Customer needed a highly reliable high-volume manufacturing process for the IVUS catheter, which incorporates ***the world's finest pitch soldered flip chip interconnect***
- **Solution**
  - Root cause failure analysis of existing product and development of a new robust assembly process
    - Defined packaging concept, re-designed substrate
    - Developed turnkey equipment line solution
    - Patented automation solution and associated fixturing
    - Assembled prototypes
    - Assisted in qualification process
    - Conducted analytical and reliability testing
  - In-house process training
- **Benefit**
  - Customer achieved high-volume manufacturing with 99+% yields within 12 months
- **Value**
  - Customer achieved #1 market share in the industry as the world's largest supplier
  - The company went public, raising $54M, and was sold for $1B



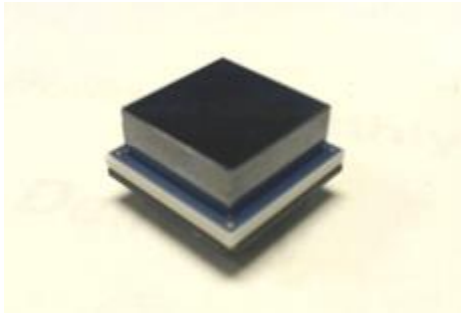
22µm tall 25µm dia. on 75µm pitch flip chip

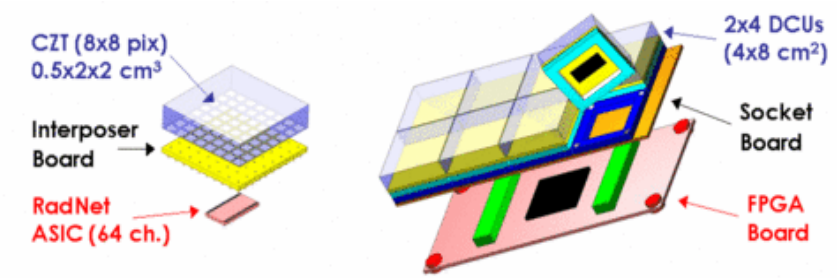


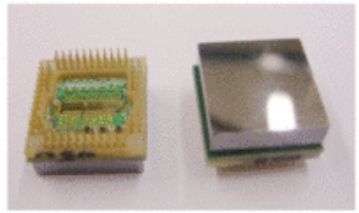
14 µm lines and spaces

CASE STUDY – CZT DETECTOR APPLICATION

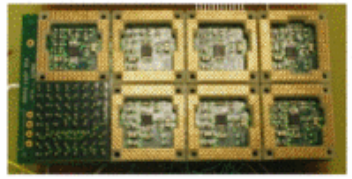
- **Challenge**
  - Customer needed to develop and implement a high-yield, high-reliability assembly process for attaching CZT crystals
- **Solution**
  - The APL developed the assembly process and the interposer substrate on which the crystal is mounted
- **Benefit**
  - A reliable interconnect and assembly solution which can withstand the rigors of a hand-held device environment
- **Value**
  - Customer won a highly competitive bid based on the cost and yield achieved with our solution







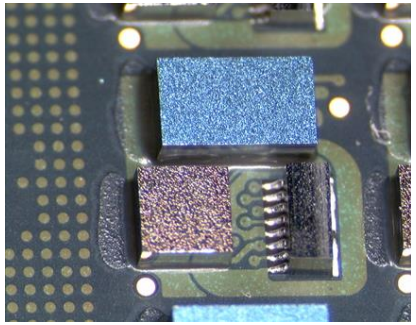
Detector Crystal Unit
(DCU: 4 cm²)

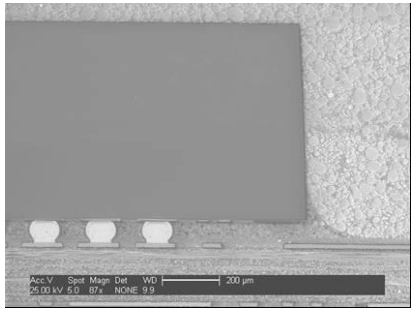


Detector Crystal Array
(DCA: 32 cm²)

CASE STUDY – SiP MAGNETIC COMPASS

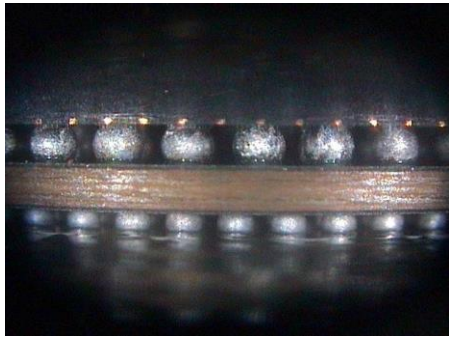
- **Challenge**
  - Customer needed a highly reliable manufacturing process for a magnetic compass, which incorporated a system-in-package application with challenging flip chip placement and rigorous specification requirements
- **Solution**
  - The APL developed a robust assembly process, re-designed the substrate, specified new materials, worked with vendor to tape flip chips vertically, and developed underfill and over-mold processes
  - Delivered tape and reeled assemblies to end customer
- **Benefit**
  - After a year of running at yields of 50 to 80% we supplied a process that ran at 99+% yields
  - Process was seamlessly transferred to sub-contractor in Malaysia
- **Value**
  - The 3-axis digital magnetic sensors are being used in a variety of smart phones and other hand-held devices

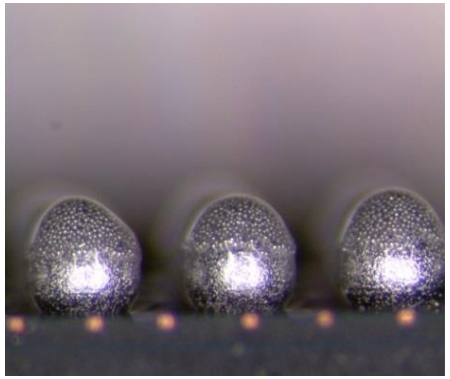




CASE STUDY – POP PROCESS DEV & TRANSFER

- **Challenge**
  - Customer needed to introduce a highly reliable manufacturing process for a Package-on-Package application to their production portfolio.
- **Solution**
  - The APL developed a robust assembly process, addressing challenges with thermally driven package dynamics
  - Hands-on, on-site training provided
- **Benefit**
  - A robust and repeatable process that is built upon an industry recognized procedure
  - Customer achieved 99.9+% yields
- **Value**
  - Customer was able implement a reliable process at approximately 5% of the cost of developing it themselves

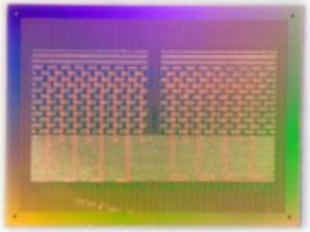




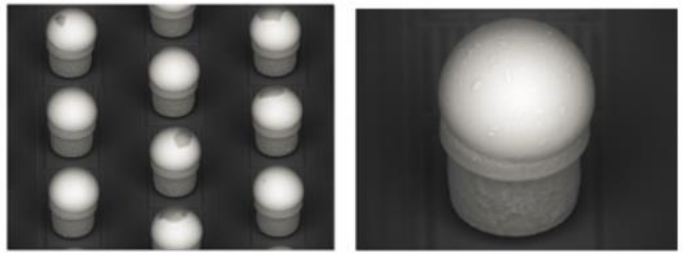
CASE STUDY – MULTI-DIE HBM MASS REFLOW

- **Challenge**
  - Accuracy: Bump diameter of 25µm
  - Four die per interposer substrate
  - 4942 bumps
  - Substrate fiducial FoV
- **Solution**
  - FuzionSC with T&R
  - LTFA
  - Precision lifter with custom tooling
- **Benefit**
  - Throughput and accuracy over large substrate
  - Vision algorithm for bump inspection
  - Post-bond inspection
- **Value**
  - Repeatable process for volume production

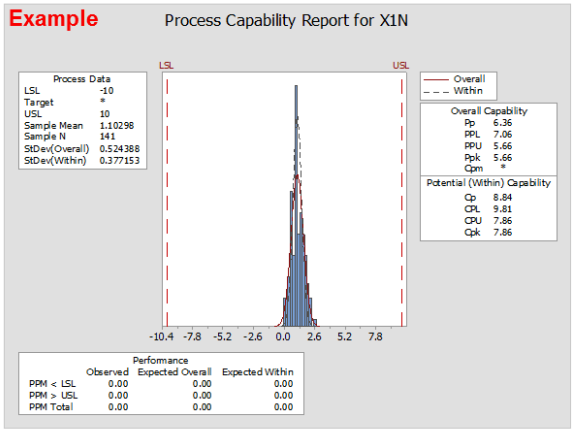
HBM Top Side



HBM Bottom Side



SEM Images of the HBM µBumps



Specification limits corresponding to Cpk values of 1.33 and 1.67 based on the above means and standard deviations:

CPK	X1N	Y1N	X2N	Y2N
1.33	±3.19 µm	±3.01 µm	±3.16 µm	±2.88 µm
1.67	±3.73 µm	±3.58 µm	±3.83 µm	±3.61 µm

HOW TO ENGAGE THE APL

Providing a strategic technical advantage

- Reach out directly as you have in the past
- Contact your Regional Sales or Service Representative
- Provide details of the project, an SOW would be best

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1980s
1990s

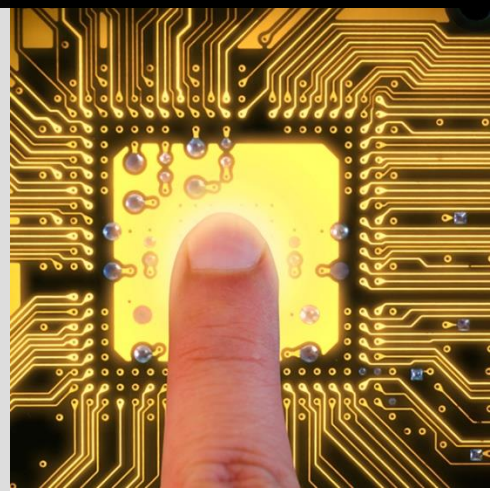
ADVANCED PROCESS LAB

As the electronics industry began to grow rapidly, we realized that our customers needed a resource to help them keep up with the changing technology landscape. From this idea, was born our Advanced Process Lab.

Their charter was to study the industry's challenges and provide our customers with the solutions and expertise needed to conquer them. More than 30 years later, our APL stands as one of the top analytical labs in the world, and includes a research consortium made up of the industry's technology leaders.

Surface Mount Technology Lab (now Advanced Process Lab) opens at Kirkwood South in 1987; George Westby is Analytical Chemist. Westby becomes driving force in growing the lab into a leading and fundamental knowledge resource in the industry.

AREA Consortium established in 1992; conducts materials and process research to identify and develop new and emerging technologies, with an emphasis on maximizing assembly yields and long-term reliability



Leadership Award

Universal Instruments
A Delta Group Company

advanced process lab

Presented to:

George R. Westby

For his vision and leadership in driving the A.R.E.A. Consortium forward for more than 34 years!

Thank you for advancing electronics assembly yield and reliability, and for helping our customers to build better.

April 1, 2026