Reliability Science Symposium
Spring
March 27-28, 2024

Center for Advanced Life Cycle Engineering (CALCE)

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CALCE at University of Maryland
Over 35 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

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
- Edmu
- Embr
- Emerson
- Electrospec, Inc.
- EMC Corp.
- Fairchild Controls Corp.
- Finisar
- FirstTissues
- Fourth Dimension
- Fujitsu Network Communications
- GE Healthcare Technologies
- General Dynamics Advanced
- Keysight
- Microsoft Corp.
- Milwaukee Power Tools
- MKS Instruments, Inc.
- Moog Inc.
- MSA
- MDS Coating Technologies
- NASA Glenn Research Center
- NASA Goddard Space Flight Ctr
- e Center
- rp.
- Corp.
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- 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**

CALCE Mission and Thrust Areas Continue to be Critical

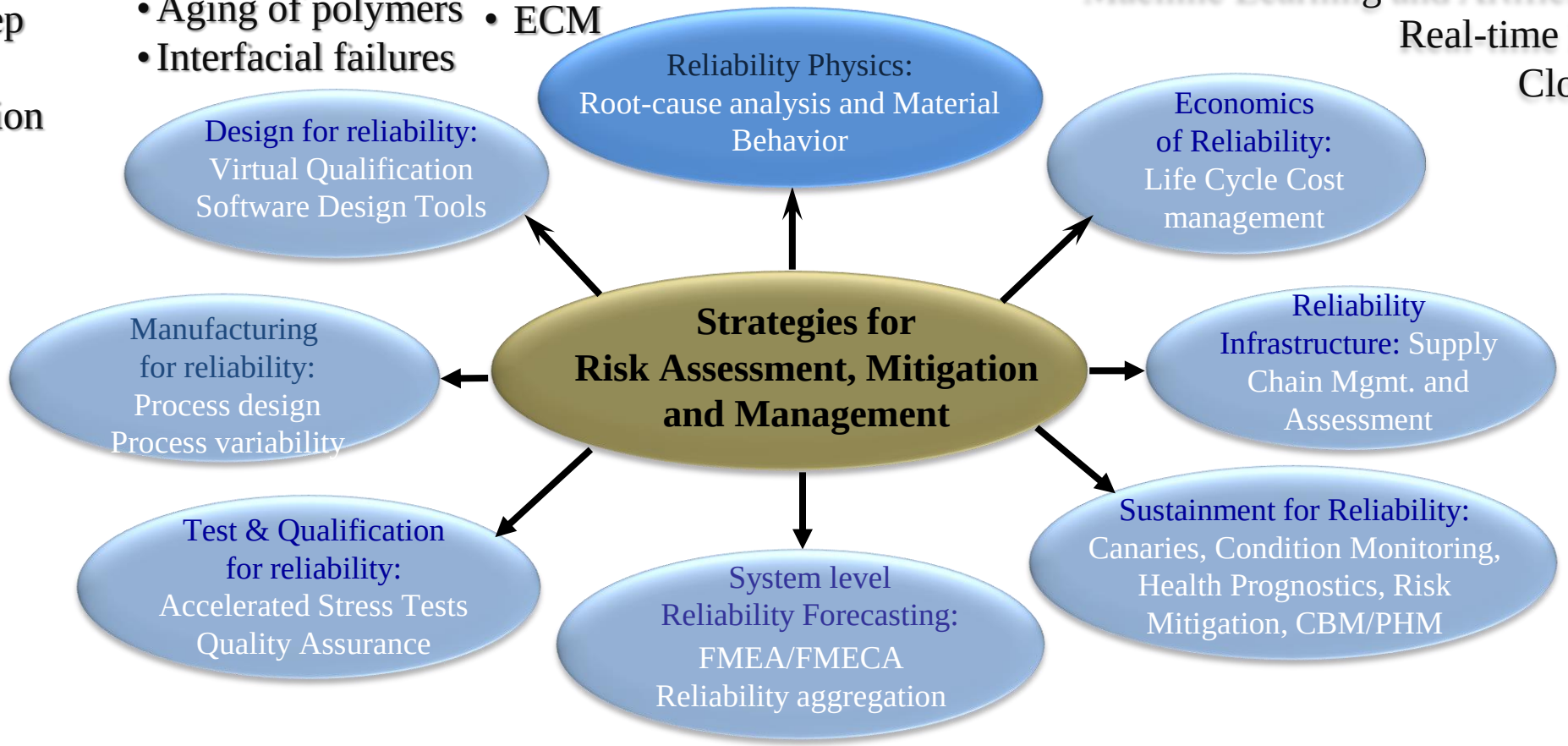
Providing a knowledge and resource base to support the development and sustainment of competitive electronic products

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

- Whiskers
- Aging of polymers
- Interfacial failures

- Corrosion
- ECM

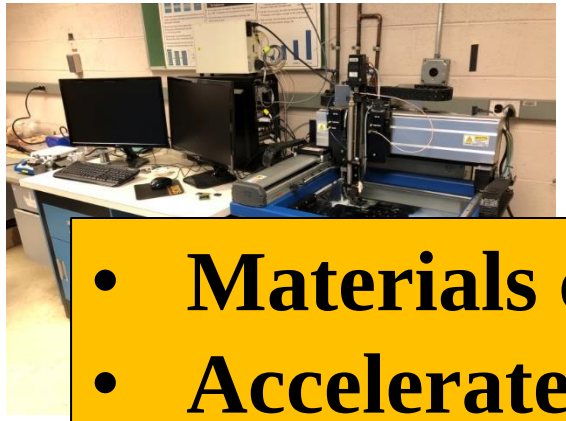
Machine Learning and Artificial Intelligence
Real-time Data Analytics
Cloud Computing
IoT



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

Extensive Test and Measurement Labs

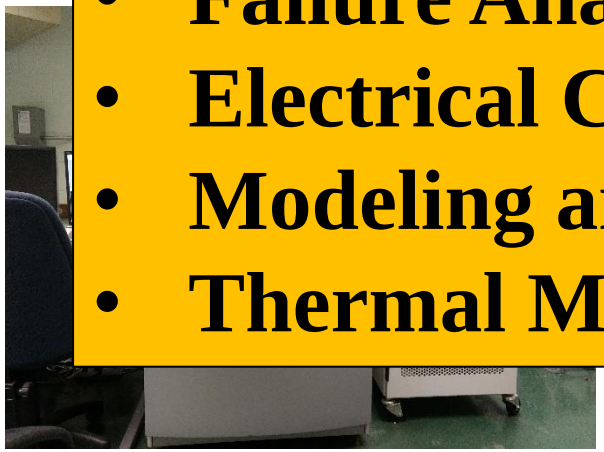
CALCE has a sophisticated test and failure analysis laboratory to support research and industry needs.



- **Materials characterization lab (incl Micro/Nano-Scale)**
- **Accelerated Environmental Testing Labs**
- **Failure Analysis Lab**
- **Electrical Characterization and Diagnostics Lab**
- **Modeling and Simulation Lab**
- **Thermal Management Labs**

Scan

Chamber

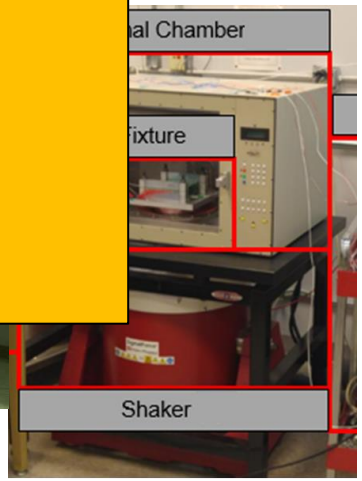


Scanning Electron Microscope and Energy Dispersive Spectroscopy

Dynamic Mechanical Analyzer

Thermomechanical Analyzer

Mixed Flowing Gas Chamber



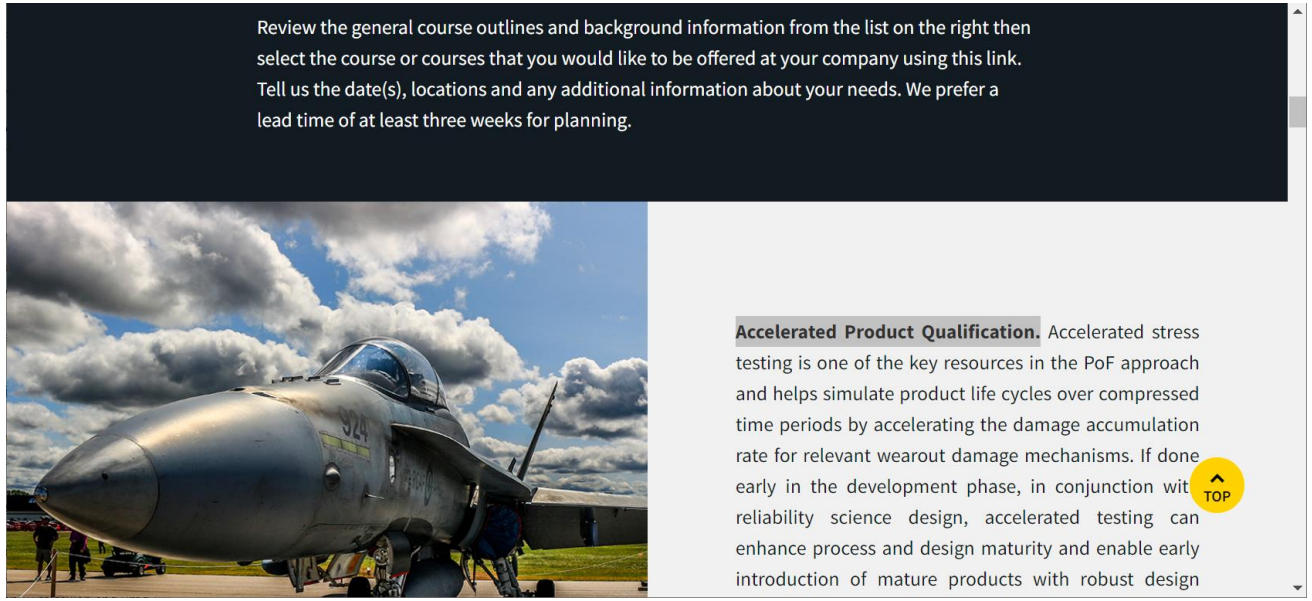
Combined Vib and Temperature Cycling

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

CALCE Professional Development

https://calce.umd.edu/professional-development-courses



- Accelerated Product Qualification.
- Counterfeit Parts Detection Using SAE AS6171.
- Component Documentation and Supply Chain Management for Counterfeit Avoidance.
- Critical System Sustainment.
- Electronic Part Obsolescence Forecasting, Mitigation, and Management.
- Electronic Product and System Cost Analysis.
- Failure Analysis of Electronics.
- High-Temperature Electronics.
- Lead-Free Readiness.
- Light Emitting Diode (LED) Reliability.
- Lithium Ion Battery Testing and Reliability
- Reliability Science.
- Prognostics and Health Management.
- Virtual Qualification and Reliability Assessment.

CALCE Standards Development and Leadership

IEEE 1413: Reliability Predictions

IEEE 1332: Reliability Program

IEEE 1856: PHM

IPC9701 (2020) SMT Solder Attachments

IEEE 1413.1: Guide for Reliability Predictions

GEIA-STD-0005-2: Tin Whiskers

IEEE 1624: Reliability Capability

SAE AS6171: Counterfeit Electronic Parts Test Methods

Picture Source: IEEE Standards Association

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:** 5 Year Effort, 2021-2026
- **Output:**
  - Solder Performance Specification
  - Solder Users Guide
- **Contact:** Michael Osterman (osterman@umd.edu) for more information

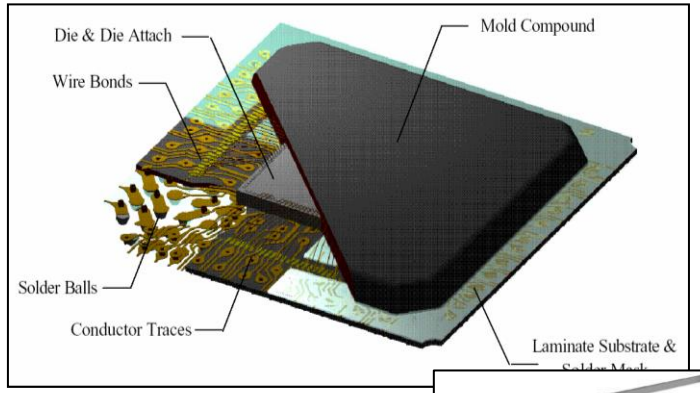
Fee-for-Service Projects

- 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
- Testing
  - Mixed Flowing Gas
  - Flower of Sulfur
  - Vibration
  - Drop
  - Temperature/Humidity
  - Temperature Cycling
- Simulation/Modeling
  - CALCE SARA Software
- Training
  - Failure Analysis
  - Physics of Failure Assessments
  - Prognostics and Health Monitoring

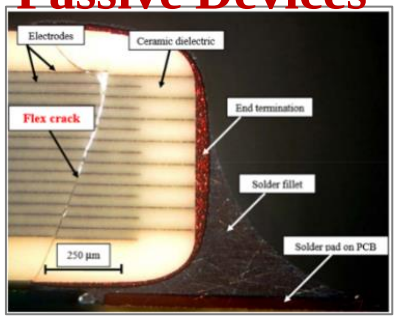
Consortium Studies include Electronic Devices and Interconnects

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

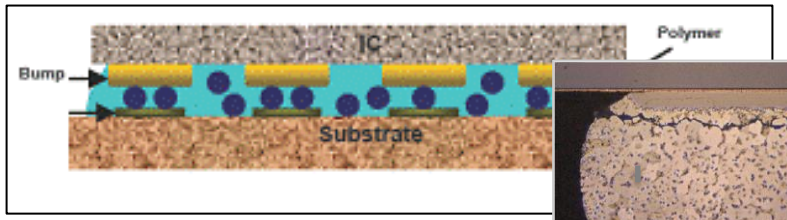
Active Devices

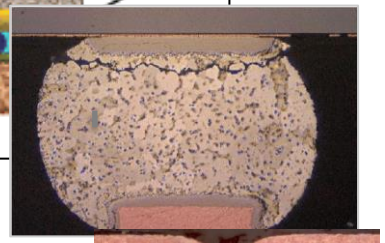


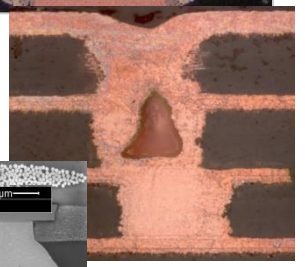
Passive Devices



Interconnects





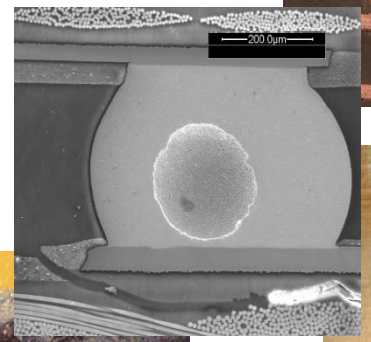


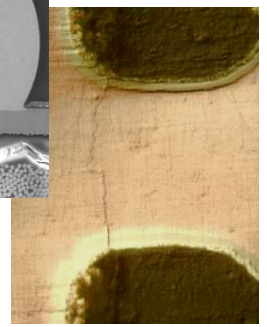
Reliability models and acceleration models can use physics-based and data-based models

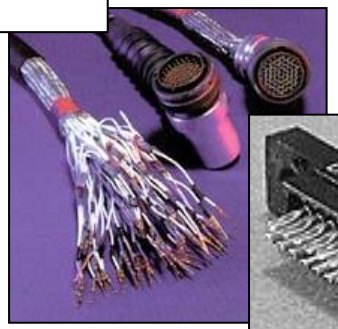
Batteries

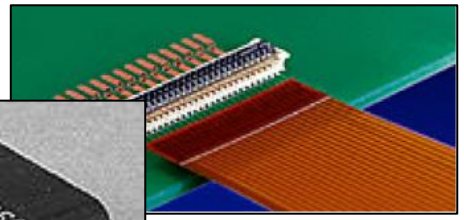
Adhesives

Printed Electronics

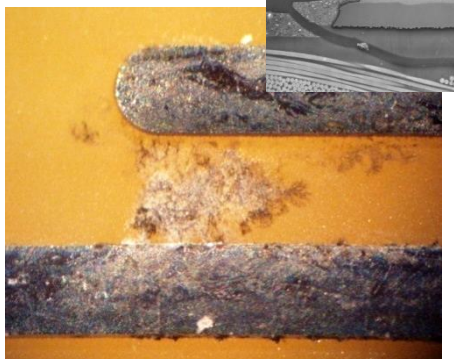








Cables & Connectors



High-Density Substrates

Consortium Studies also include Prognostics and Health Management

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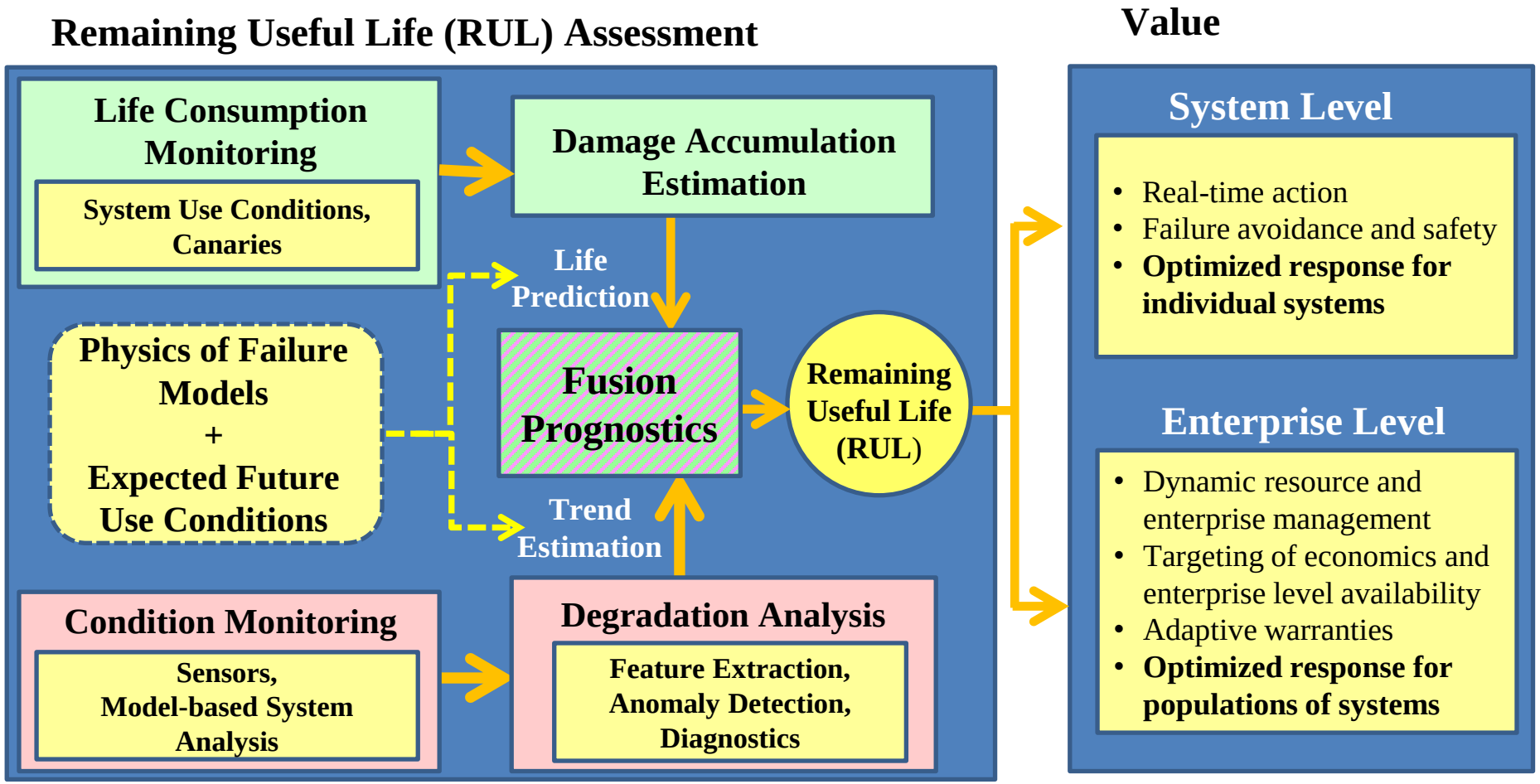
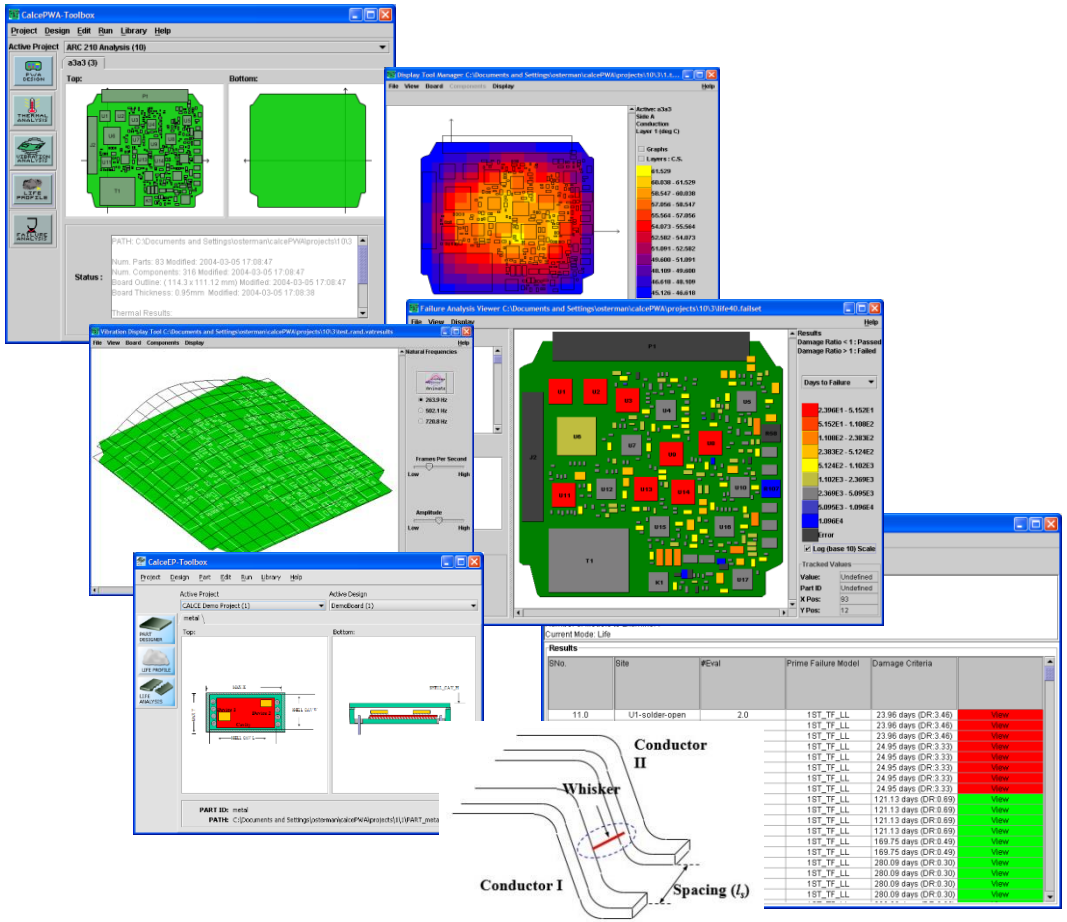


CALCE Simulation Assisted Reliability Assessment Software

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



Assembly, Package and Device Failure Assessment Modules

Body Module Computer

83% reduction in design issues

>10% reduction in time to market

Engine Controller

Virtual qualification of engine Controller identified life limiting design issues

Radio System

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

Software is available for free,
Member get early access to feature and data sets
Training is available

2024 Projects

C24-19 Evaluation of Multilayer Ceramic Capacitors (MLCCs) for Use with Ripple Current (Continuation of C23-19)

C24-22 Fretting Wear and Lubrication of Polymer/Metal Contacts (Continuation of C23-22)

C24-25 Development of a PHM Methodology for Printed Circuit Board Assemblies

C24-03 Effect of Aging and Recrystallization on Performance of Oligocrystalline SAC Solder Joints

C24-26 Paint Delamination and Scratch Resilience for Electronic Products

C24-10 Development of Advanced Board Level Reliability Prediction Model for Power Devices under Autonomous Driving Condition

C24-09 Board level reliability assessment of Bi-based hybrid low melting solder as a function of Bi diffusion

C24-07 Reliability of Lead-free High-Performance Solder Interconnects

C24-08 Reliability of Low Temperature (i.e. BiSn) Solder Interconnects

C24-15 Development of Derating Guidelines for Lithium Ion Batteries

SYMPOSIUM ON COUNTERFEIT PARTS & MATERIALS

SMTA calce

JUNE 25-27, 2024

COLLEGE PARK, MD, USA

The Symposium on Counterfeit Parts and Materials is organized by SMTA in conjunction with CALCE at the University of Maryland. Contact **Dr. Diganta Das** (**diganta@umd.edu**) for more information on the Technical Program and Professional Development Courses and **Karlie Severinson** (**karlie@smta.org**) about the event, exhibition opportunities, accommodation, and registration.

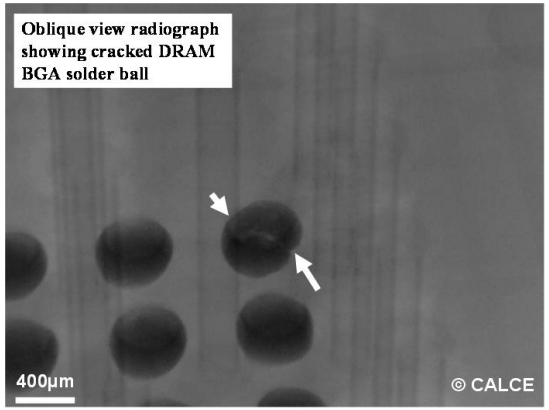
June 25-27, 2024
College Park Marriott Conference Center
College Park, MD

https://smta.org/mpage/counterfeit/

ABSTRACTS ARE BEING ACCEPTED NOW

Short-Course on Failure Analysis of Electronics

at University of Maryland
College Park, MD, USA
November 12-15, 2024



1. Failure analysis techniques
2. Failure mechanisms of electronic products
3. Physics-of-failure and root cause analysis
4. Hands-on laboratory sessions

Course fee: $3000 ($2500 for CALCE Members)

For more information, please contact:

Michael Osterman: +1 (301) 405 3498, osterman@umd.edu

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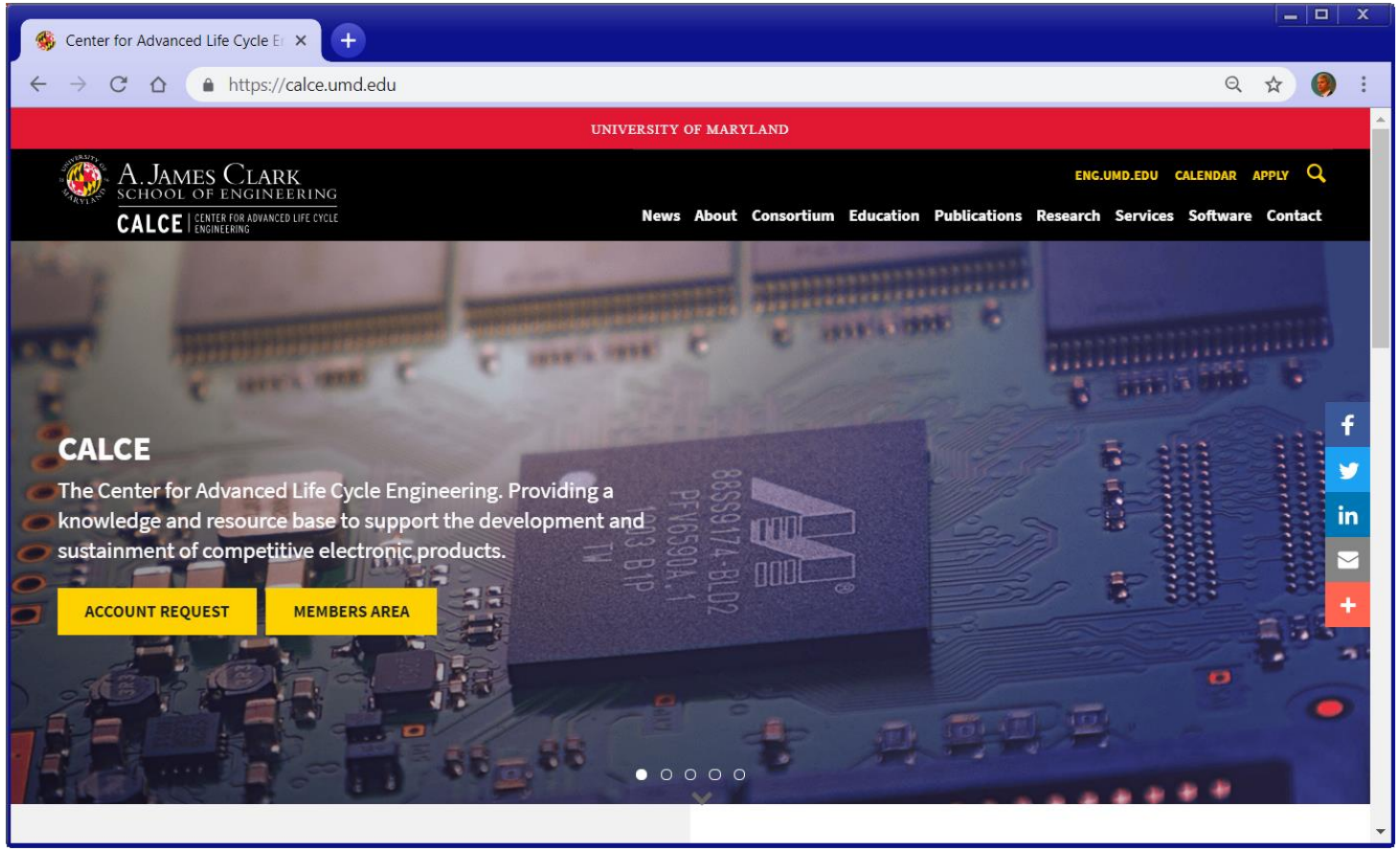
Questions



https://calce.umd.edu/

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