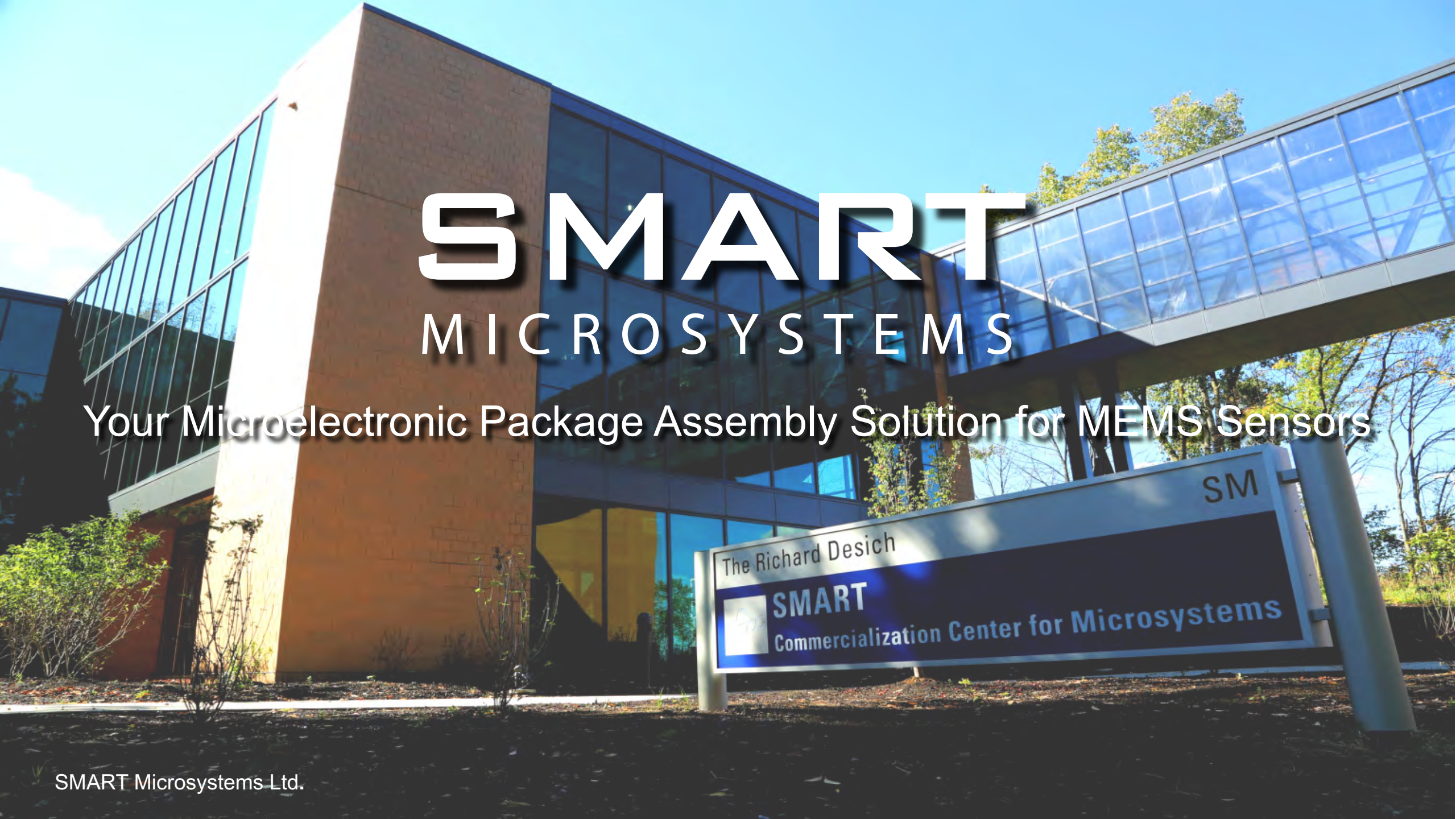
SMART
MICROSYSTEMS

Your Microelectronic Package Assembly Solution for MEMS Sensors



SMART Microsystems Ltd.

Why MEMS is Important

Growing Industry Segments

About SMART Microsystems

What We Do

How We Do It

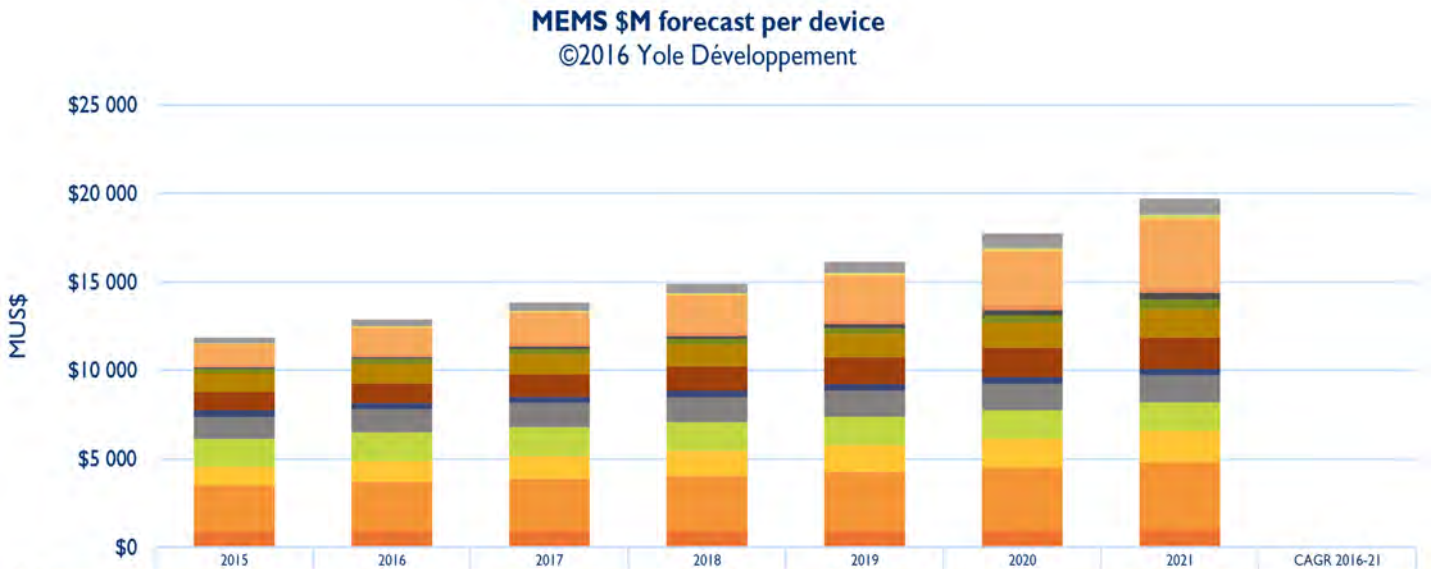
Working with SMART

Why MEMS is Important

MEMS Sensors Market Growth

CAGR 13.8% Over 2016-2021

- Large growth driven by Consumer and Automotive applications
- High growth seen in Environmental, RF, and Optical MEMS
- MEMS pressure sensors dominant in Aerospace, Automotive, Consumer, and Medical



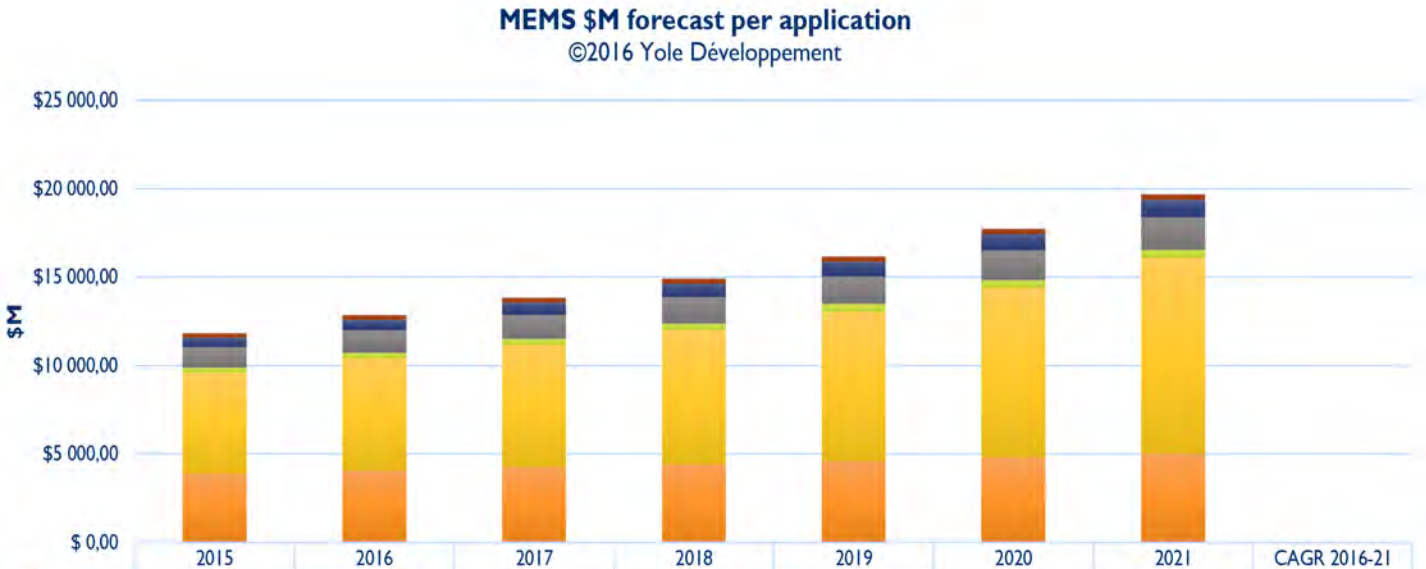
	2015	2016	2017	2018	2019	2020	2021	CAGR 2016-21
Others	$ 336,16	$ 381,84	$ 454,75	$ 550,92	$ 644,09	$ 793,87	$ 924,95	19,4%
Environmental MEMS	$ 27,63	$ 29,78	$ 33,65	$ 45,38	$ 66,35	$ 113,09	$ 155,50	39,2%
Oscillators	$ 44,80	$ 53,76	$ 64,51	$ 74,32	$ 85,61	$ 98,63	$ 113,62	16,1%
RF MEMS	$1 125,06	$1 501,64	$1 756,03	$2 084,45	$2 521,73	$3 063,10	$3 809,83	20,5%
Microfluidics	$ 142,22	$ 160,90	$ 182,92	$ 209,95	$ 238,70	$ 267,40	$ 297,57	13,1%
PIR & thermopiles	$ 97,82	$ 113,10	$ 137,34	$ 167,86	$ 234,99	$ 283,61	$ 400,33	28,8%
Microbolometers	$ 255,00	$ 292,99	$ 317,97	$ 331,08	$ 325,84	$ 408,25	$ 530,36	12,6%
Optical MEMS	$1 057,58	$1 074,61	$1 135,99	$1 208,68	$1 293,15	$1 408,61	$1 603,69	8,3%
Inertial combos	$1 044,52	$1 126,67	$1 251,76	$1 393,93	$1 541,88	$1 682,21	$1 784,14	9,6%
Digital compass	$ 339,13	$ 345,97	$ 352,51	$ 363,14	$ 368,17	$ 378,29	$ 382,18	2,0%
Gyroscopes	$1 241,39	$1 286,19	$1 333,48	$1 397,37	$1 445,69	$1 516,76	$1 522,11	3,4%
Accelerometers	$1 578,11	$1 613,65	$1 629,98	$1 619,39	$1 599,75	$1 574,30	$1 567,56	-0,6%
Microphones	$1 064,56	$1 190,31	$1 298,09	$1 403,80	$1 518,52	$1 637,23	$1 817,27	8,8%
Pressure sensors	$2 605,64	$2 774,76	$2 958,48	$3 129,88	$3 328,50	$3 543,71	$3 789,83	6,4%
InkJet heads	$ 892,41	$ 926,96	$ 923,66	$ 932,51	$ 946,95	$ 963,77	$ 998,50	1,5%

Market Drivers

Opportunities for New Applications

- Big influences from IoT, Wearables, and Automotive
- Existing infrastructure - Connectivity, Software, Power, Data Management
- Evolution of the economy - SMART Connected Products*

** "How Smart, Connected Products Are Transforming Companies"*, Michael Porter, Harvard Business Review, December 2015

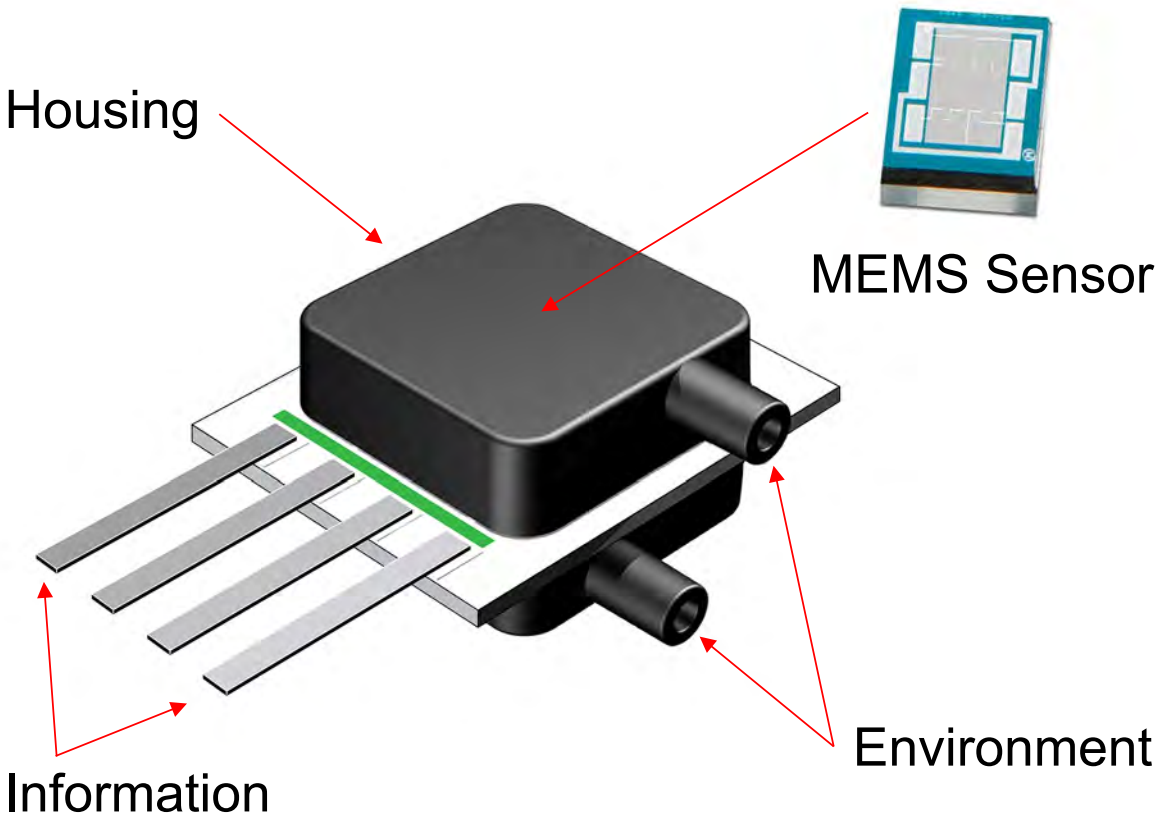


	2015	2016	2017	2018	2019	2020	2021	CAGR 2016-21
Telecom	$ 265,89	$ 262,79	$ 272,37	$ 284,45	$ 282,08	$ 288,61	$ 313,01	3,6%
Medical	$ 534,74	$ 602,84	$ 683,58	$ 774,43	$ 855,46	$ 935,50	$1 019,18	11,1%
Industrial	$1 163,78	$1 277,66	$1 361,44	$1 457,59	$1 550,67	$1 685,37	$1 820,35	7,3%
Defense	$ 281,36	$ 303,99	$ 329,17	$ 359,48	$ 384,78	$ 418,10	$ 443,15	7,8%
Consumer	$5 741,70	$6 369,00	$6 941,75	$7 641,13	$8 508,49	$9 615,78	$11 109,60	11,8%
Automotive	$3 733,66	$3 914,71	$4 091,55	$4 241,98	$4 415,40	$4 617,62	$4 811,88	4,2%
Aeronautics	$ 130,89	$ 142,16	$ 151,24	$ 153,60	$ 163,03	$ 171,86	$ 180,28	4,9%

MEMS Sensors Packaging Challenge

Stimulus Delivery

- Environment isolation/exposure, mechanical stress, thermal effects
- Components, mechanical interfaces, and electrical interconnects
- Material selection based on application



Growing Industry Segments

Aerospace

- Miniaturization driving applications for MEMS sensors
- Reduction of size, weight, and power consumption
- Requirement for high reliability

Industrial

- More data from MEMS sensors drives performance and efficiency
- Proactive maintenance of industrial systems reduces downtime
- Requirement for high reliability with power and communication infrastructure

Medical

- Opportunities for MEMS sensors in clinical and consumer markets
- Low cost, light (no) weight, and fast response time
- Non-invasive, real time measurements for improved outcomes

About SMART Microsystems

SMART Facilities and Location

MEMS Sensors Microelectronic Assembly

- Launched in 2011
- Located in Elyria, Ohio USA
- Facilities - 15,000 sq ft with 5,000 sq ft ISO 5 and ISO 6 cleanrooms
- Engineering and Manufacturing Services

The SMART Team

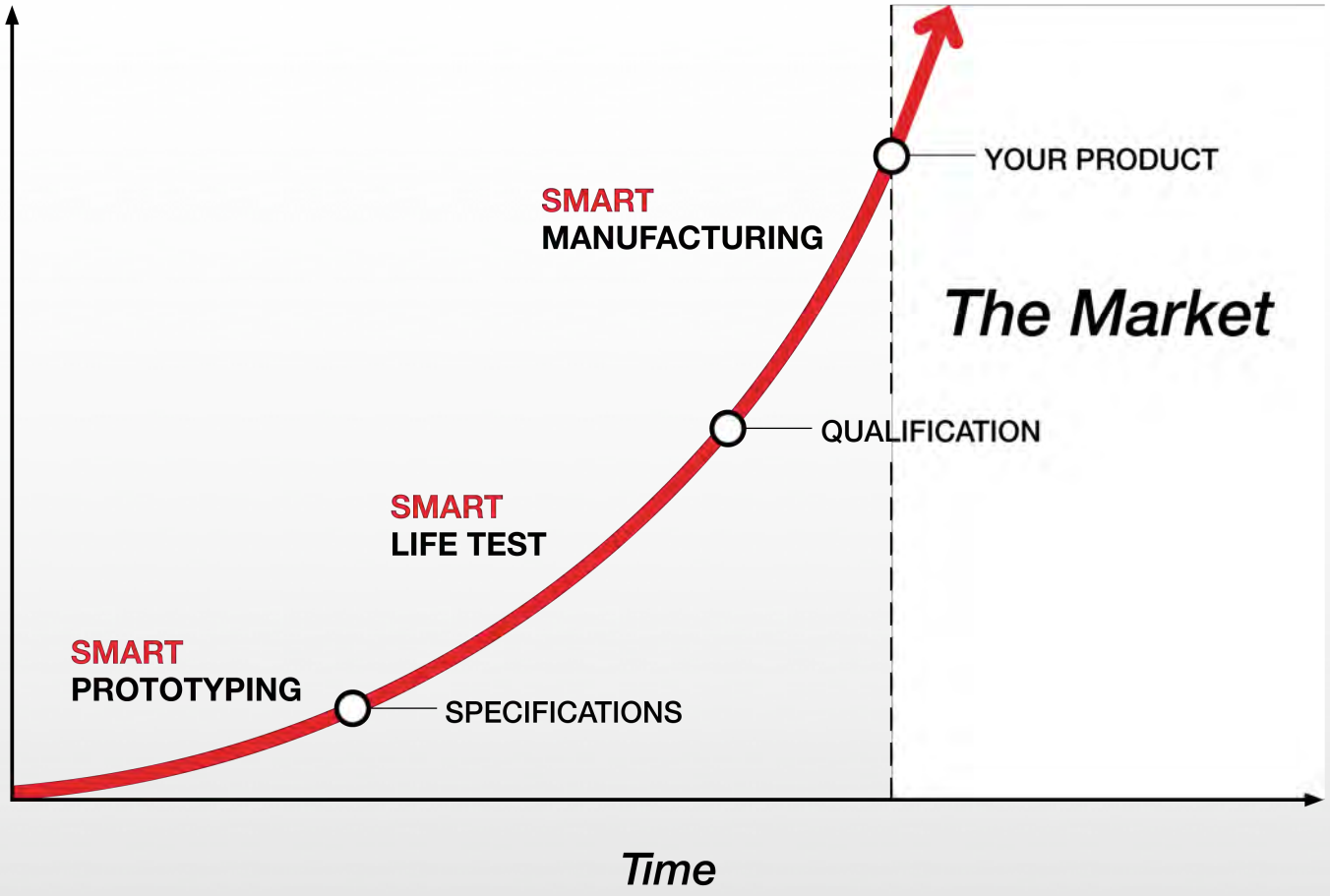
Committed to Immediate and Long Term Value to Customers

- Technical merit, high quality, and customer satisfaction
- Significant experience in product development
- Management team with proven track record

The SMART Advantage

Lowest Overall Development Time and Cost

- **Proven** New Product Development Strategies
  - *Test Early, Test Often*
  - *Concurrent Engineering*
- **Focus** on niche applications
- **Flexibility** for non-standard/custom designs



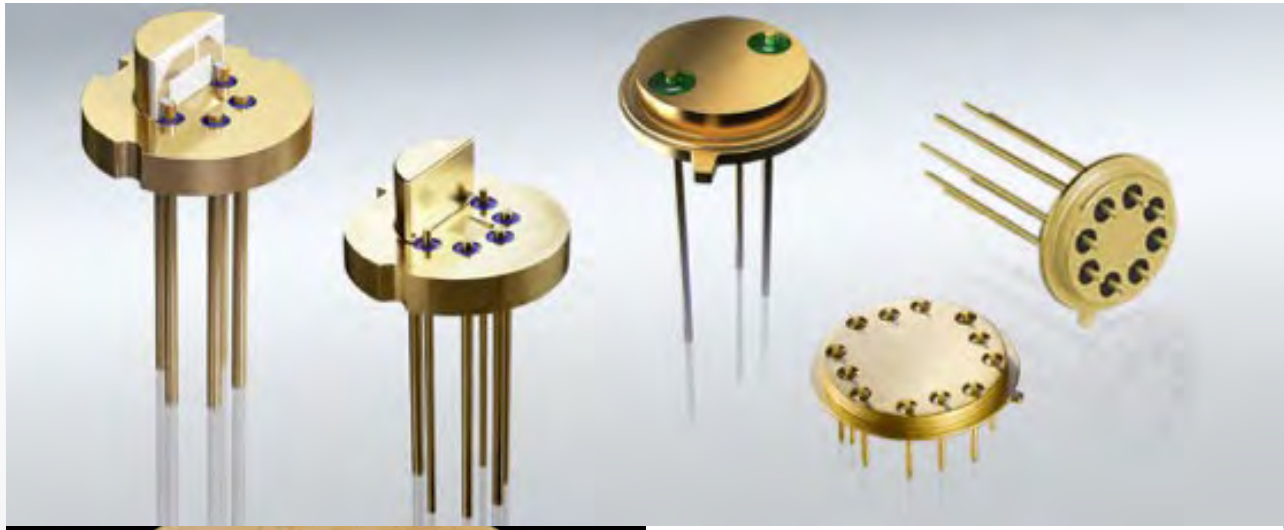
What We Do

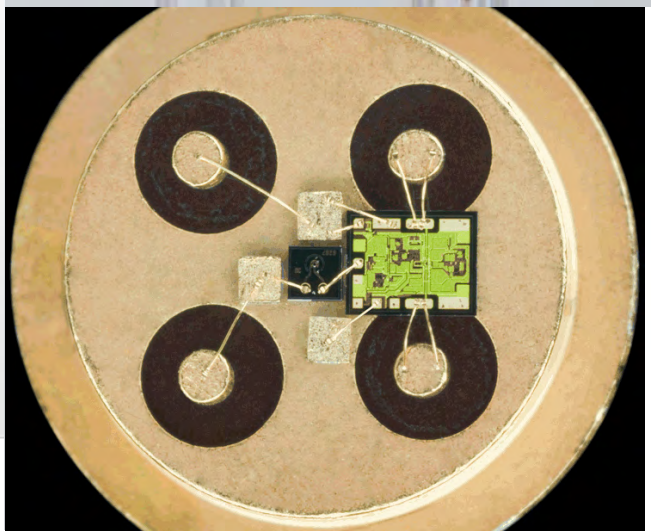
TO Header Assembly

Applications – optical sensing, imaging/illumination, pressure sensing, environmental sensing, industrial chemical sensing

Process Capabilities

- **Die Attach** – epoxy, solder, sinter, thermocompression
- **Wire Bond** – gold ball and wedge
- **Lid Attach** – epoxy, solder



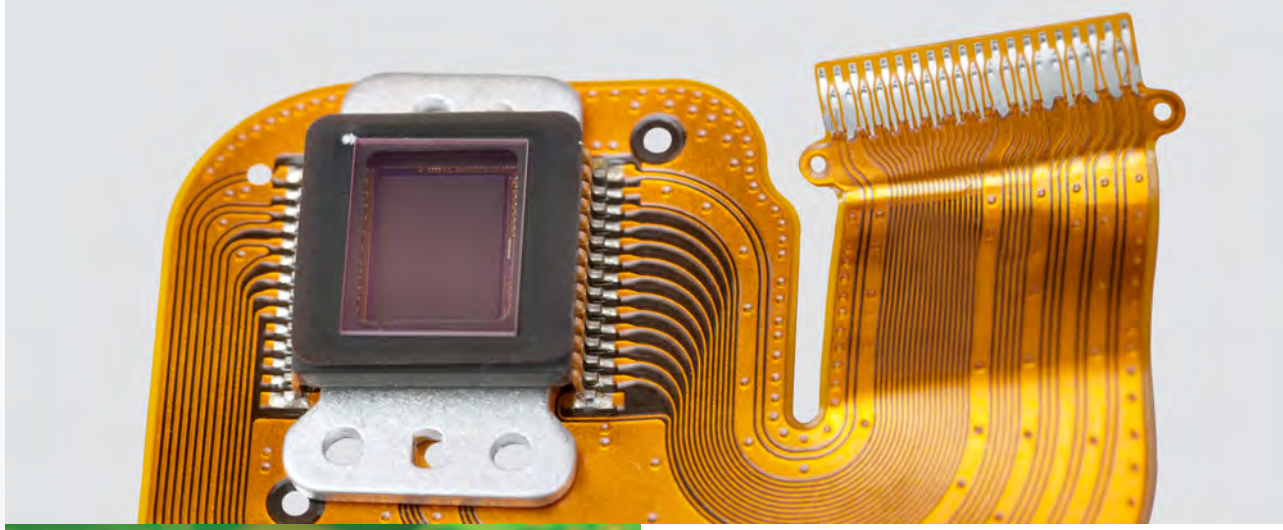


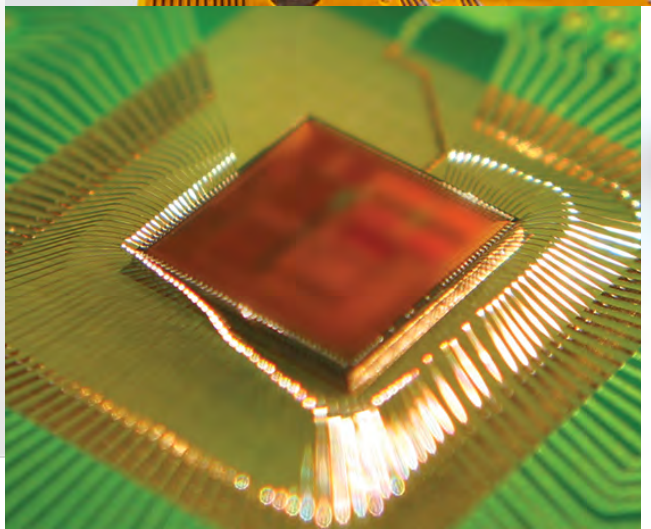
Chip on Board / Chip on Flex

Applications – flow actuators, optical devices, pressure sensors, lab on a chip

Process Capabilities

- **Die Attach** – epoxy, tape
- **Wire Bond** – gold ball/wedge, aluminum wedge
- **Encapsulation** – dispense, parylene, lid attach



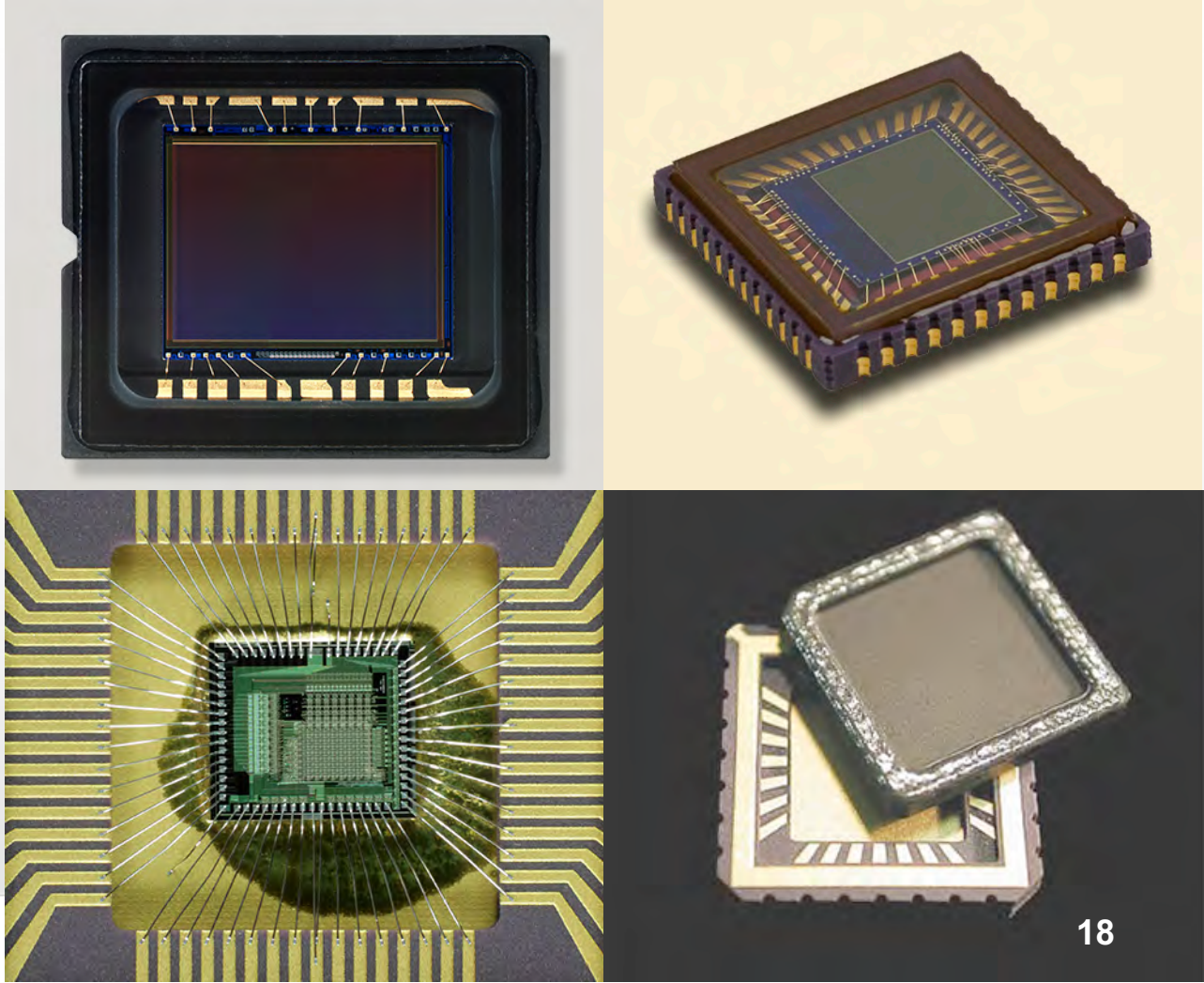


Open Cavity QFN and Ceramic Package

Applications – image sensors, chemical sensors, resonators, inertial sensors, lab on a chip

Process Capabilities

- **Die Attach** – epoxy, solder, sinter, thermocompression
- **Wire Bond** – gold ball/wedge, aluminum wedge
- **Lid Attach** – epoxy, solder



Custom Package Assembly

Applications – optical sensors, pressure sensors, chemical sensors

Process Capabilities

- **Die Attach** – epoxy, solder, sinter
- **Wire Bond** – gold ball/wedge, aluminum wedge
- **Encapsulation** – dispense, parylene, lid attach

How We Do It

Die Attach

Auto Die Attach – *Datacon Evo 2200 Plus*

- Epoxy die attach, flip chip, sintering, eutectic attach, multi-chip module
- X/Y placement accuracy: ±7µm

Vacuum Solder Reflow – *SST 5100*

- Hermetic package sealing
- Vacuum minimum 50mTorr
- Operating temperature range of 100 to 500°C

Manual Die Attach – *Tresky T-3002FC3*

- Epoxy die attach, thermocompression, flip chip

Wire Bonding

Gold Ball Bonding – *K&S iConn*

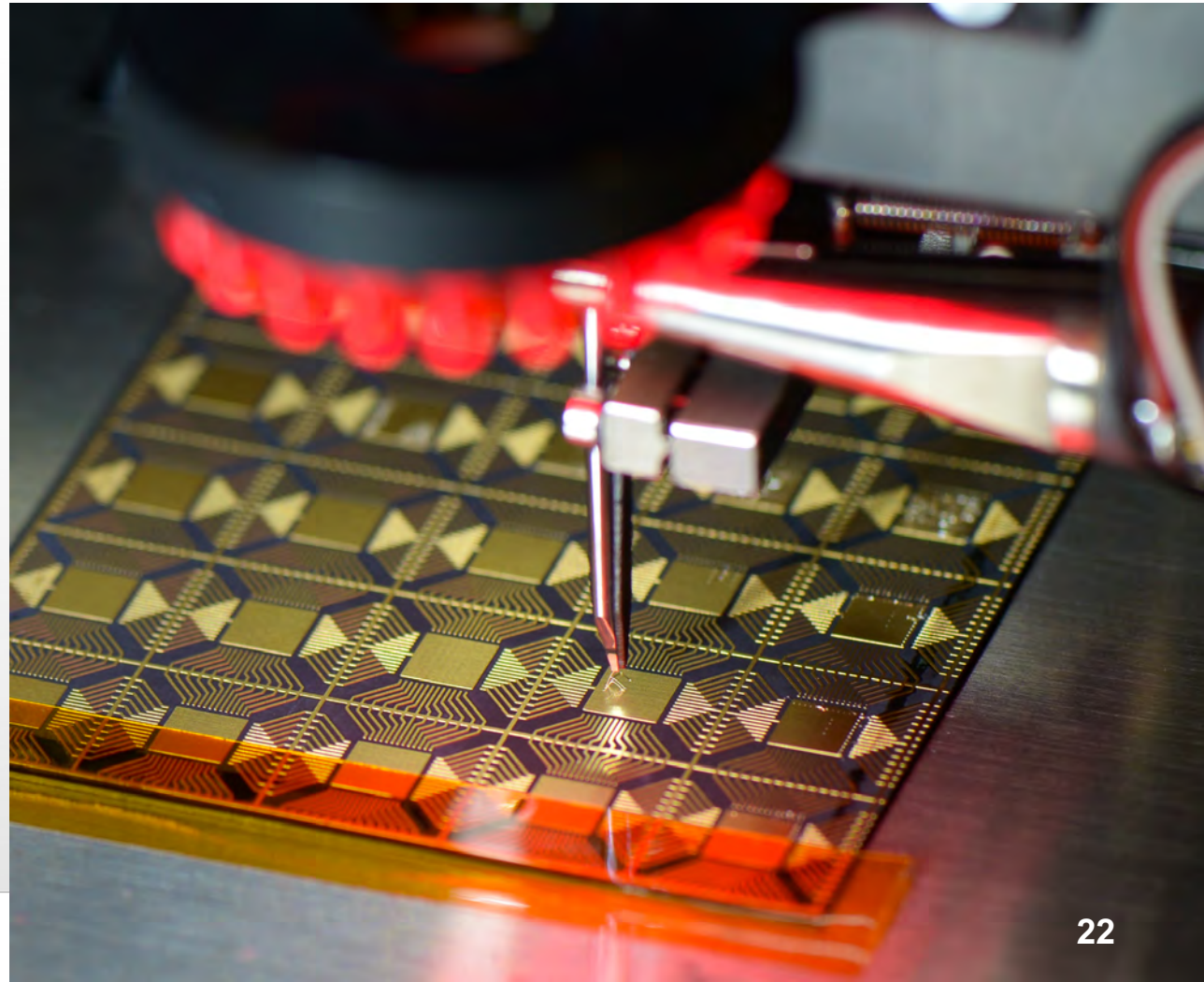
- Ball Bonding and Stud Bumping
- Wire diameters: 0.6 to 2.0 mil

Fine Gauge Wedge Bonding – *Hesse BJ820*

- Wire diameters: 0.7 to 2.0 mil
- Ribbon: 0.25x1.4 mil to 1x10 mil
- Wire and ribbon materials: aluminum, gold

Heavy Gauge Wedge Bonding – *Hesse BK939*

- Wire diameters: 4 to 20 mil
- Ribbon: 3x30 mil to 16x80 mil
- Wire and ribbon materials: aluminum



Encapsulation

Dispense

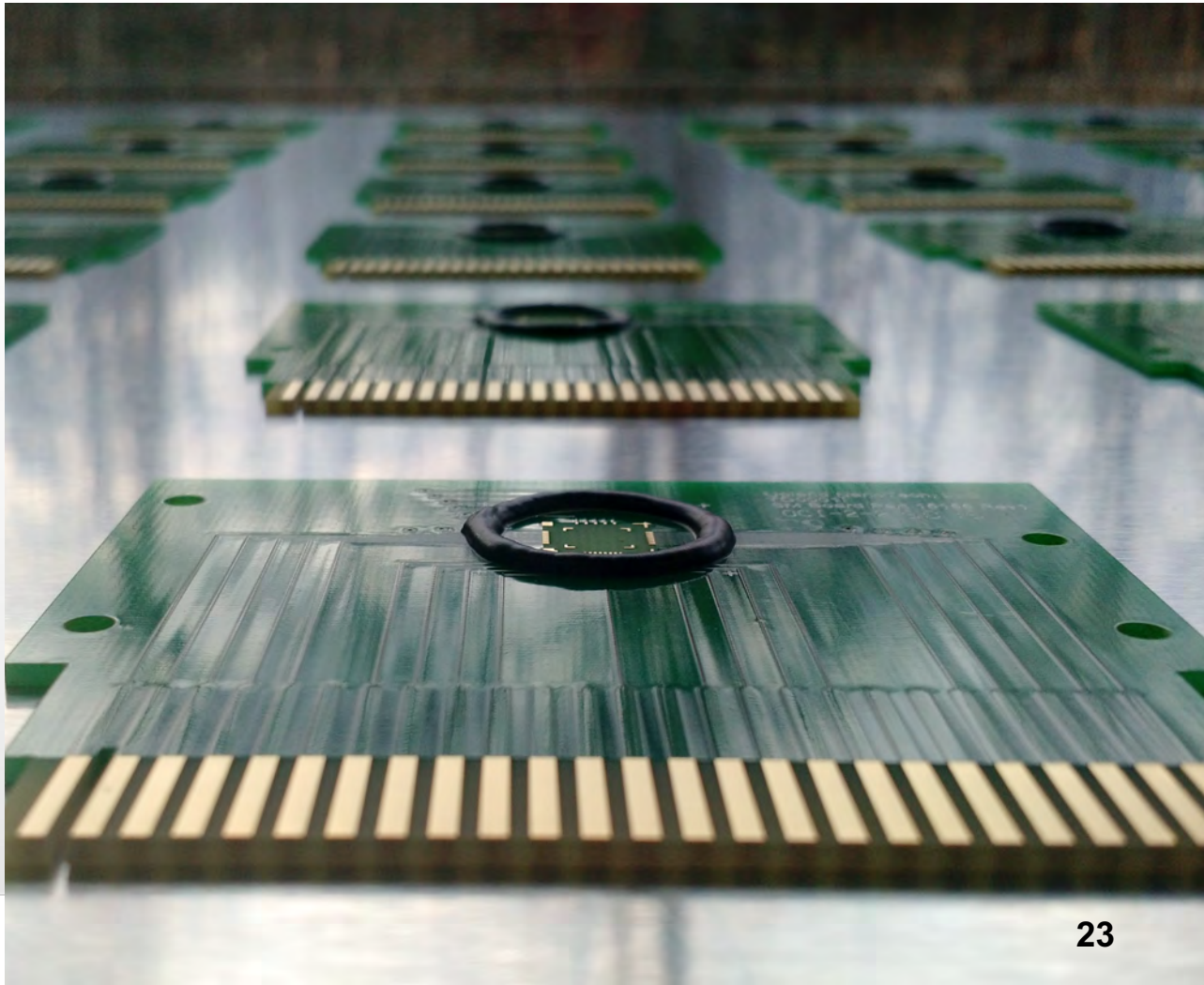
- Dam and fill, glob top, potting
- Epoxies, heat cures, humidity cures, thixotropic adhesives
- Time/pressure dispense, auger dispense, and jetted dispense

Lid Seal

- Solder, epoxy, tape
- Hermetic and non-hermetic

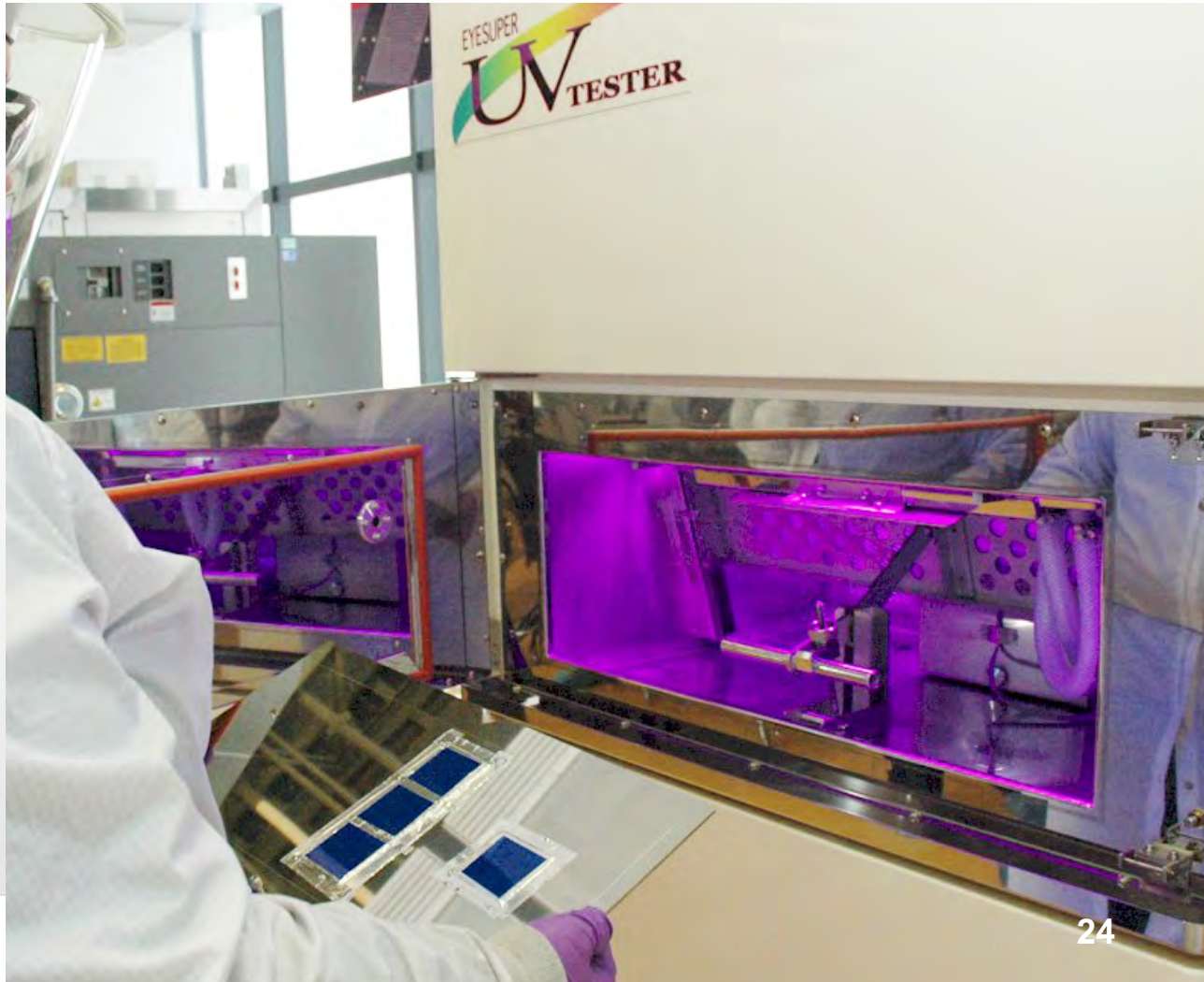
Parylene

- Type C and Type N



Environmental Testing

- Thermal/Humidity Cycling
- Highly Accelerated Stress Test (HAST)
- Thermal Shock
- High/Low Temperature Storage
- Accelerated SUV Radiation Test
- Vibration



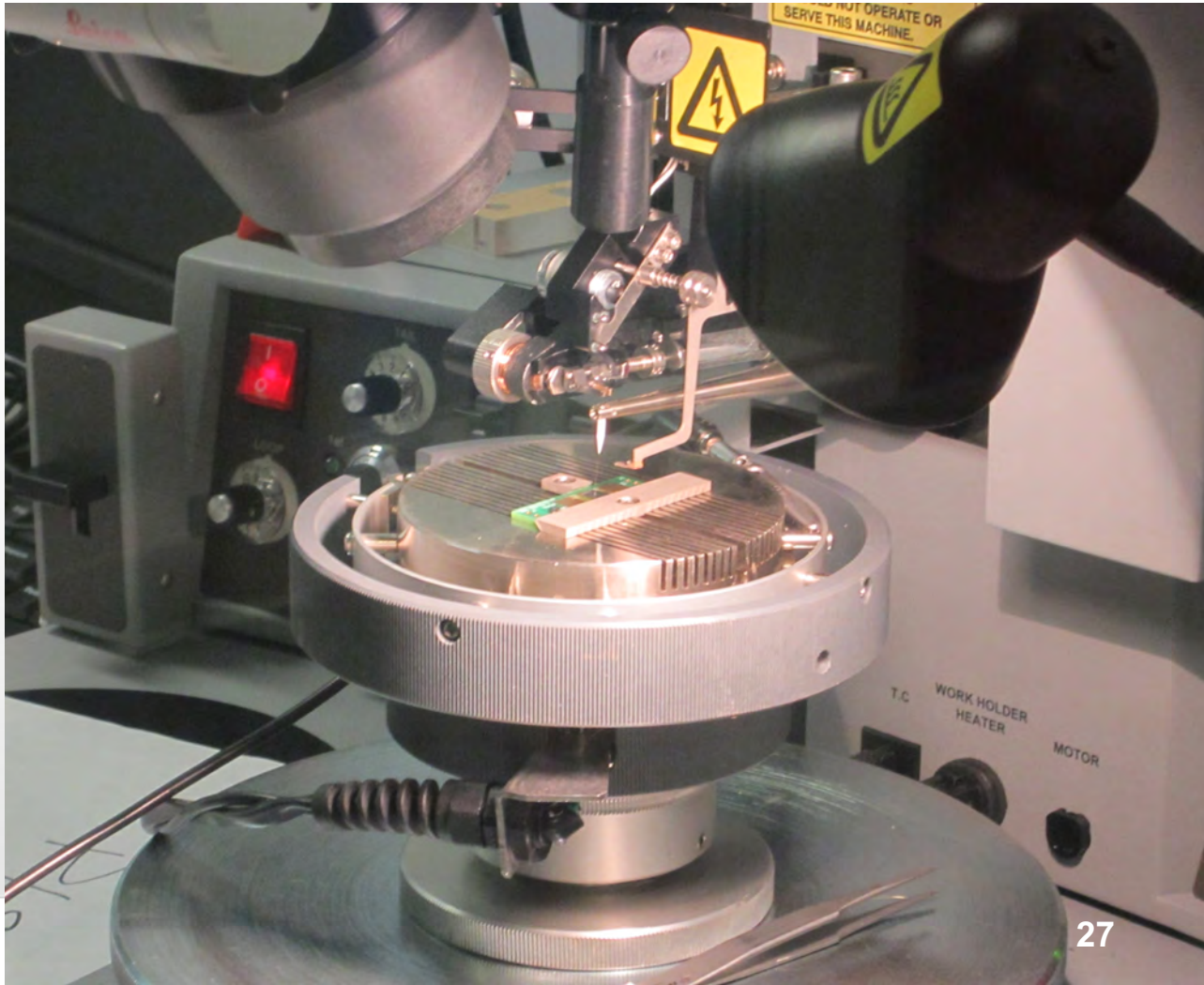
Failure Analysis

- 3D X-ray
- Scanning Electron Microscope
- Emmision Dispersion Spectroscopy
- Scanning Acoustic Microscopy
- Interferometer Surface Profiling

Working with SMART

Proof of Concept and Prototypes

- Trials to test new materials and processes
- Process development for new products
- Build and deliver samples



Environmental Life Testing

- Early testing of new materials and processes
- Prototype testing
- Product qualification

Manufacturing

- Microelectronic sub-assemblies
  - Primarily MEMS sensors
- Annual volumes 100 - 100k units
- Custom US supplier

SMART Qualifications

SMART Quality System

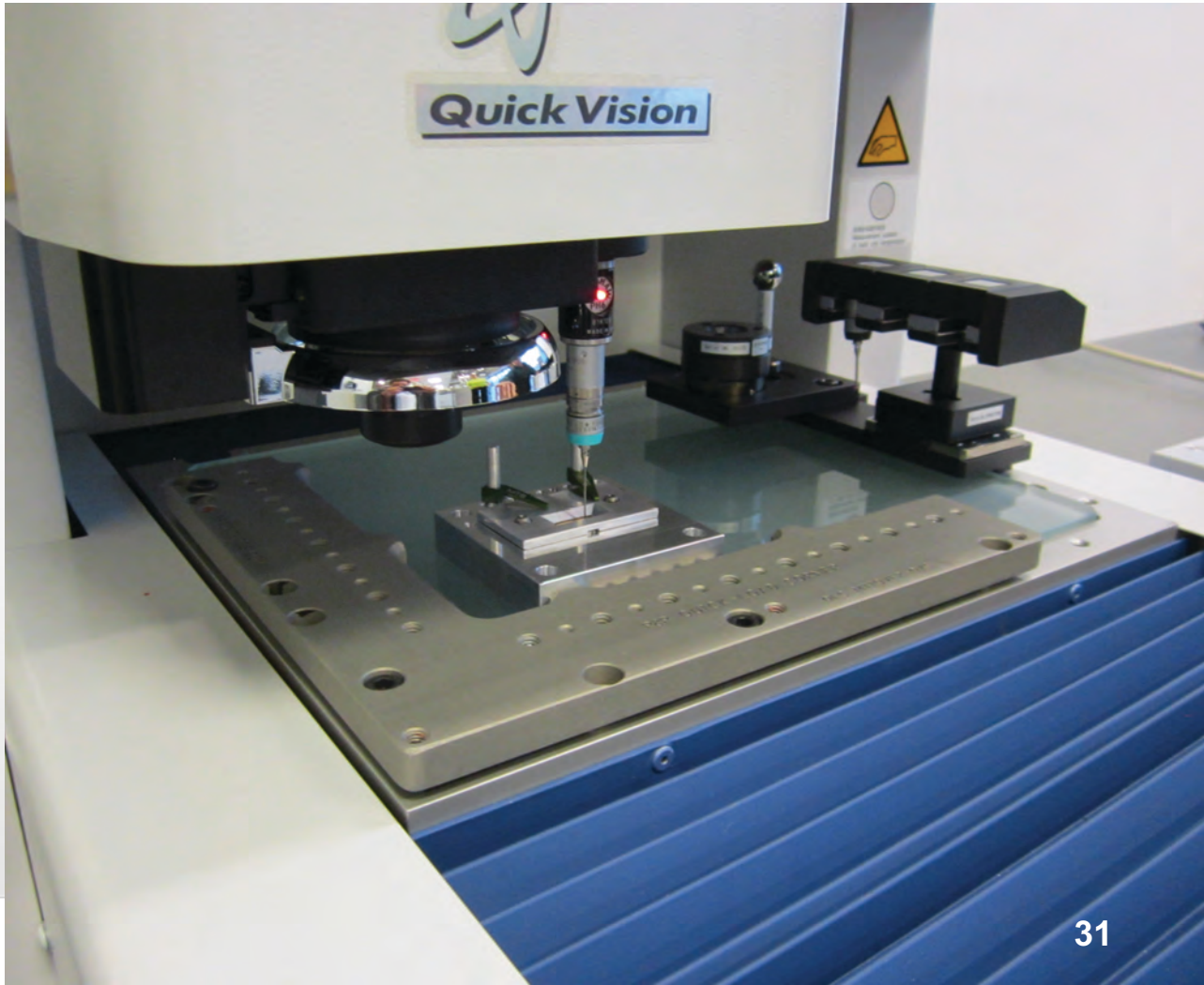
ISO 9001:2008 Certification

- On-time delivery, yield, customer satisfaction

Quality Control

- Coordinate measurement system
- Shear and pull testing

ISO 9001 CERTIFIED



Proven Track Record

- 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

		Inspect and Test			Dicing			Die Attach			Wire Bond			Encapsulation			Environmental Life Test			
		Acoustic Microscope	3D Xray	Interferometry	Wafer Inspect	Wafer Dicing	Die Sort	Epoxy	Solder Reflow	Vacuum Solder Reflow	Fine Gauge	Heavy Gauge	Gold Ball	Adhesive Dispense	Lid Seal	Parylene	Thermal Shock	Thermal/Humidity Cycle	Accel UV Durability	High Temp Storage
Prototyping	Medical Pressure Sensor		■	■	■	■	■	■		■	■		■	■						■
	Fluidic Chemical Sensor					■	■	■			■			■		■				
	High Temp IC Packaging				■	■	■		■				■		■					
Life Test	Specialty Materials	■	■	■			■										■	■		
	Films & Coating Materials	■															■		■	
	Shelf Life Test					■						■						■		■
Manufacturing	Optical Industrial Sensor						■						■							
	Lab on a Chip				■	■	■	■					■	■						
	Aerospace Pressure Sensor						■	■					■							

Summary

We're Experts. SMART has expertise in pressure, chemical, and optical MEMS sensors.

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We're Flexible. SMART has the capability to quickly adapt to customers' new requirements.

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We're Your Partner. SMART partners with its customers to add the required support and expertise to get their product to market.

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We're Conveniently Located. Located in Northeast Ohio, SMART customers benefit from one of the very few highly experienced MEMS sensors package assembly suppliers in North America.

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SMART Microsystems Ltd.

141 Innovation Drive, Elyria, Ohio 44035

Telephone: 440-366-4203

www.smartmicrosystems.com