BAYFLEX SOLUTIONS

Deutsches Flachdisplay Forum

March 2023

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bayflextechnologies.com

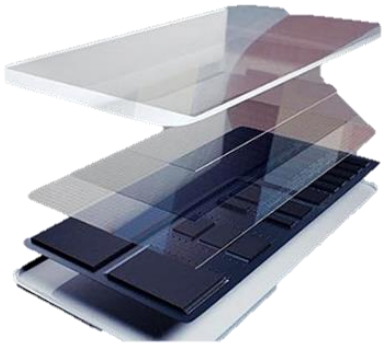
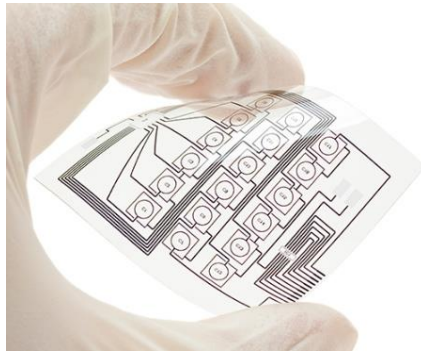
Apologizes

- Wolfgang Mildner, of MSW Tech, will be speaking on my behalf today
- MSW Tech is Bayflex Solutions' partner in Europe

Getting to know us better

- **Yuasa Systems**, is the global leader in **continuous mechanical test systems** for R&D and manufacturing since 1992, with over 1,100 installations worldwide including many in the flexible electronics supply chain from Europe, North America and Asia.
  (participant in IEC and ISO standards bodies & member SID)
  www.yuasa-system.jp/en
- **Bayflex Solutions** is Yuasa's representative for North America and Europe. Based in San Francisco bay area, also develops **lab automation and data analytics** optimized for reliability systems since 2015. Nuremberg, DE office for regional support.
  (Member **OE-A**, IPC, SEMI/Flex, Nextflex)
  www.bayflextechnologies.com



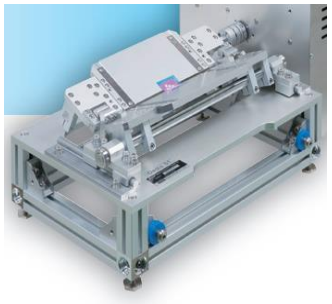



Bayflex Yuasa Modular Solutions

- Interchangeable Mechanical Testers + Motor Drives for Versatility
- Upgradable Options in Data, Optics and Hostile Configurations

1

Mechanical Testers



REPEAT

2

Motor Drive Unit

MEASURE

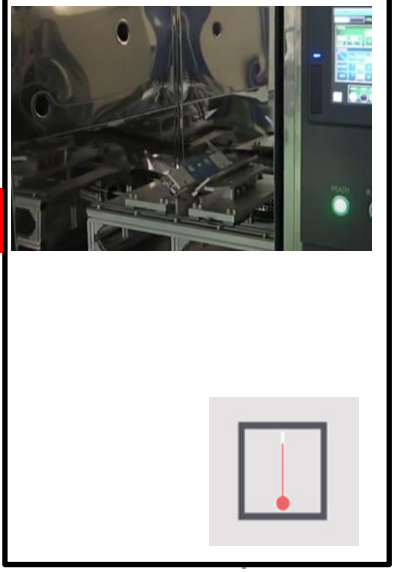
3

Lab Automation & AI analytics

OBSERVE

4

Hostile Systems



Mechatronics Testing

Overwhelming shift from LCD to OLED display components

Recent Market drivers seems to be Larger OLED displays, Wearable & In-Car applications

Refinement of testing assessments for new form factors

No testing standards emerging for Micro LED

Flexible Display Challenges

Ensure **Integrity** of New Materials & Micro Electronics while in **Continuous Use** (cracks, contact failures)

Continuous Testing in Complex **Hostile Conditions** (bend, flex. temperature, humidity)

Detect **Micro Strain** fractures of New Materials (delamination, deformation)

Recent New Mechanical Stress Failures

- Recent Market drivers seems to be Larger OLED displays, Wearable & In-Car applications
- Refinement of testing assessments for new form factors
- No testing standards emerging for Micro LED
- Both FOLD and FLEX mechanical motions are valid

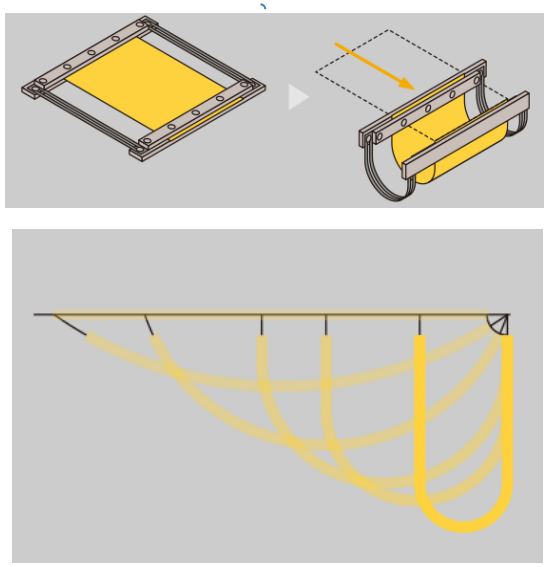
Deformations	Fold	Flex	Twist	Roll	Stretch	Bend
Cracked	possible	possible	YES	Possible	YES	possible
Delaminated	YES	YES	YES	Possible	possible	possible
Bent Permanently	YES	YES		YES		possible
Stretched Permanently			possible		YES	possible
Torn			YES		possible	

Transition from LCD to OLED assessments

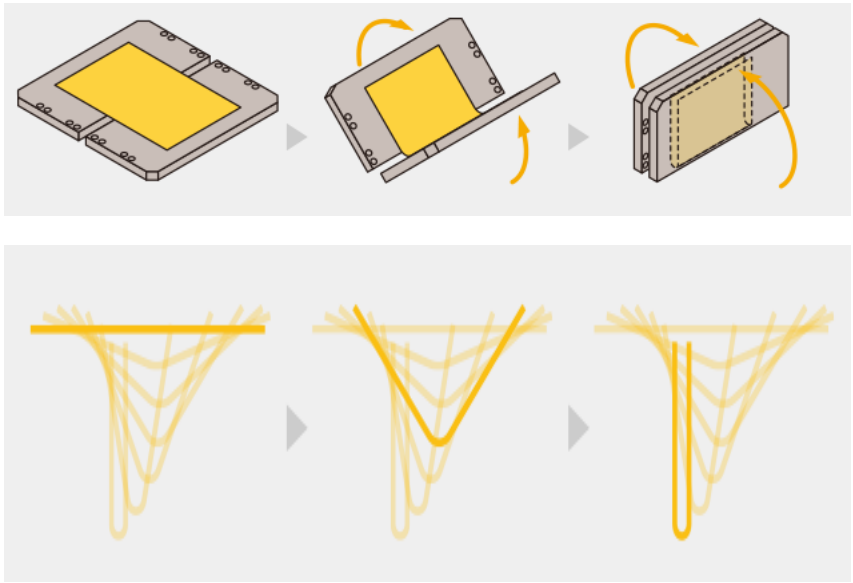
- “U-Shape” Butterfly motion originally required to understand effect of motion on rigid samples
  Still effective for LCD display modules and Panel edge assessments (semi-rigid, rigid and curved forms)

- Evolution to Clamshell motion to assess effect of motion on single pivot point to determine module integrity
  De-facto approach for OLED display modules (incl. flexible, slideable, rollable and wearable forms)

“Butterfly” U-shape motion to simulate gentle warping with a push rod movement

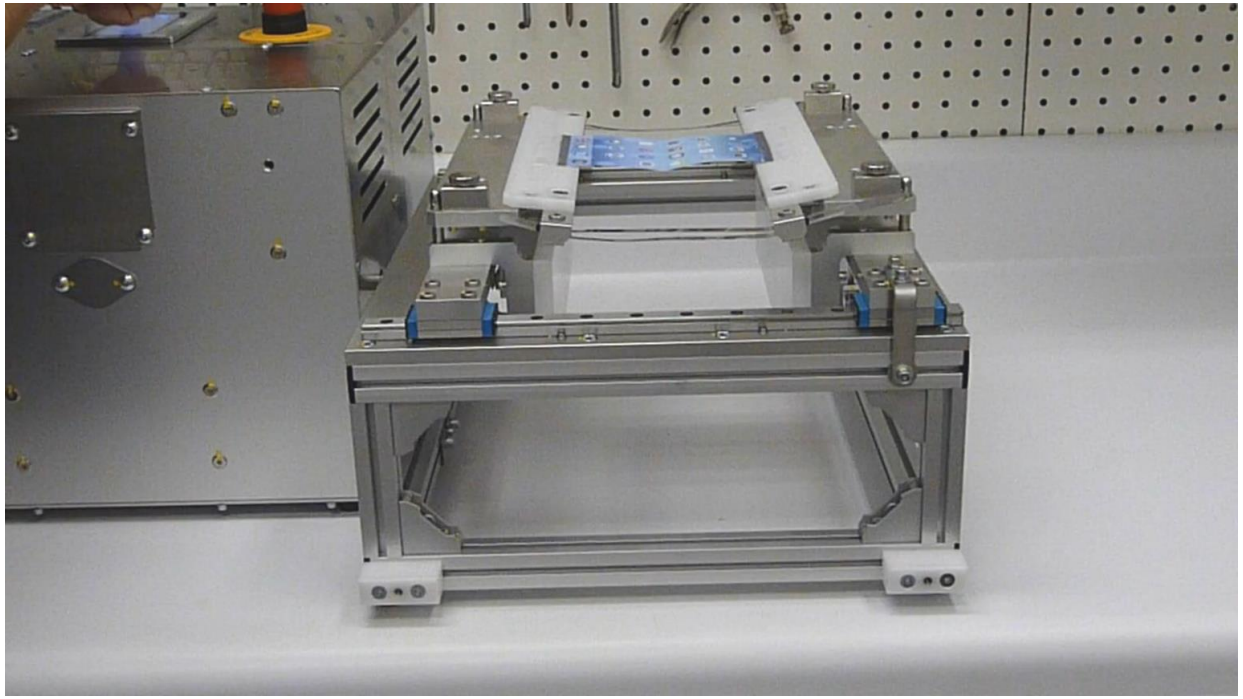


“Clamshell” motion to simulate flexing with a double hinge movement



Motions compared

Butterfly Motion
(Yuasa FS Folding Tester)



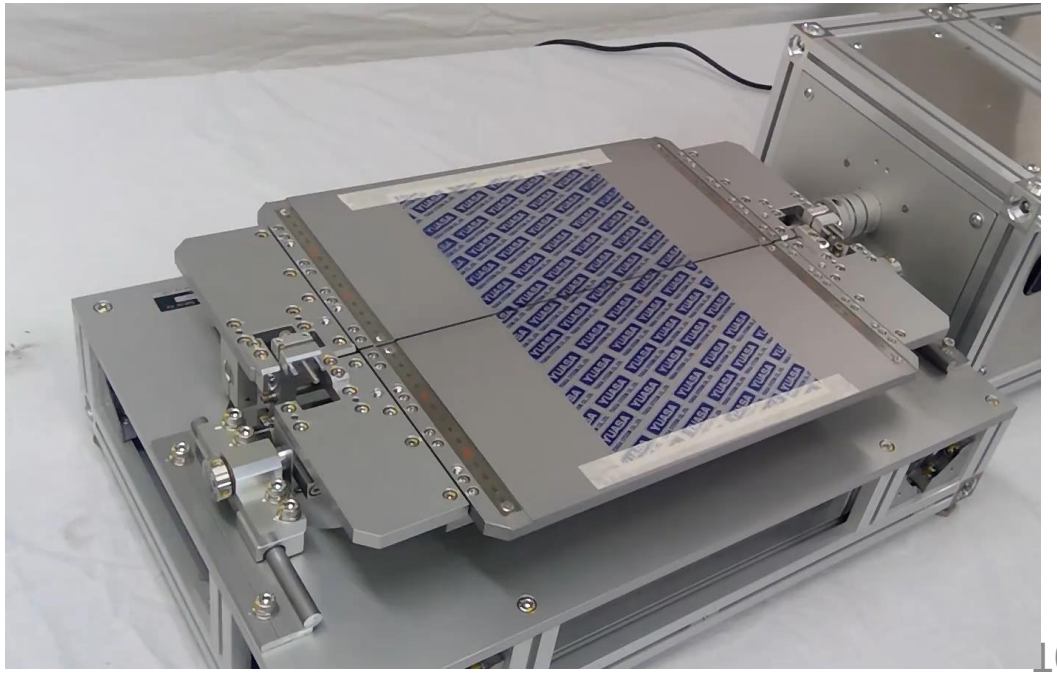
Clamshell Motion
(Yuasa CS Flexing Tester)

Larger Form Factors

- With slowing growth in the Smartphone market, higher value innovations are shifting to larger form factors
  Dual screen Laptops, Tablets, Automobile Screens

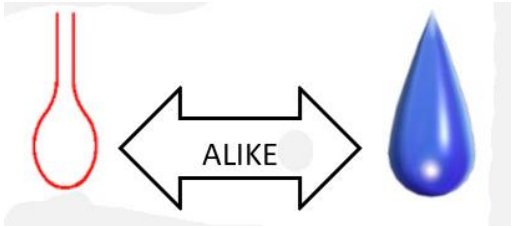
- Larger Clamshell Holding Plates are desired to accurately replicate form factors, including reproducing complex “Hold and Fold” mechanical motions to simulate actual usage

- Product Differentiators are form factors (slideable, rollable) and Hinge mechancism design.

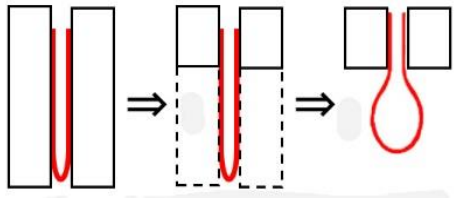


Simulated Hinge Design

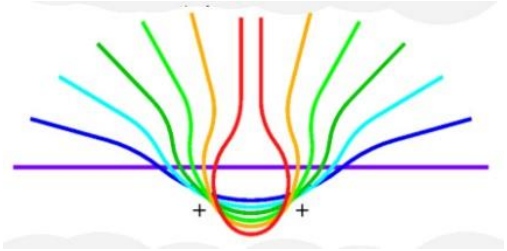
- By adjustment of the neck and bulb dimensions around the radius, enables simultation of different design forms. Also known as the Teardrop mechanism



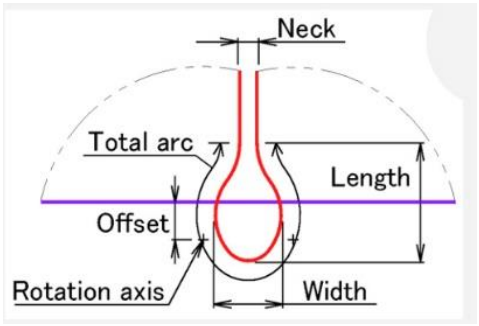
The CS-Teardrop shape is very similar to an actual tear



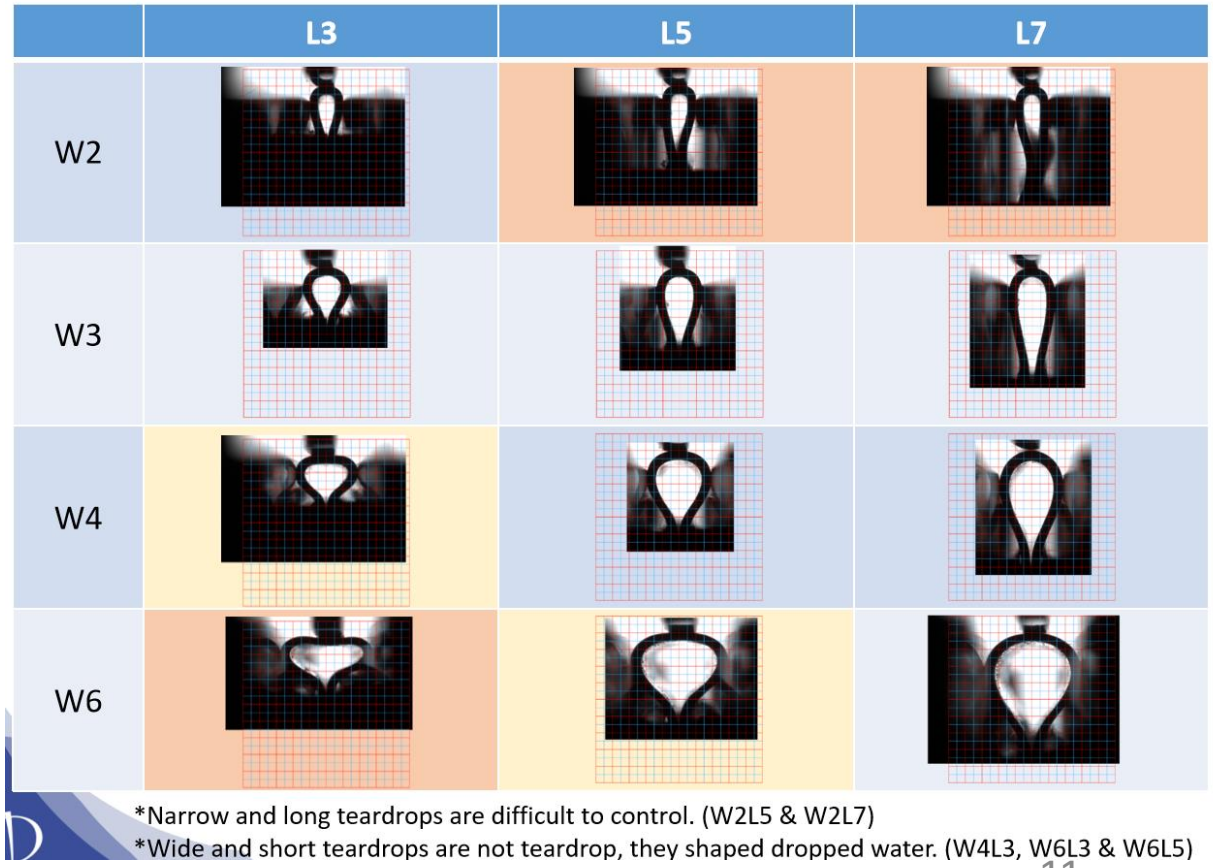
U-shape folding without full vertical support becomes a teardrop shape



The CS-Teardrop shape during flexing



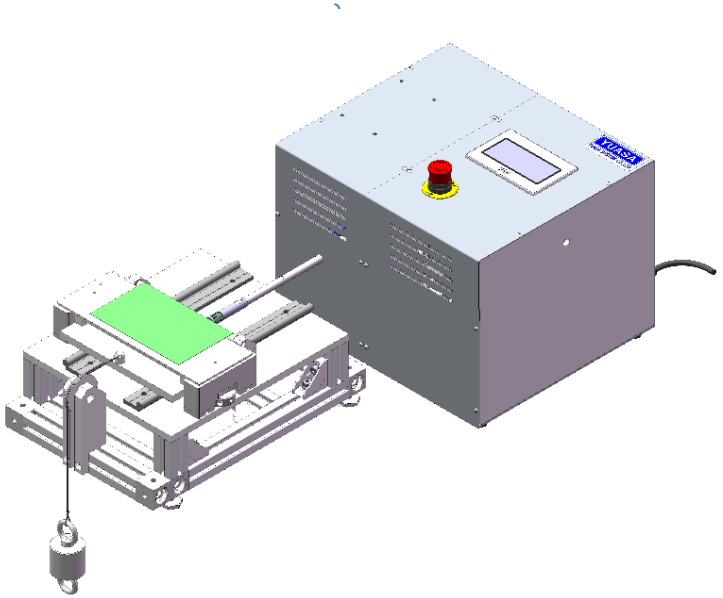
Parameters for adjusting CS-Teardrop shape

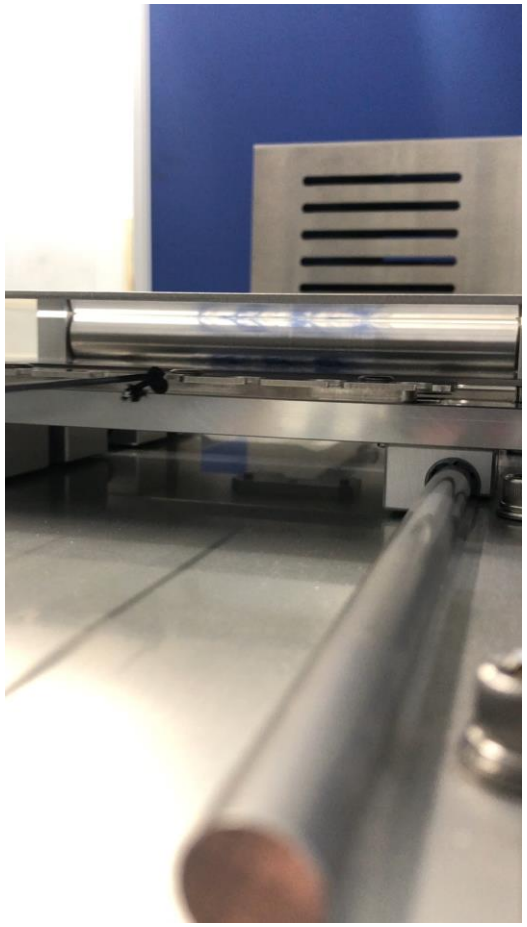


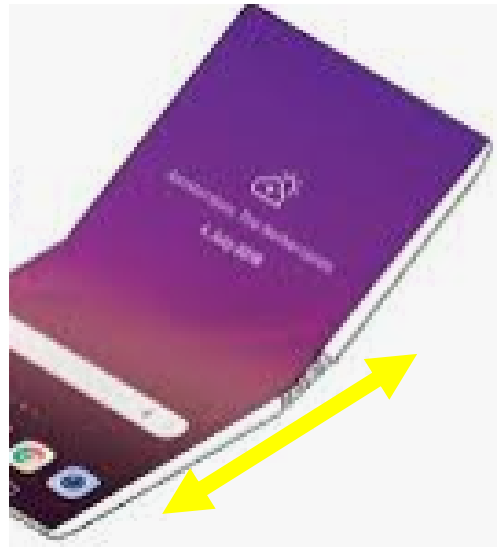
Slide/Rolling Form Factors

- Precise control over short distance rolling assessments is a new addition to long run testing to understand a variety of spring based coiling mechanisms seen to date to extend or slide the display device

- Basic function still evaluated by flexing mechanical motion



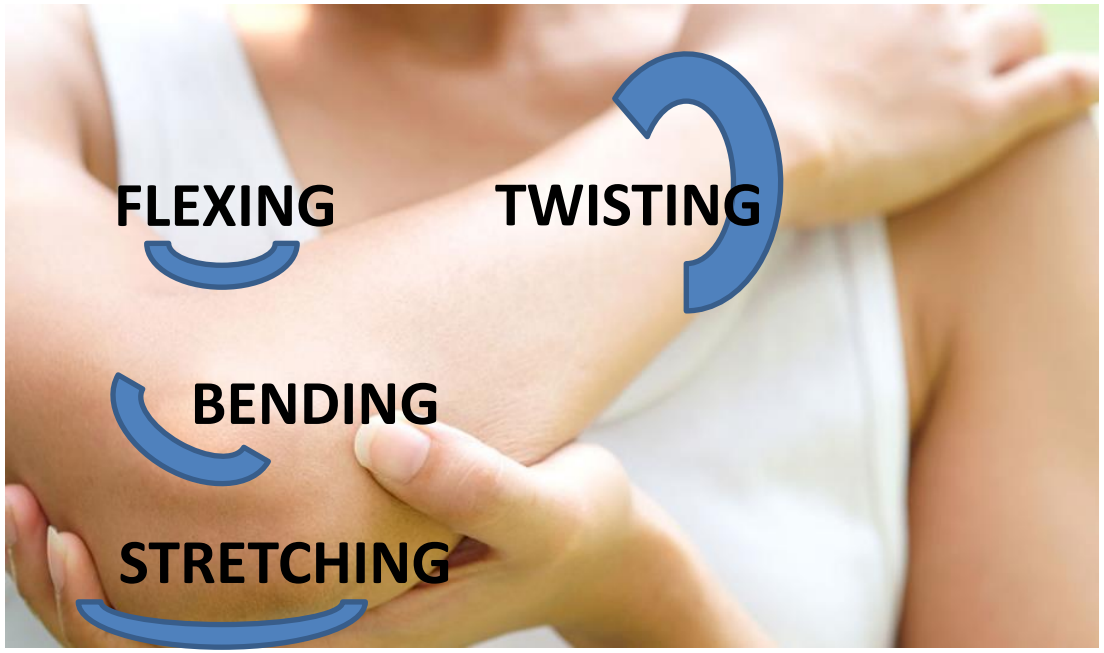


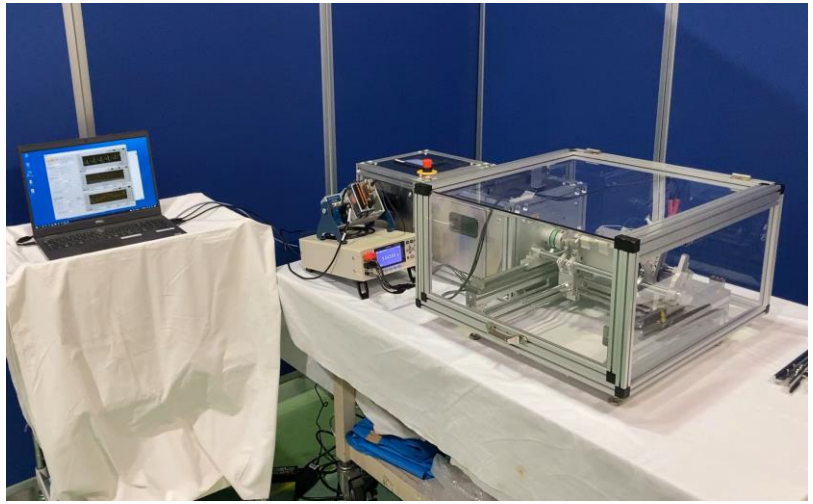


Wearable Form Factors

- Precise control over existing clamshell mechanism over a mandrel type device to simulate wrist size (from 0mm up to 70mm) is deemed useful

- Additional assessments to replicate human body movement (flex, stretch, twist, bend) is additionally sought for non-display related items. Increased need to harvest functional electronic data





Data Analysis

Additional sensors & measurement

Growing need to capture images/video for deeper and faster analysis

Smarter / Intelligent detection of long run assessments

Future expectations for Machine Learning and even Artificial Intelligence for flexible electronics

Integration with Hostile environments deemed a must

Need for Better Data Transition

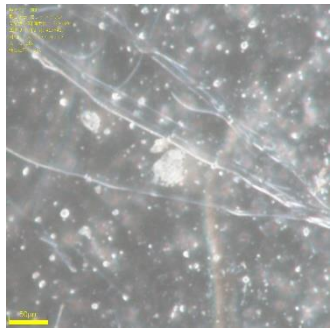
bayflex solutions

Opportunities of Data Efficiency is Exponential (Predictive, Scale to Manufacture, Product Lifecycle)

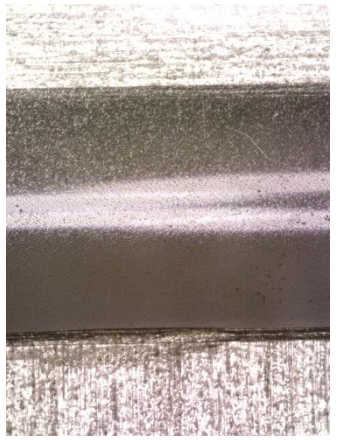
- Optical Imaging used for Inspection, Analysis and Prediction (image recognition and data computation)
- Expanding Universe of Data Harvesting (resistance, torque, load cell, temperature, humidity …)
- Monitoring/Control of Application specific devices, Environmental Chambers for Adv. Lab Automation
- One Reliability Constant for R&D, QA Qualification, Manufacturing, End-Device Monitoring

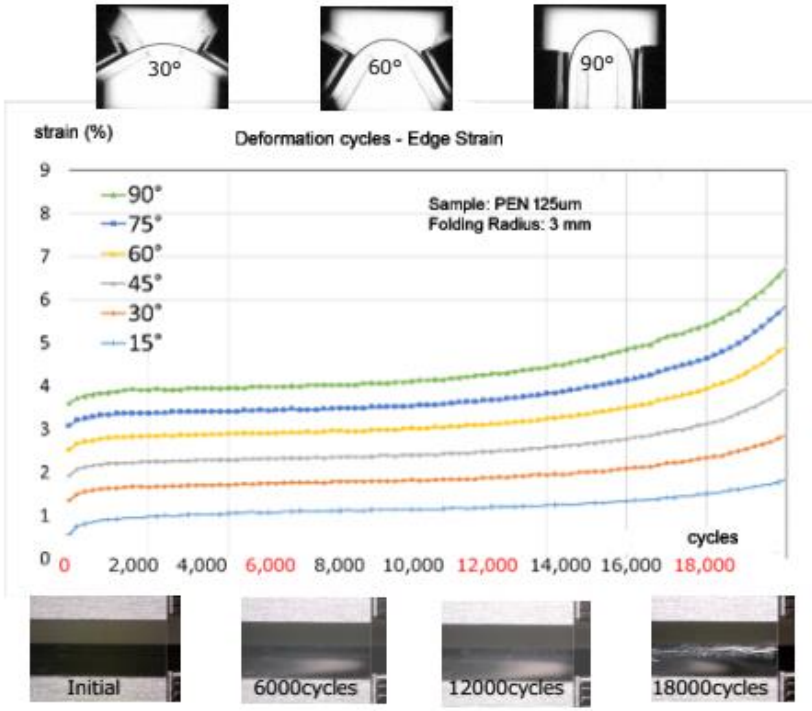
Note:
Uncompressed Continuous Image for 200K cycles @ 75TB
> whereas most laptop SSD capacity is 1-2 TB
> Cloud first architecture is mandatory

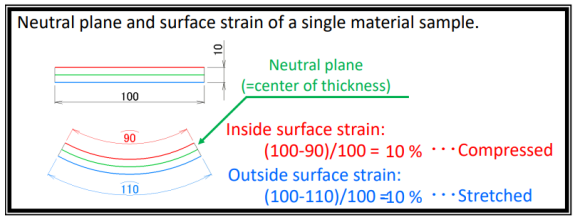
Material Breakage



Material Fatigue





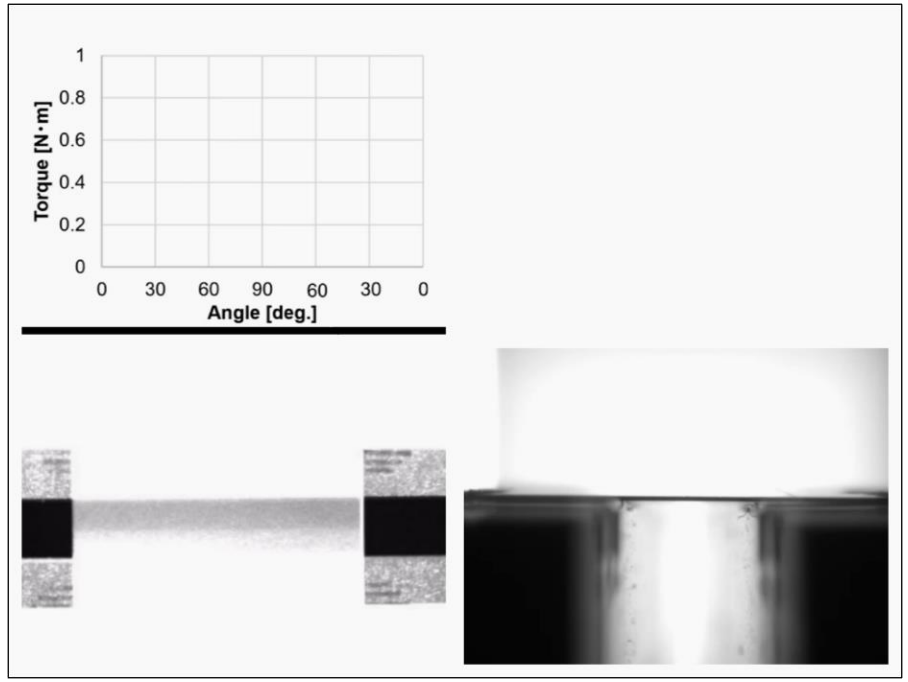


Reliability Performance Benchmarks

Flexible Display / MetaVerse / Wearable Applications

- Multiple layer Testing
- Delamination / Deformation
- Optical Imaging for Realistic Product / Human Movements,
- in Hostile Environments
- measuring Resistance, Torque etc.
- Expanding to capture Biosensors by laser and electronic pulses

- Established Consumer Electronics standards over 1 mil cycles, 200K component level

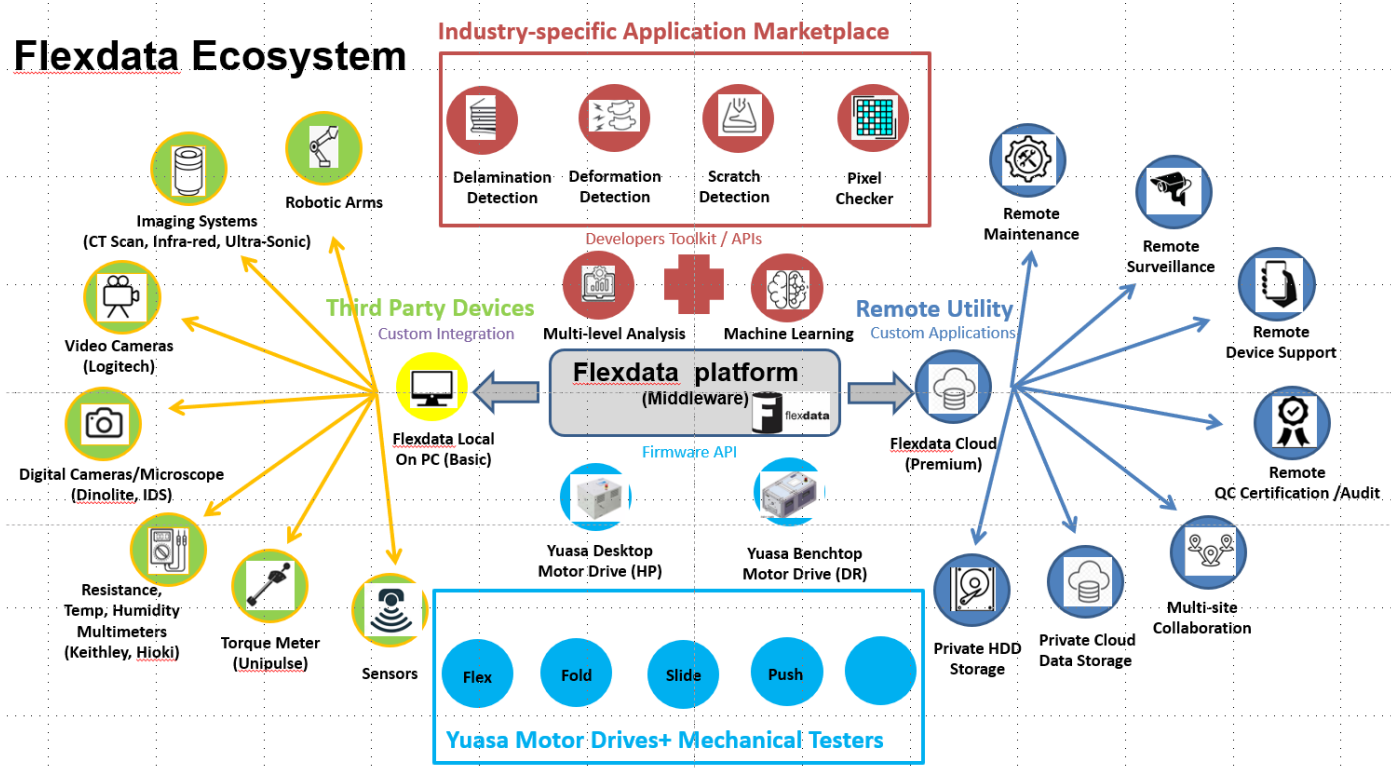


Top and Side View Image capture
Synchronized to Torque Meter

Our Flexdata Philosophy

Core Elements

- Disclosure
  Published Technical Approach & Architecture
- Independent
  Designed in Third Party Device Integration
- Low Barrier
  Cloud Architecture, Provided or Client Cloud for Collaborative development/Supply Chain
- Accessible
  Easy of Use/Re-Use for Complex assessments, Remote surveillance/operation
- Client-led Development
  Major N.America/Europe Companies/Institutes



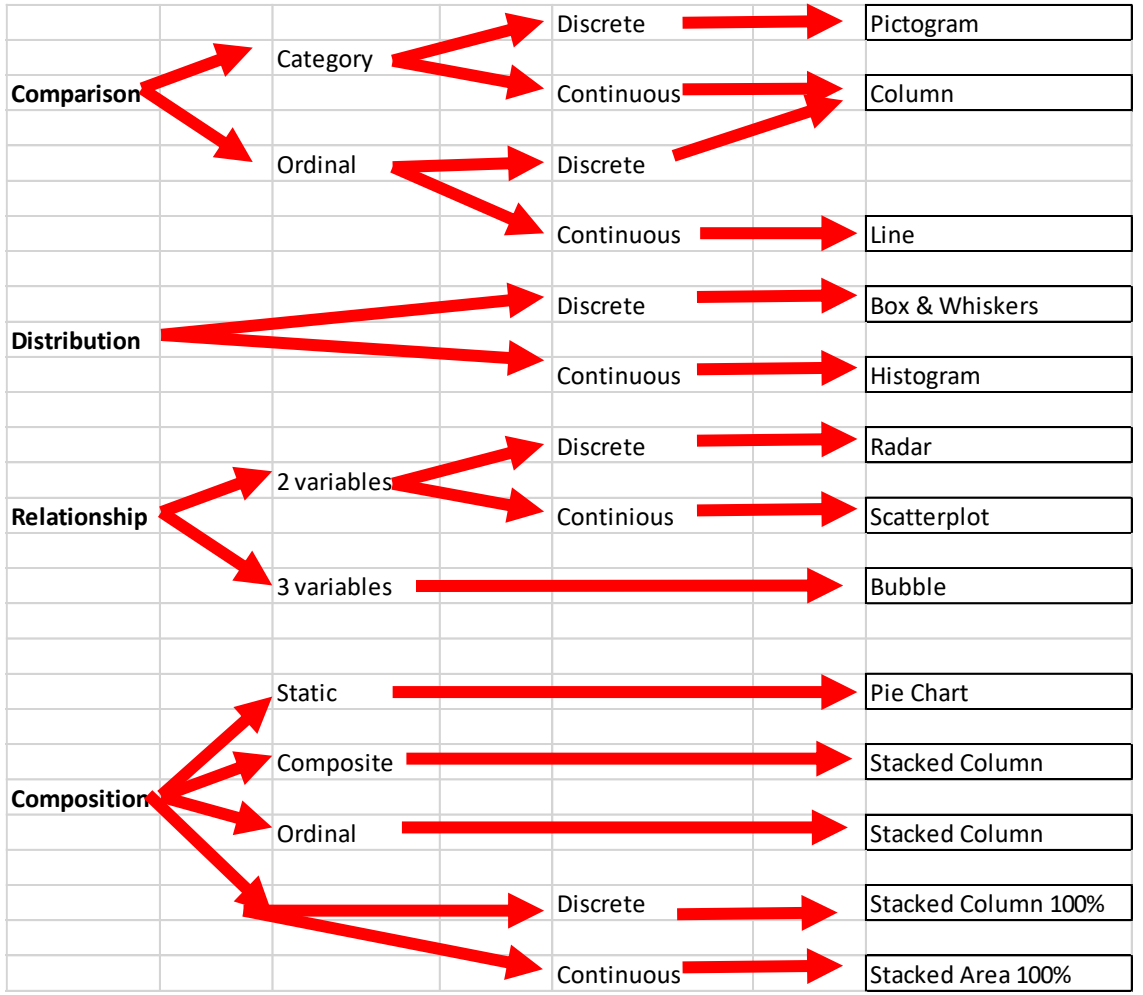
Looking Ahead

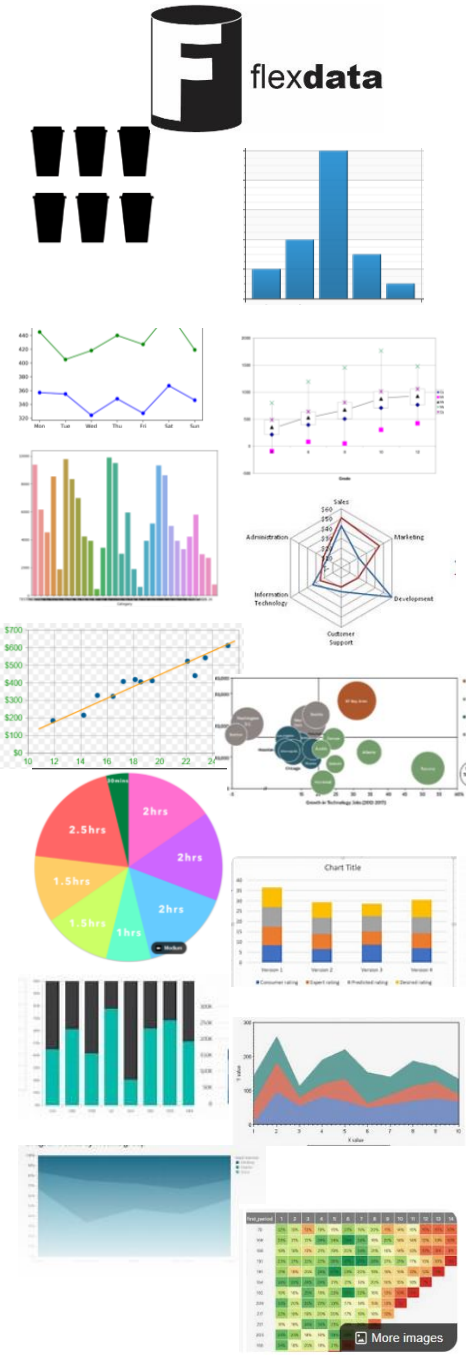
Data Visualization:
More Data, More Images …
How to present information to make a better decision faster –
Seek Data Relationships
(both Known & Unseen)

Data Types
- Category
- Ordinal
- Discrete
- Continuous

Presentation Types
- Colour
- Hues
- Shapes
- Width
- Heat Maps etc.

➔ Collect only Useful Data
➔ Use appropriate Analytical Tools
➔ Integrate libraries e.g. Matplotlib





Looking Ahead..contd.

Data Scrubbing

Store & Improve accuracy of data

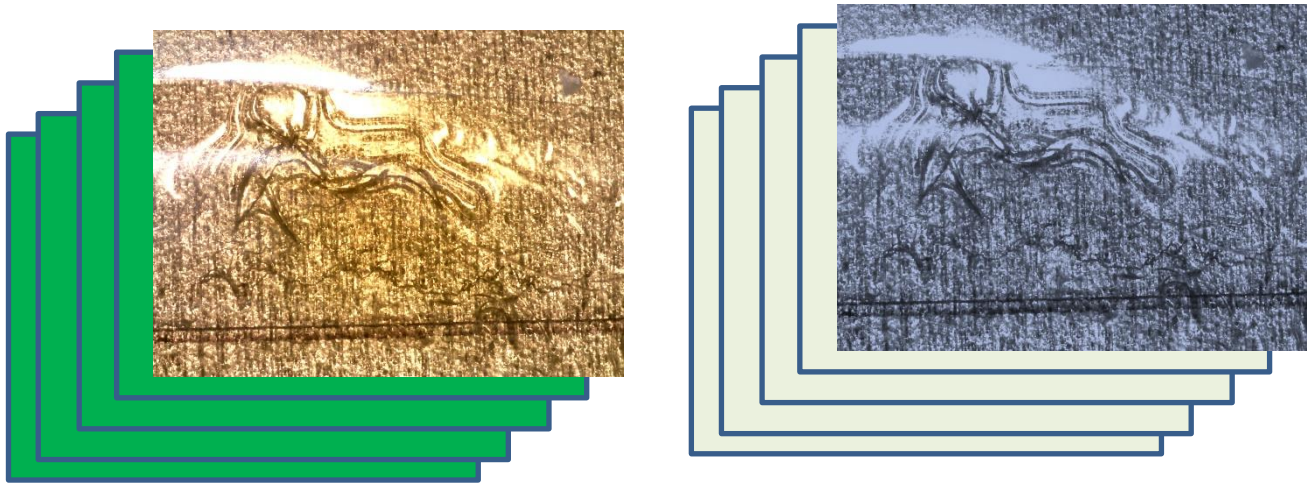
- Parsing — Identifies data
- Correction — Fixes data
- Standard — Adheres to format/rules
- Matching — Eliminates duplication
- Consolidate — Combines data sets

➔ Visualization + Data Scrubbing = Machine Learning

➔ Seek data relationship (rules based) patterns for Unique predictive analysis

Visual Recognition

Compare Good/Fail images



Microbubble Images (Delamination)

➔ Input = Yes, No, Maybe = Visual Recognition (requires many samples)

➔ Seek data relationship (unsupervised) patterns for Unique predictive analysis

Combination of rules based and unsupervised pattern recognition leads to generative Artificial intelligence

Data Performance Preparedness

Which level is your organization?

- Level D0 Denial – No Data / Don’t Know
- Level D1 Human level - Pen & Paper
- Level D2 PC level - Excel, Macro (No Images)
- Level D3 Specialist level – Matlab, C++, etc.
  & Manufacture specific applications
- Level D4 Cloud Architecture
  – Integrated Data / Image Framework
- Level D5 Advanced Cloud
  - ML / AI enabled Data Modelling
  incl. Digital Twins (optimize feedback)

Business Reward

Flexdata as your co-pilot in Flexible electronics Reliability improvement

- Fractional / Scalable Investment to streamline/augment existing Engineers

- Mechanical Engineer Time $130K @ 15% time = $20K / Yr.
- Lab Tech $52K @ 70% time = $36K / Yr.
- Matlab Software Engineer $ 250K @ 30% time = $80K / Yr.
- Data Scientist $80-180K = $130K / Yr.

➔ Better Human Capital Deployment / Higher Retention /
Augment Multi-skills for Technicians / Lack of Data Scientists

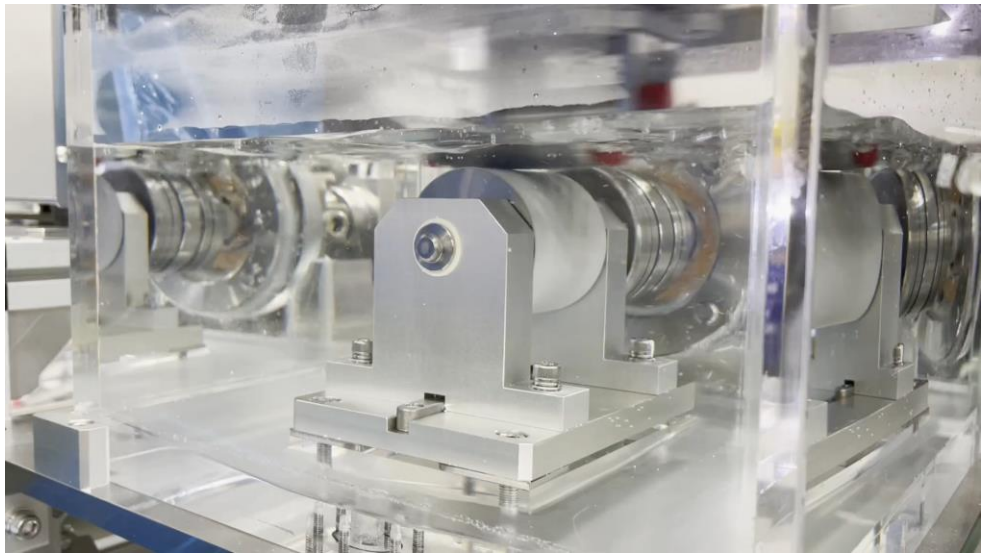
➔ Decrease Courier/Shipping Costs of Samples – with secure Audited data
More specific feedback communication with Supply Chain

➔ Higher productivity with Multi-level, Multi-site Analytics & Advanced applications
Lab instrumentation Approach proven in Pharma & Clinical development

➔ Incalculable Opportunity Profit/Loss with Speed to Market

Hostile Environments

- Retrofit Kits for Existing Chambers (temperature, humidity)
- Requests for Compact (Mobile), Multi-purpose, Fully Integrated Multi-environment for Wearable Devices



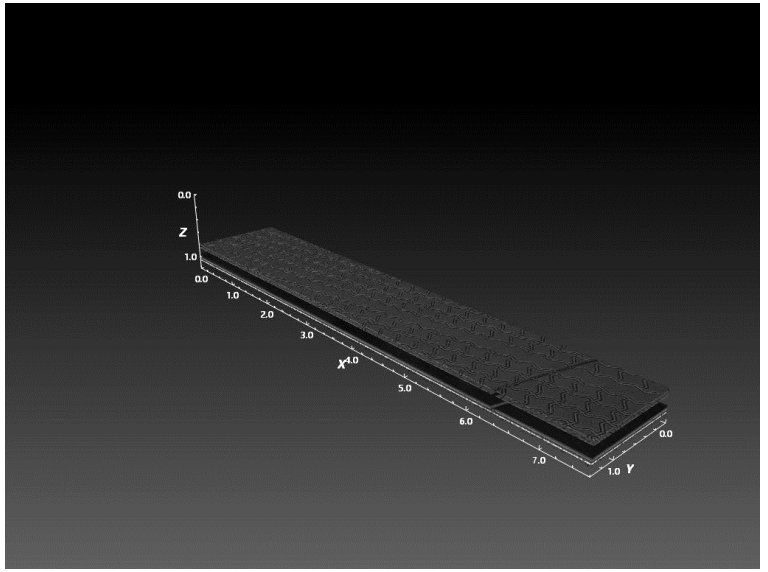
Seeking Groundbreakers

Expand the Wheel - Open to Collaboration with;

- Device Manufacturers (Meters, Robotics, Flying Probe, R2R)
  New Accessory Integration thru GPIB/USB interface
  Feedback to Manufacturing Systems

- Application / Product (Visualization, Testing Assessments)
  Matlib Integration, Connections to existing Material Databases

- Start-ups solving critical scaling issues
  Seed investments thru Bayflex Technologies



Multi layer Delamination concept (w Early Charm Ventures)

Gratitude amplified;

- Clients
- Collaborative Partners
- Strategic Partners

More…

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