Your Microelectronic Package Assembly Solution for MEMS Sensors
Overview

• Launched in 2011
• U.S. service provider for microelectronic packaging of MEMS sensors
• Turn-key microelectronic MEMS sensor solutions
  - Prototype development
  - Environmental life test
  - Manufacturing services
• Located in Elyria, OH
  - 15,000 sq. ft. facility
  - 5,000 sq. ft. ISO 5 (class 100) & ISO 6 (class 1000)
• Experienced MEMS engineering team
  - Transition product development to the market
  - Specifications, design-to-cost, and on-time delivery
• Support a variety of MEMS devices for multiple markets
Microelectronic Packaging

Markets

INDUSTRIAL CONTROLS
- Automation systems
- Industrial processes
- Internet of Things

MEDICAL
- Athletics
- Personal fitness
- Wellness
- Home health care

AEROSPACE
- High-performance
- Small size
- Low cost
Microelectronic Packaging

Services

PROTOTYPE DEVELOPMENT
• Proof of concept and feasibility
• Process development
• Engineering expertise

ENVIRONMENTAL LIFE TEST
• Identify reliability issues
• Avoid issues in field of use
• Turnkey testing and overflow support

MANUFACTURING SERVICES
• Scale up
• Low-volume production
• Quality assurance

smartmicrosystems.com
The SMART Advantage

Lowest Overall Development Time and Cost

The Market

Time

SMART PROTOTYPING
SMART LIFE TEST
SMART MANUFACTURING
QUALIFICATION
YOUR PRODUCT

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**Microelectronic Packaging**

**Applications**

**Overview**

- Microelectronic Packaging is critical to bridging the gap between component and environment for the intended application of a device.
- Uses mature technology processes for die attach, wire bonding and hermetic lid seal.
- Core to leveraging the functions and performance of MEMS structures in a system.
- Heterogeneous packaging integrates dissimilar chips (e.g. ASIC, photonic, MEMS sensors, etc) into single package.

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MEMS Pressure Sensor

MEMS Chemical Sensor

Optical Sensor
Applications

MEMS Pressure Sensors

- Measures pressure of gases or liquids
- Acts as a transducer which generates a signal proportional to pressure
- Technologies - Piezoresistive or Capacitive
- Applications
  - Biomedical (e.g. catheters for blood pressure measurement)
    - Sensitivity of Capacitive MEMS are most suitable for biomedical
  - Automotive, Aerospace & Military - Monitoring & Control of fluid/gas flow, speed, water level, & altitude
Applications

MEMS Chemical Sensors

- Detect the presence, concentration, or quantity of a given analyte
- Complex devices depending on the nature of the substance to be analyzed
- Generally optimized for a particular application
- May be combination of microfluidics and a sensor functionalized to detect a specific substance

Applications

- Food processing - fluid sample analysis for bacteria
- Medical devices - analyze blood & other biological fluids
- ‘Lab-on-a-chip’
Applications

Photonics
• Optical sensing, fiber optic, imaging and illumination
• Precision component placement critical to the reliable performance of photonic devices
• Benefits of these devices - immunity to RFI/EMI
• Applications
  • Telecommunications
  • Hi-resolution cameras
  • Infrared detectors
  • Medical imaging for lesions & wounds
Capabilities

Microsystem Integration Solutions

Test and Inspection
- Microscopy – optical, acoustic, SEM, X-ray
- Interferometry
- Bond Testing
- Characterization – pressure, motion, and chemical

Microelectronic Packaging
- Wafer dicing
- Wafer inspection/sorting
- Die attach
- Wire bonding
- Encapsulation

Environmental Life Testing
- HAST
- Thermal shock
- Thermal/humidity cycling
- Accelerated UV irradiation
- High temperature storage
**Microelectronic Packaging**

**Test and Inspection**

**Acoustic Microscopy**

- Available transducers: 15MHz, 30MHz, 50MHz, 75MHz, 100MHz, 230MHz
- Imaging techniques available: Surface, Interface, Bulk, Loss of back echo, tray scanning, Q-BAM, Thru-scan, STAR Mode, and virtual rescanning
- 12” x 12” scan area
- Up to 16K x 16K (268 Megapixels) Very High-Res (VHR™) Enhanced Scanning and Data Acquisition Format with Zoom Enlargement (4K x 4K standard)
- Acoustic Impedance Polarity Detector simultaneously displays both phase (i.e., polarity) and amplitude information

Sonoscan Acoustic Microscope
Test and Inspection

Scanning Electron Microscopy (SEM)

- Resolution: 4nm @ 1kV, 1.5nm @ 15kV
- Imaging field: 3.5mm
- Sample size: 50mm diameter max
- Electron gun: cold-cathode field emission
- Robinson Backscattered Electron (BSE) detector
- X-ray EDS
Test and Inspection

3D X-Ray

- µCT technique to create 2D X-ray slices in any plane of a printed circuit board assembly without the need to cut the board
- 160 kV Tube with up to 10 W Tube Power
- Nordson DAGE 2 Mpixel @ 25fps XiDAT3 Digital Image Intensifier with Real Time Image Enhancements
- Geometric Magnification 2,000x, System 12,000x and Total 60,000x with Digital Zoom
- Maximum Board Size: 29” x 22.8” (736 x 580 mm)
- 70° Oblique Views without Loss of Magnification

Nordson X-Ray
Test and Inspection

Interferometry

- Characterizes and quantifies topographical features
  - Surface Roughness
  - Step Height
  - Critical Dimensions
- Non-Destructive Tests
- Profile heights ranging from < 1 nm up to 20000 µm
- Vertical Scan Range 150 µm
- Max Scan Area 20 µm
- Maximum Sample Size 89 x 203 x 203 mm
- RMS Repeatability < 0.01 nm (0.0004 µin) RMSσ
- Step Height Accuracy ≤ 0.75% Repeatability ≤0.1% @ 1σ
- 5x Objective, 20x Objective, 10x Glass Compensated Objective
**Test and Inspection**

**Bond Tester**
- Perform destructive and non-destructive force testing to bonds
- Export data and reports into Word, Excel, and .csv
- Customizable data tables and graphs
- Fitted with top down camera for inspection pictures after bond test is performed
- Currently available test cartridges:
  - T1KG – Tweezer and stud pull up to 1 kilogram
  - S250G – Shear up to 250 grams
  - S50KG – Shear up to 50 kilograms
  - P100G – Hook pull up to 100 grams
  - PP50KG – Push/Pull up to 50 kilograms
- Accuracy +/-0.1% of the full scale for the selected range
- Step Height Accuracy ≤ 0.75% Repeatability ≤0.1% @ 1σ

Nordson Dage Bond Tester
Microelectronic Packaging

Dicing

Wafer Dicing

• Max wafer size: 6” diameter (round or square) and up to 10mm thick
• Utilizes tape rings or grip rings to hold materials
• Performs cutting, dicing and scribing operations
• Spindle speeds: 3,000 to 60,000 rev/min
• Resolution of the axes:
  - X Axis – 0.1 mm
  - Y Axis – 100 nanometres
  - Z Axis – 100 nanometres
  - Theta axis: 6 million lines; 0.0004 ° resolution
• Dicing speed: 0.1-500mm/sec
• Videoscope alignment uses either pattern recognition or vision system two point alignment
• Blade capacities: 50mm to 76.2mm

LoadPoint Wafer Dicing and Wash Station

• Range of materials includes Alumina, BGA and CBGA moldings, Ceramic, Glass, Lead, Zirconate Titanate, Fibre Board and Silicon
Microelectronic Packaging

**Dicing**

**Wafer Inspection**
- Stage accommodates up to 200 mm wafers
- Typical image size 2752 x 2200 pixels with 4.54 µm resolution per pixel with repeatability ± 2 µm
- Brightfield/Darkfield Optics at 2.5x and 5x with high spatial resolution camera imaging 19 fps
- Automatic reporting generated includes defect density maps and defect count histograms
- Software includes Die Yield Analyzer for patterned wafer recognition
- Programmable automatic quantification and qualification of features of interest
- Programmable automatic and manual image capture parameters of focus, lighting, magnification, and movement

**Die Sort**
- Die size: ≥0.17mm square and up
- Die thickness: ≥0.020mm
- Max wafer size: 300mm
Die Attach/Flip Chip

Die Attach

- Epoxy die attach, flip chip, sintering, eutectic attach, multi-chip module
- X/Y placement accuracy: ±7μm @ 3 sigma
- Theta placement accuracy: ±0.15° @ 3 sigma
- Die thickness down to 20μm
- Speed: up to 7,000 units per hour
- Integrated dispense
- Material presentations: grip ring and film frame (for wafers up to 300mm), waffle pack, Gel-Pak
- Substrates: FR4, ceramic, BGA, flex, boat, lead-frame, waffle pack, Gel-Pak, JEDEC tray
Die Attach/Flip Chip

Solder Reflow

- Accommodates 18” wide boards and substrates and maximum clearance of 2.2”
- Tunnel length of 105” includes 9 heating zones each with independently controlled top and bottom heaters
- Maximum temperature 450 °C with PID temperature control ± 1°C per zone and ± 3° cross-belt temperature tolerance
- Internal controlled cooling zone 30” length includes 3 cooling zones with top and bottom cooling
- Balanced flow of air or nitrogen capable of producing controlled atmospheres less than 25 ppm O₂
- CPK & SPC data and alarm logging with timed download and profile printout capability
Microelectronic Packaging

Die Attach/Flip Chip

Vacuum Solder Reflow

- Flux-less and void-free soldering
- Hermetic package sealing
- Controlled cooling in N2 gas
- Automatic control of vacuum and gas backfill pressure
- Vacuum minimum 50mTorr
- Chamber gas pressure maximum 40psig
- Operating temperature range of 100 to 500°C
- Uniform heat distribution supplied by single sheet graphite heating element
- Automatic control of heating and cooling ramp rates
- Formic acid capable
- 12.0x12.0 inch thermal working area

SST 5100 Vacuum Solder Reflow
Wire Bonding

Fine Gauge Wire/Ribbon Bonding

- Wire diameters: 17.5µm to 50µm (0.7 to 2.0 mil)
- Ribbon: 6x35µm to 25x250µm (0.25x1.4 mil to 1x10 mil)
- Wire and ribbon materials: aluminum, gold
- Fine pitch is available
- Bond area: 305mm x 410mm (12.3” x 16.14”)
- Accuracy: 1µm at 3 sigma
- Speed: up to 6 wires/second
- Loop Length: 70 µm up to 20 mm, depending on wire diameter
- Various loop form functions:
  - Constant wire length
  - Constant loop height
  - Individual loop shapes

Hesse Mechatronics
Fine Gauge Wedge Bonder
Microelectronic Packaging

Wire Bonding

Heavy Gauge Wire/Ribbon Bonding
- Wire diameters: 100µm to 500µm (4 to 20 mil)
- Ribbon: 0.075x0.75mm to 0.4mm x 2mm (3x30 mil to 16x80 mil)
- Wire and ribbon materials: aluminum, copper
- Bond area: 300mm x 500mm (13.8” x 19.7”)
- Accuracy: 2µm at 3 sigma
- Speed: up to 3 wires/sec
Microelectronic Packaging

Wire Bonding

Gold Ball Bonding

- Wire diameters: 15 to 50µm (0.6 to 2.0 mil)
- Wire materials: gold
- Fine pitch capability: 40µm
- Minimum loop height: 100µm (standard and worked loops)
- Bond area: 56mm x 80mm
- Accuracy: +/- 2.0µm
- Speed: up to 15 bonds/second including programmable looping
- Looping capability: standard and worked (BGA1-BGA3, Spider, J Wire, CSB)
- Stand-off Stitch bond (SSB) capable
- Stud bumping
- Wire material: gold
- Speed: Up to 30 bumps/second including programmable smoothing

K&S IConn Gold Ball Bonder
Microelectronic Packaging

Encapsulation

Adhesive Dispense

- Dam and fill
- Glob top
- Potting
- Epoxies, heat cures, UV cures, thixotropic adhesives
- Time/pressure dispense, auger dispense, and jetted dispense
- Weight controlled dispensing
- X-Y repeatability: ±25µm
- Z-axis repeatability: ±25µm
- X-Y Travel: 525 x 525 mm (20.7 x 20.7 in.)
- Z Travel: 75 mm (2.95 in.) maximum

Nordson Asymtek Dispense System
Microelectronic Packaging

Encapsulation

Lid Seal
- Solder, epoxy, tape
- Hermetic and non-hermetic
- TO headers, DIP packages, open cavity plastic packages, ceramic packages

Parylene Coating
- Chamber Size 12 inch dia. x 12 inch high (8.5″/31.5cm dia. x 11.19″/28.4cm H, useable size)
- Dimer Capacity 125 grams
- Cold Trap using Mechanical Chiller
- Deposits Parylene type C at 0.0002″ per hour
- Deposits Parylene type N at 0.00003″ per hour
Environmental Life Test

HAST

- Unsaturated or saturated humidity control
- Multi-mode system (wet bulb/dry bulb) controls humidity at steady state and during ramps
- Programmable controller with temperature, humidity, and count-down display
- 12 Specimen power terminals, allows power-up of specimens
- Two feed-through ports
- Meets specification EIA/JEDEC Test Method A110 & 102C

Espec HAST Chamber
Environmental Life Test

Thermal Shock
- High temperature exposure: 60°C to 200°C
- Low temperature exposure: -65°C to 0°C
- Temperature stability: ±0.5°C
- Feed-through port
- Meets specifications Mil-Std 883 1010.7/1010.8, IEC 61300-2-47, JEDEC JESD47E, JESD22-A104

Thermal/Humidity Cycling & Steady-State
- Temperature range: -35°C to 180°C
- Temperature stability: ±0.3 °C (up to 100°C)
- Heating rate: 5.2 °C/min
- Cooling rate: 3.5 °C/min
- Humidity range: 10% to 98% RH
- Humidity stability: ±2.5 % RH
- Feed-through port
- Meets specifications JESD22-A100C, JESD22-A101C, IPC/JEDEC J-STD-020D.1
Microelectronic Packaging

Environmental Life Test

Accelerated UV Durability

- 30x irradiation over conventional weatherometers
- Acceleration factors up to 110x (material dependent)
- Irradiation: 1500W/m²
- Light wavelength: 295-450nm
- Light uniformity: 90%
- Temperature control: 50°C to 85°C during irradiation; 35°C to 75°C during dark; 30°C during dew
- Humidity control: 40% to 70% RH during irradiation; 50% to 90% RH during dark; 97% to 100% RH during dew
- Black panel temperature stability: ±3°C
- Test modes: continuous irradiation or combinations of irradiation, dew, and dark

EYE Lighting SUV-W161 Super UV Tester
Environmental Life Test

Vibration Table

Vibration table test limits:

- Sine Force - 40 lbf Peak
- Random Force - 28 lbf rms
- Shock Force - 150 lbf peak
- Acceleration
  - 75g Driven
  - 150g Resonant
  - 300g Shock Pulse
- Frequency - up to 6.5 kHZ
Customers by Geography

**International**
- Canada

**National**
- Alabama
- California
- Connecticut
- Delaware
- Georgia
- Maryland
- Michigan
- Massachusetts
- New Jersey
- Pennsylvania
- Texas
- Washington
- Wisconsin

**Ohio**
- Brecksville
- Cleveland
- Columbus
- Elmore
- Elyria
- Geneva
- Highland Heights
- Lewis Center
- Mansfield
- Mayfield Heights
- Medina
- Milan
- North Ridgeville
- Oberlin
- Peninsula
- Solon
- Strongsville
- Toledo
- Twinsburg
Major Accomplishments

- Provided over 50 customers with very first MEMS sensor prototypes
- One project went from design to working prototypes in 90 days
- Successfully brought several new development programs to production readiness

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THANK YOU

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