calce

Introduction

to

Center for Advanced Life Cycle Engineering

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CALCE at University of Maryland
Over 30 Years of CALCE Support of the Electronic Industry

- Research, test and consulting services (contracts through UMD, lab services, consortia membership)
- Over 800 research projects, $100 million in research funding, and 1000+ published articles) for design, manufacture, life assessment and life management of electronics components, products and systems
- Continuing learning opportunities (more than 300 webinars, 100+ keynotes at conferences, 200+ short courses)
- Skilled engineers (over 300 Ph.D. and 500 M.S. degrees) with sophisticated problem solving skills for design, manufacture and test of reliable products that meet the targeted applications
- Over 500 practicing engineers working for organizations such as Apple, Dell, Google, Honeywell, Intel, Microsoft, NASA, Northrop Grumman, Samsung and Schlumberger

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CALCE Clients

- ABB Switzerland Ltd.
- ACell, Inc.
- ACC Electronix
- Advanced Bionics
- Aerojet Rocketdyne
- Agilent Technologies, Inc.
- Allergan
- America II Electronics, Inc.
- American Panel Corporation
- Amazon Web Services
- Anadigics, Inc.
- Ansaldo STS USA, Inc.
- Applied Biometrics
- AprilAire
- ASML
- AST
- ATV Semapp
- Austria Microsystems AG
- Avaya Global Operations
- BAE Systems Electronics & Integrated Solutions
- Baker Hughes Inc.
- Bartlit Beck Herman
- Beijing Weibu Technology Limited Liability Company
- Bloomberg
- Boeing Co.

- Bombardier Aerospace
- Butterfly Networks
- Celestica International
- Chrysler Corp.
- Club
- CNN
- Coch
- Colli
- Cont
- Curti
- Cum
- CSX
- Dakt
- Defe Activ
- Dell,
- Delp
- Dow
- Dow
- DFR
- Edm
- Emb
- Emerson
- Electrospec, Inc.
- EMC Corp.
- Fairchild Controls Corp.
- Finisar
- FirstTissues
- Fourth Dimension

- Fujitsu Network Communications
- GE Healthcare Technologies
- General Dynamics Advanced
- Microsoft Corp.
- Milwaukee Power Tools
- MKS Instruments, Inc.
- Moog Inc.
- MSA
- MDS Coating Technologies

- NASA Glenn Research Center
- NASA Goddard Space Flight Ctr
- Samsung Electronics Co.
- Sandia National Laboratories
- Savenia Labs.
- Schlumberger Oil Drilling Services
- Seagate
- Selex Electronics Systems Ltd

- Silicon Powers
- SpaceQuest
- SORAA
- Souriau
- Stratasys, Inc.
- Stryker
- Stanley Black and Decker
- Sun Metals
- Sunpower
- Team Corp.
- TEKELEC
- Telcare, Inc.
- Trilumia.
- Teradyne, Inc.
- Tessera
- Tintronics Industries
- Toyota Research Institute of N.A.
- Triumph
- TU CIC Virtuhcon
- U.S. Army ARDEC
- U.S. Army CECOM
- U.S. Army Research Lab.
- Unison Industries
- Universal Lighting Technologies
- Vertiv
- Waites
- Whirlpool
- X-Wave

- **Consumer and mobile products**
- **Telecommunications and computer systems**
- **Energy systems (generation/storage/distr)**
- **Industrial systems**
- **Automotive systems**
- **Aerospace systems**
- **Medical systems**
- **Defense systems**
- **Equipment manufacturers**
- **Government Labs and Agencies**

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CALCE Mission and Thrust Areas Continue to be Critical

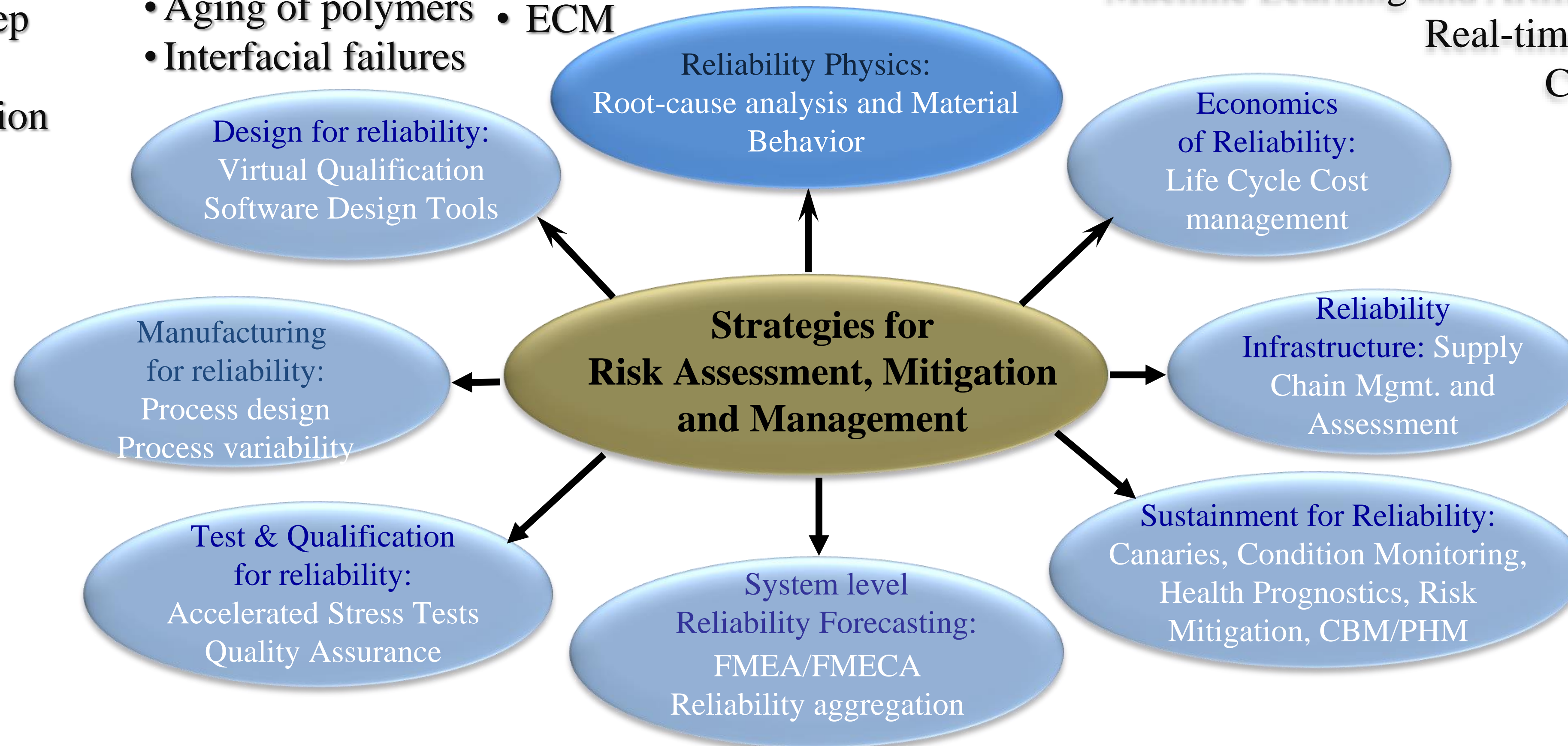
Providing a knowledge and resource base to support the development and sustainment of competitive electronic products

- Fatigue and Fracture
- Plasticity, creep
- Wear/fretting
- Electromigration
- ESD/EOS
- TDDB

- Whiskers
- Aging of polymers
- Interfacial failures

- Corrosion
- ECM

Machine Learning and Artificial Intelligence
Real-time Data Analytics
Cloud Computing
IoT



Convergence of Reliability-Physics (RP) and Artificial Intelligence (AI)

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CALCE Activities

- **Education**
  - University degree programs, on-site customized professional development courses, web based seminars, workshops and symposia.
- **Standards Development**
  - Participation on standards development through societies and organizations such as IEEE, IPC, and SAE
- **Contracts**
  - Research and service contracts with negotiated terms with University.
- **Test Services and Failure Analysis**
  - Design review, simulation assisting product life assessment, material and product testing, supply chain management, and root cause failure identification.
- **Research Consortia**
  - Shared research projects, supplemental projects, access to software and seminars, consulting, and discounts on test services and failure analysis

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2022 Symposium on Counterfeit Parts and Materials: June 28-30, 2022 (https://smta.org/counterfeit)

- This long-running symposium returns in-person and continues to provide relevant information that can solve problems today while planning for a different business and technology environment in the future. Changes in the electronics supply chain had been fast and furious in the last decades, and its impact on companies' practices is still evolving.
- Join this symposium to present your experience and learn about how the industry is addressing the counterfeit electronics issues we are facing today.
- Abstract Submission Deadline: March 24, 2022
- Contact Dr. Das (diganta@umd.edu) if for more information.

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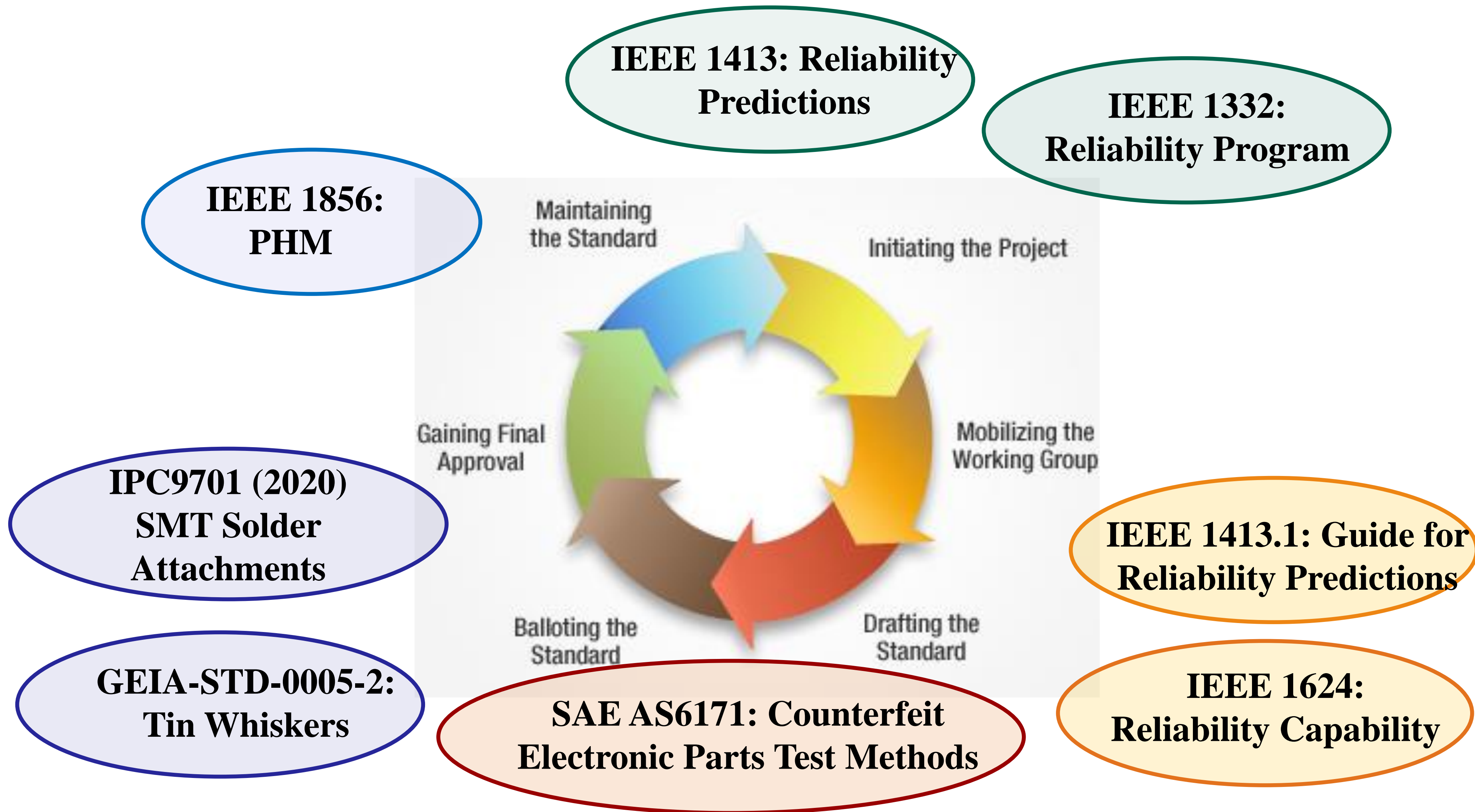
CALCE Standards Development and Leadership



Picture Source: IEEE Standards Association

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USPAE DoD Lead-Free Solder Performance and Reliability Assurance Project

- **Objective:** Provide the technical basis to compare and qualify solder alloys for select defense mission applications.
- **Funding:** $40 Million, 5 Year Effort, 2021-2025
- **Output:**
  - Solder Performance Specification
  - Solder Users Guide
- **Contact:** Michael Osterman (osterman@umd.edu) for more information

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CALCE Fee-For-Service Projects

- Projects are developed through discussions with project sponsor.
- Costed Fee-For-Service Project Proposal is submitted to project sponsor
- Projects are initiated when
  - Project sponsor returns signed copy or the costed Fee-For-Service Project Proposal
  - Project sponsor provides payment method – PO, Credit Card
  - Project sponsor provides project materials

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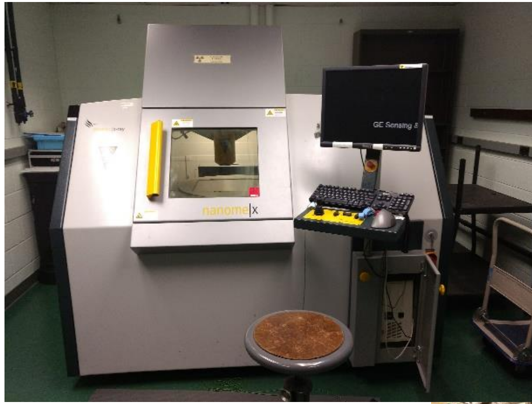
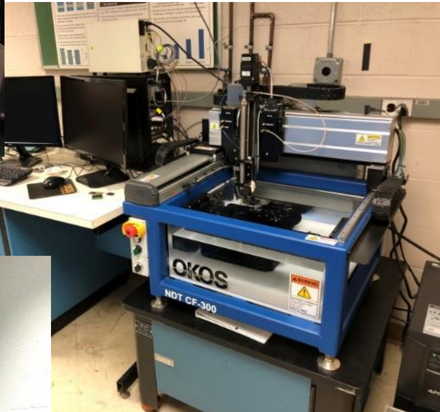
Extensive Test and Measurement Labs

CALCE has a sophisticated test and failure analysis laboratory to support research and industry needs.



X-ray Inspection

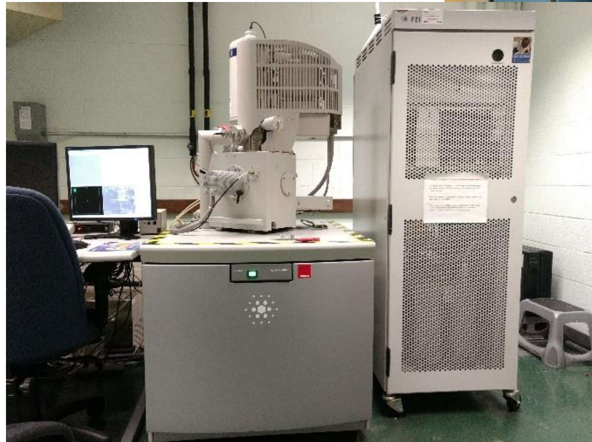


Scanning Acoustic Microscope

FTIR

Temperature Cycling Chambers

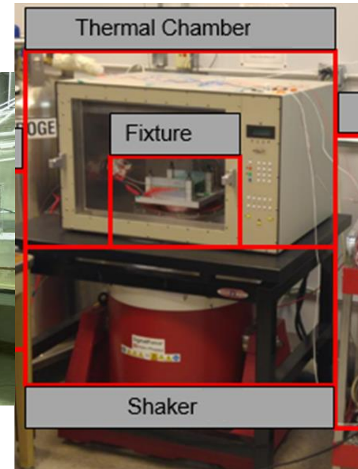
HALT Chamber



Scanning Electron Microscope and Energy Dispersive Spectroscopy

Thermomechanical Analyzer

Mixed Flowing Gas Chamber



Combined Vib and Temperature Cycling

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Examples of Fee-for-Service Projects

- Battery Characterization
  - Capacity Measurement
  - Capacity Fade
  - Impedance Measurement
  - Construction Analysis
- Failure Analysis
  - Internal Board Shorts
  - External Board Shorts
  - Solder Interconnect
  - IGBT
- Material Characterization
  - Board Construction
  - Solder Joint/Intermetallic Formation
  - CTE Measurements
  - Plating Thickness
- Simulation/Modeling
  - CALCE SARA Software
- Testing
  - Mixed Flowing Gas
  - Flower of Sulfur
  - Vibration
  - Drop
  - Temperature/Humidity
  - Temperature Cycling
- Training
  - Failure Analysis
  - Physics of Failure Assessments
  - Prognostics and Health Monitoring

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CALCE Simulation Assisted Reliability Assessment Software

https://calce.umd.edu/calce-simulation-assisted-reliability-assessment-sara-software

Open Access

Assembly, Package and Device Failure Assessment Modules

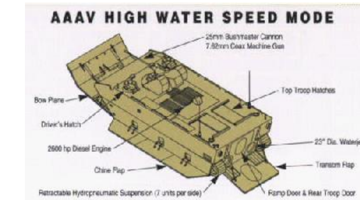
GM

83% reduction in design issues

>10% reduction in time to market

AAAV

Virtual Qualification of circuit cards providing life expectancy



Honeywell

Virtual qualification of engine Controller identified life limiting design issues

Rockwell Collins

Identified design life issue saving customer an estimated $27 million dollars

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CALCE EPS Consortium Research Program

Research Program Theme

(Identification and development of technologies, methodologies, and guidelines for assessing, mitigating, and managing the risks associated with the design, manufacture and fielding of electronic products and systems)

Research Roadmap Thrust Areas

- Failure Identification and Reliability Modeling
- Environmental and Operational Assessment of Products
- Risk-informed Technology Insertion Methodologies

Road Maps

- New Technologies, Materials and Processes
- Failure Mechanism
- Power and High Temperature Electronics
- Prognostics, AI and Machine Learning
- Part Management and Sustainment

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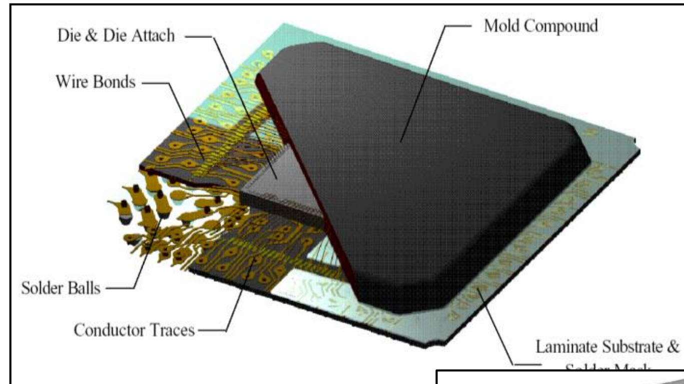
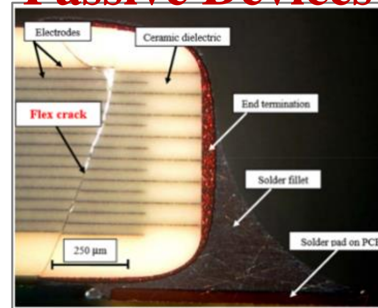
Reliability of Electronic Devices and Interconnects

CALCE Team: M. Azarian, D. Das, A. Dasgupta, B. Han, P. McCluskey, M. Osterman, M. Pecht, and P. Sandborn

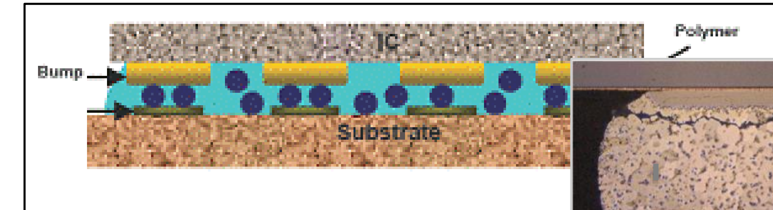
Active Devices

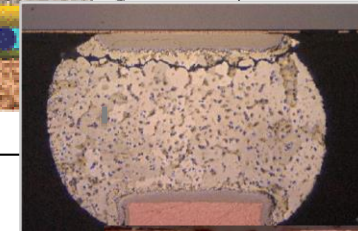


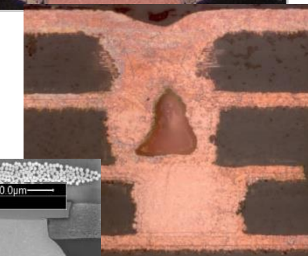
Passive Devices



Interconnects



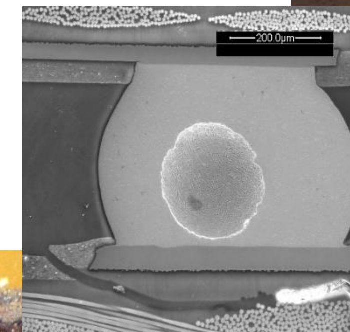


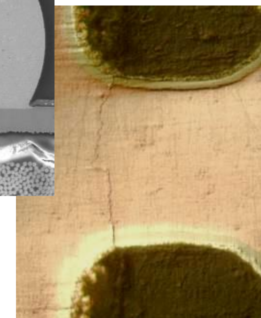


Reliability models and acceleration models can use physics-based and data-based models

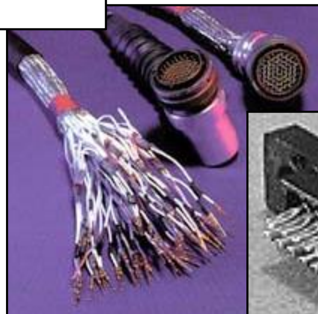
Adhesives

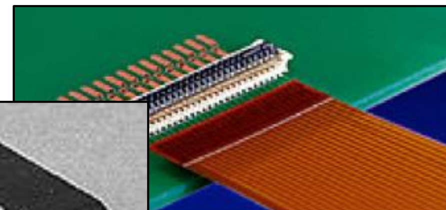
Printed Electronics



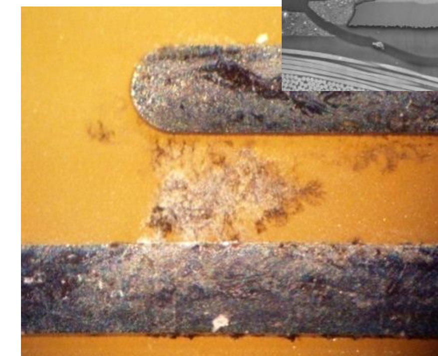


Batteries





Cables & Connectors



High-Density Substrates

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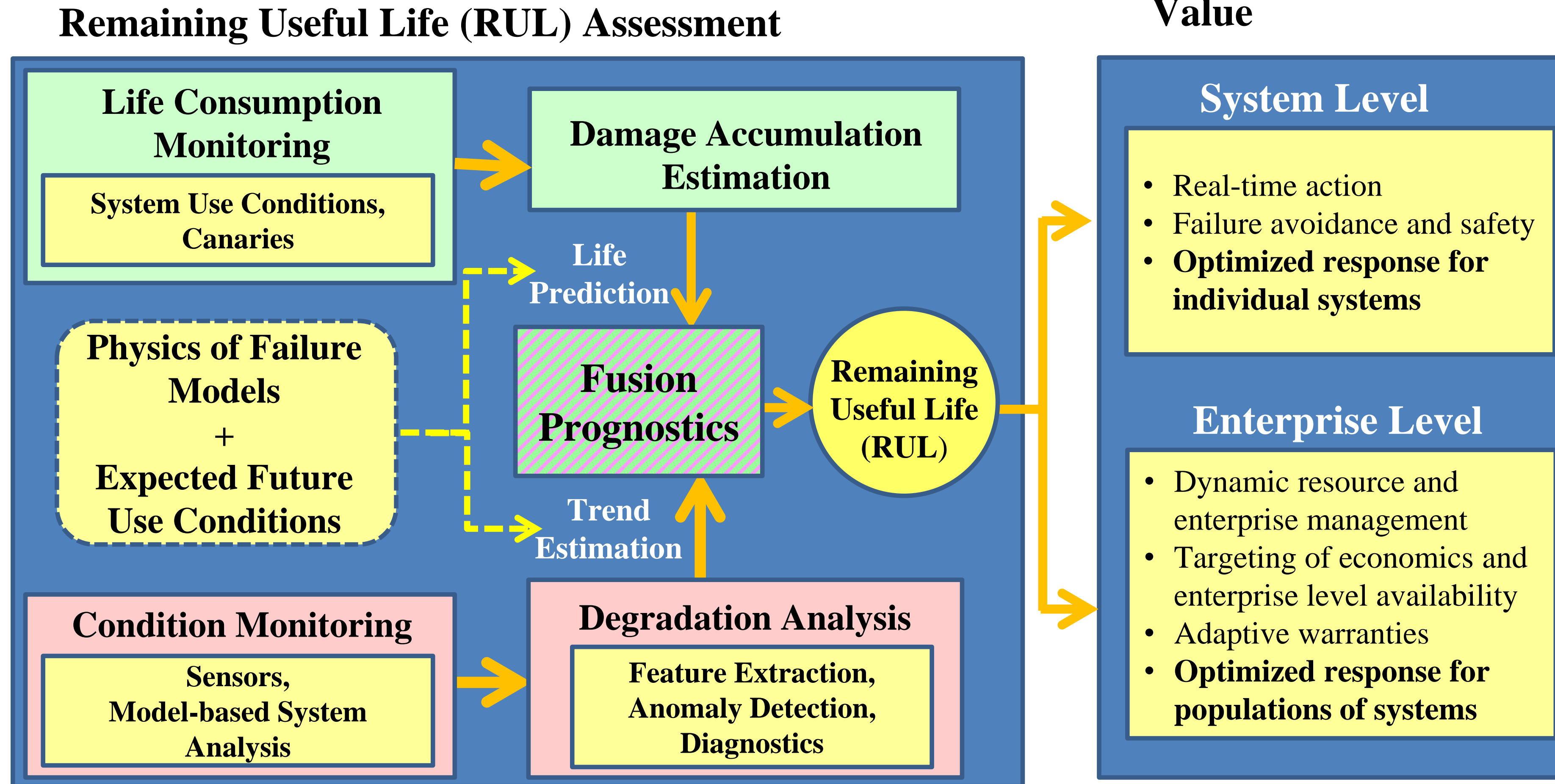
Prognostics and Health Management

CALCE Team: M.H. Azarian, D. Das, A. Dasgupta, P. McCluskey, M. Osterman, M. Pecht, P. Sandborn



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CALCE Consortium 2022 Projects

- C22-02 Effect of Driving Conditions on Accumulated Solder Joint Damage
- C22-03 Fatigue under Multiaxial Cyclic Creep in Oligocrystalline SAC Solder Joints
- C22-07 Reliability of Low Temperature (e.g. BiSn) Solder Interconnects
- C22-08 Reliability of Third Generation Solder Interconnects
- C22-19 Derating and Rapid Assessment of Multilayer Ceramic Capacitors (MLCCs) for Use with Ripple Current
- C22-14 Component Life Assessment Methodology Development
- C22-15 Paint Durability for Electronic Products
- C22-22 Evaluation and Selection of Lubricants for Mechanical Interfaces
- C22-12 Development of an IGBT Testing and Screening Procedure

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Benefits of Consortium Membership

https://calce.umd.edu/join-calce-eps-consortium

- Participation in current consortium research projects
- Input into consortium research roadmap
- Shared access to results from over $100 million in research
- Technical exchange with other members
- Access to CALCE web site
- Advanced access to latest CALCE Simulation Assisted Reliability Assessment software and software support (EPSC)
- Attendance at semiannual CALCE technical meetings
- Access to CALCE instructional information
- Interaction with CALCE graduate students
- Technical consulting with CALCE Research Staff
- Involvement in the CALCE internship program
- Discount on lab services and CALCE sponsored events

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Agenda Tuesday March 22

10:00 am Research Presentations – Session 1

- Derating and Rapid Assessment of Multilayer Ceramic Capacitors (MLCCs) for Use with Ripple Current
- Evaluation and Selection of Lubricants for Mechanical Interfaces
- Long Term Storage Reliability of Hybrid and Polymer Aluminum Electrolytic Capacitors
- Reliability Challenges of Wide Bandgap and Ultra-Wide Bandgap Semiconductor Electronics in Extreme Environments
- Development of an Insolated-Gate Bipolar Transistor (IGBT) Testing and Screening Procedure
- Component Life Assessment Methodology Development

1:00 pm Research Presentations – Session 2

- Enterprise Network Modeling for Counterfeit Part Disruption
- Effect of Driving Conditions on Accumulated Solder Joint Damage
- Reliability of Low Temperature and 3rd Generation Solder Interconnects
- Modeling Solder Interconnect Damage for Complex Temperature Cycles
- Fatigue under Multiaxial Cyclic Creep in Oligocrystalline SAC Solder Joints
- Paint Durability for Electronic Products

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Agenda – Wednesday March 23

10:00 am Student Presentations

- Explainable AI for PHM
- Reliability and Safety Analysis using Digital Twins
- Machine Learning and Machine Vision: Applications to Counterfeit Detection
- Water Ingress Protection Testing and Assessment of Portable Electronics
- Electrolyte Influence on Lithium Dendrite Formation
- Are current vibration qualification methods adequate for multiaxial vibration environments ?
- Creep behavior of micron-scale porous sintered silver features seen in high-temperature interconnects and in 3D printed conductors
- Durability of 3D printed electronics under extreme drop conditions
- Additively-fabricated flexible temperature and humidity sensors made from CNT/GO Inks
- Compound failure modes in SMT interconnects under combined vibration and temperature cycling
- Failure Manifestation for Power Electronics Modules

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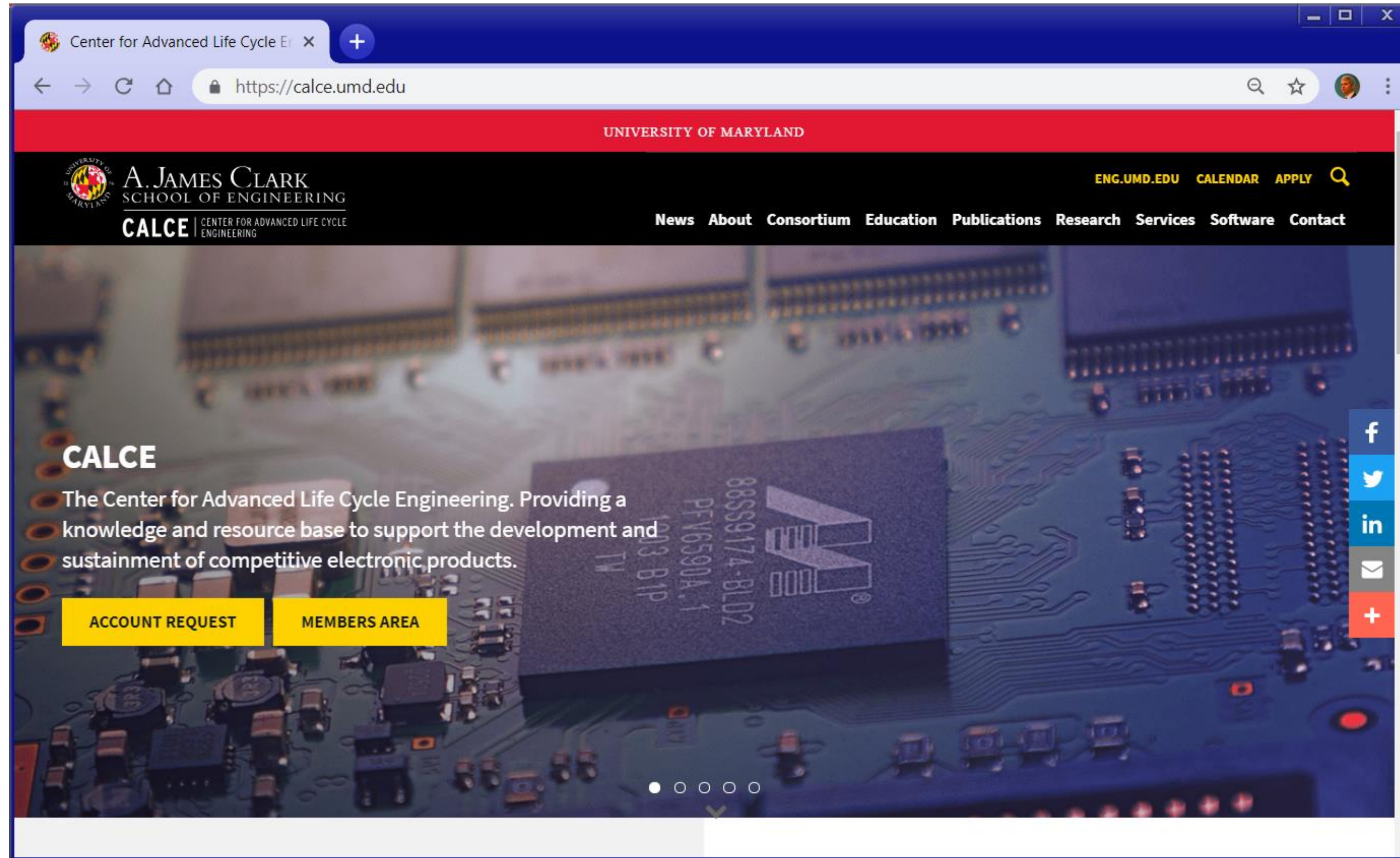
Questions



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