Welcome to the CALCE Reliability Science Symposium

March 16, 2021

https://web.calce.umd.edu/symposiums/RS/2021/Spring/

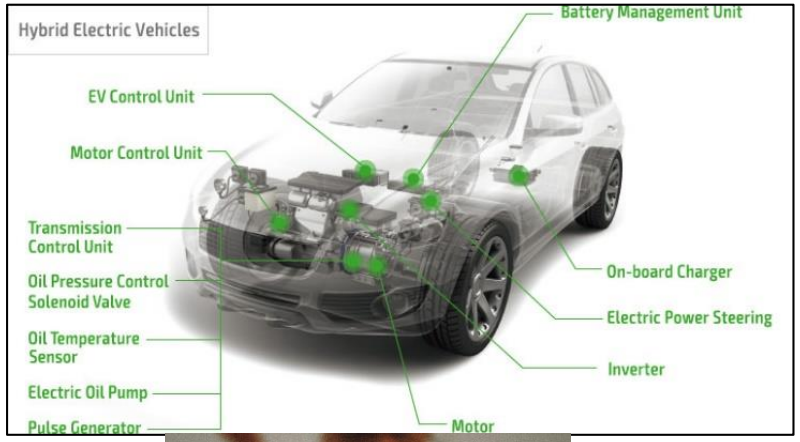
The reliability of electronic products and systems is increasingly critical for autonomous vehicles and vehicle safety systems. The reliability science symposium will present risk assessment, management, and mitigation techniques for heterogeneous integration, additive manufacturing, electrical contacts, life models, prognostics, battery failure mechanisms and life prediction.

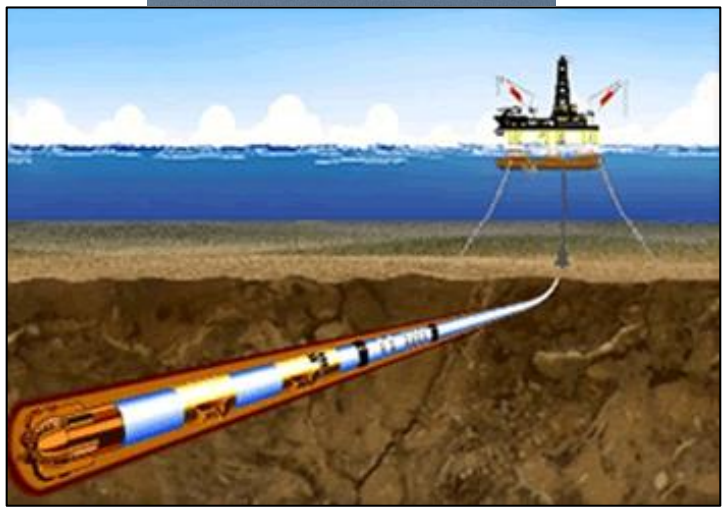
Center for Advanced Life Cycle Engineering

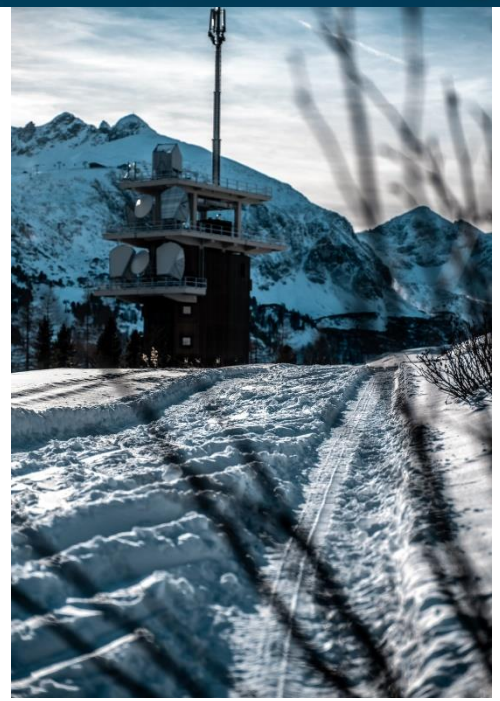
Spring 2021
March 16, 2021

Michael Osterman
osterman@umd.edu
Center for Advanced Life Cycle Engineering
University of Maryland
College Park, MD 20742
USA
(301) 405-8023
http://www.calce.umd.edu

Electronics have become a Vital Part of All Things







CALCE Mission and Thrust Areas Continue To Be Critical

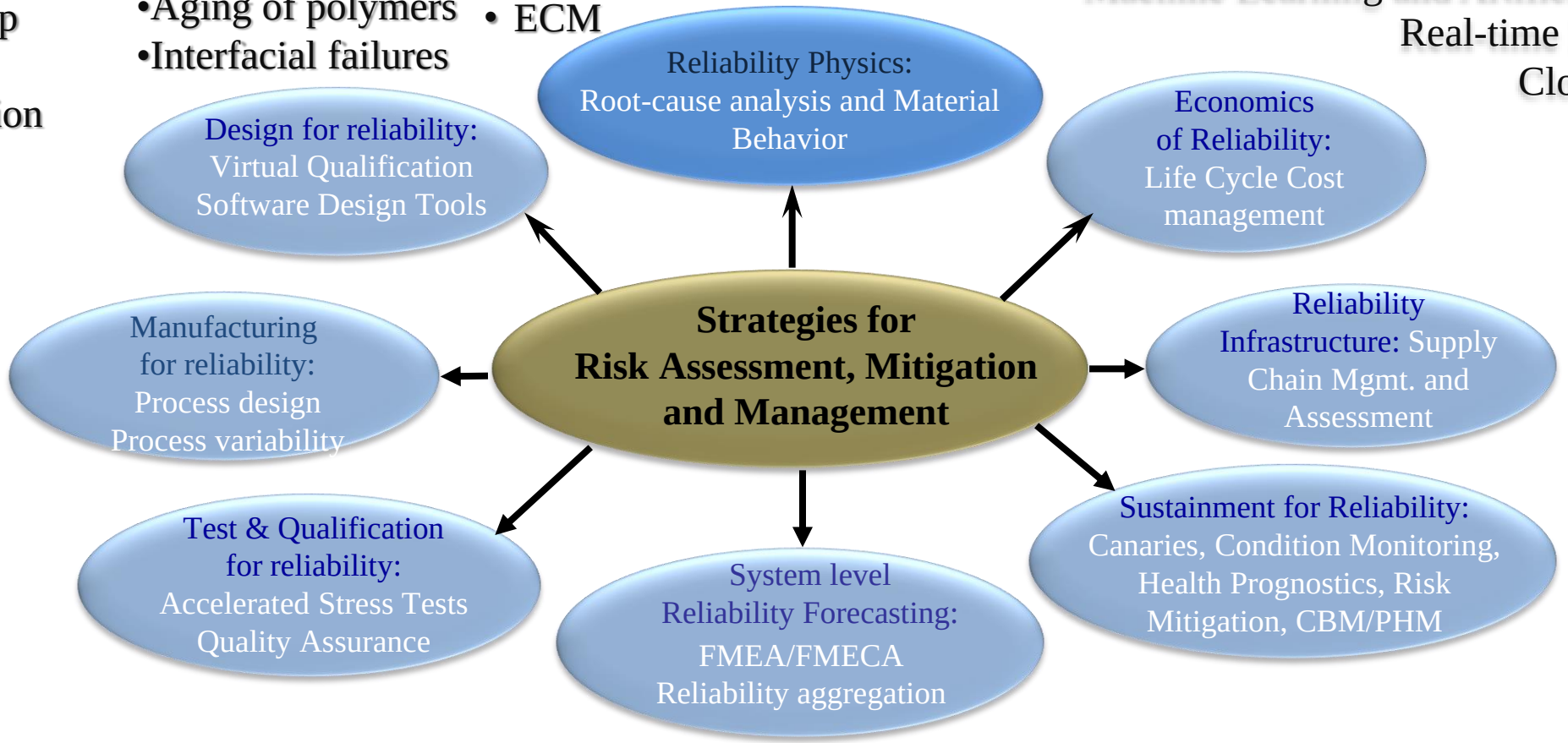
Providing a knowledge and resource base to support the development and sustainment of competitive electronic products

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

- Whiskers
- Aging of polymers
- Interfacial failures

- Corrosion
- ECM

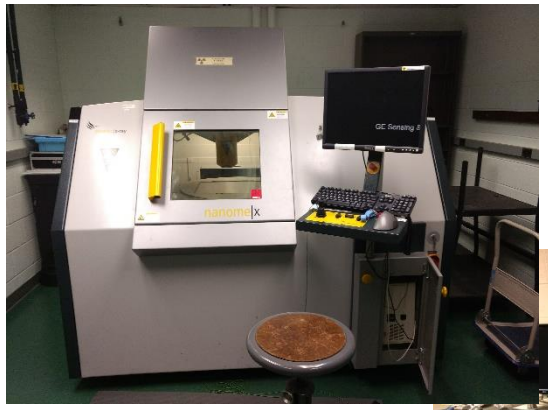
Machine Learning and Artificial Intelligence
Real-time Data Analytics
Cloud Computing
IoT



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.



X-ray Inspection

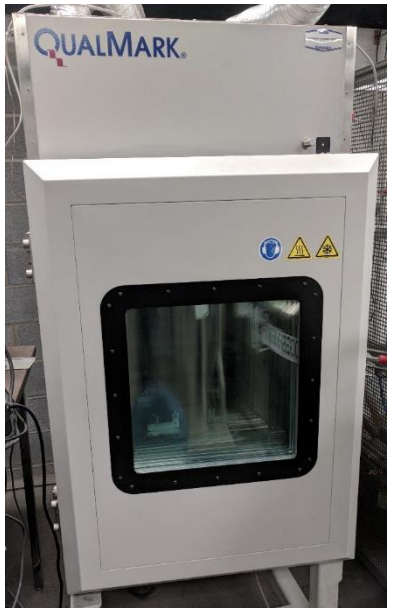
Scanning Acoustic Microscope

Scanning Electron Microscope and Energy Dispersive Spectroscopy

FTIR

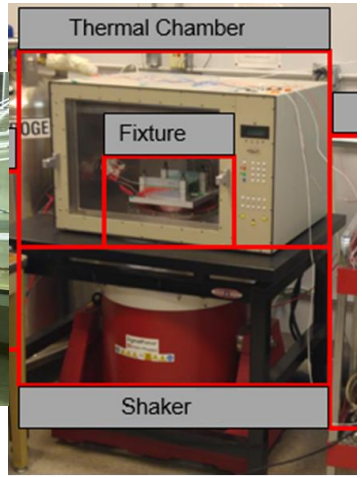
Thermomechanical Analyzer

Temperature Cycle Chambers



HALT Chamber

Mixed Flowing Gas Chamber



Combined Vib and Temperature Cycling

Over 30 Years of CALCE Support of the Electronic Industry

- research, test and consulting services (UMD contract, lab service, consortia membership) .
- over 800 research projects, $100 million in research funding, 1000 published articles) for design, manufacture, life assessment and life management of electronics components, products and systems
- continuing learning opportunities (more 300 webinars, 100 keynotes at conferences, 200+ short courses)
- highly skilled engineers (over 300 Ph.D.’s and 500 M.S.’s) 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
- Embi
- 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.
- 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 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 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

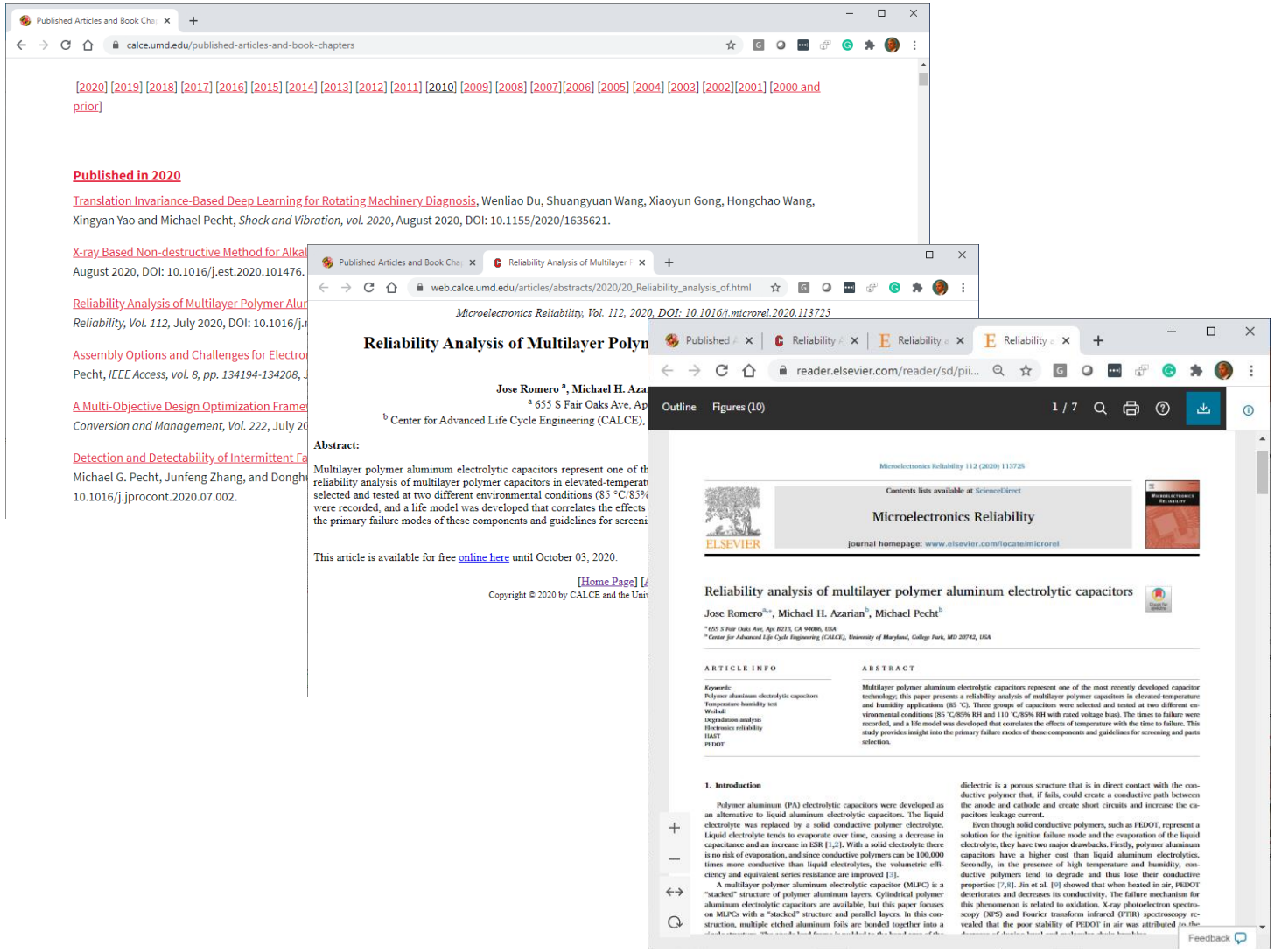
IEEE 1624: Reliability Capability

SAE AS6171: Counterfeit Electronic Parts Test Methods

Picture Source: IEEE Standards Association

CALCE Publications

https://calce.umd.edu/published-articles-and-book-chapters

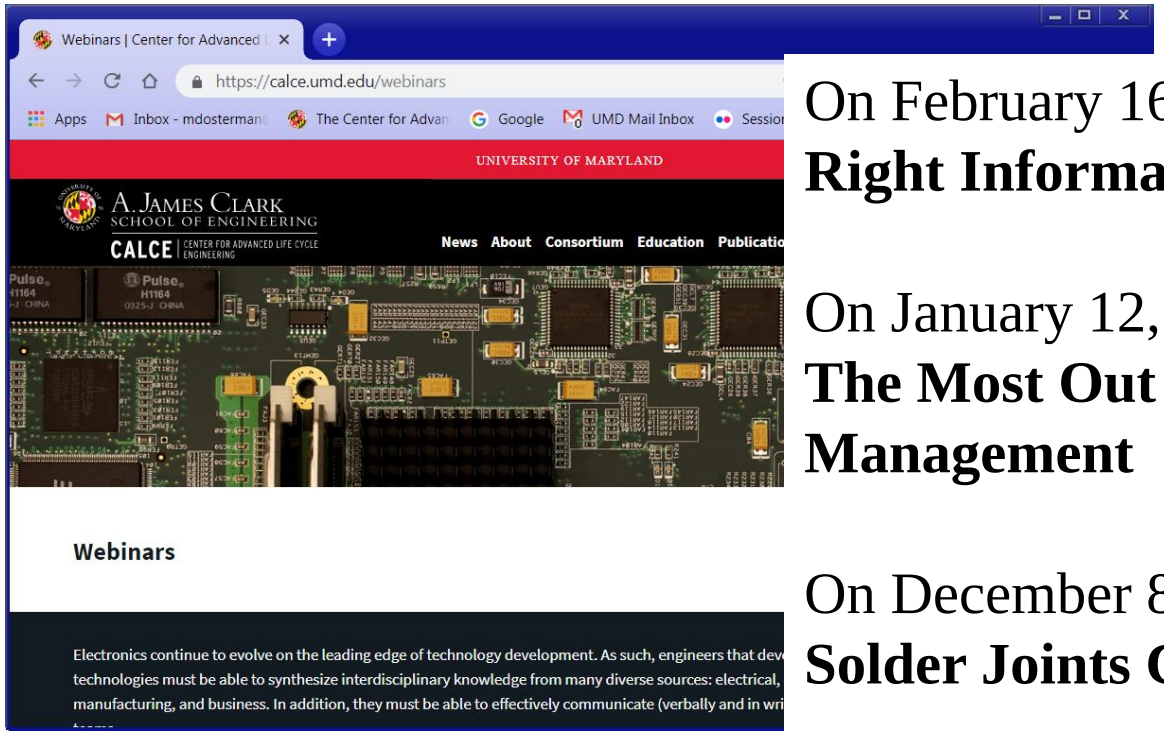


The CALCE website offers a comprehensive collection of publications by CALCE faculty and investigators. With a collection of over 1,000 publications, the CALCE Publication Archive contains a wide selection of journal articles, conference papers, book chapters and more that span the breadth of CALCE's existence, from its inception in 1985 to its most recent research.

CALCE Webinars

https://calce.umd.edu/webinars

CALCE Members have access to over 3 years of recordings and presentations.



On February 16, 2021, Diganta Das presented **Are You Getting the Right Information for Your Electronic Parts?**

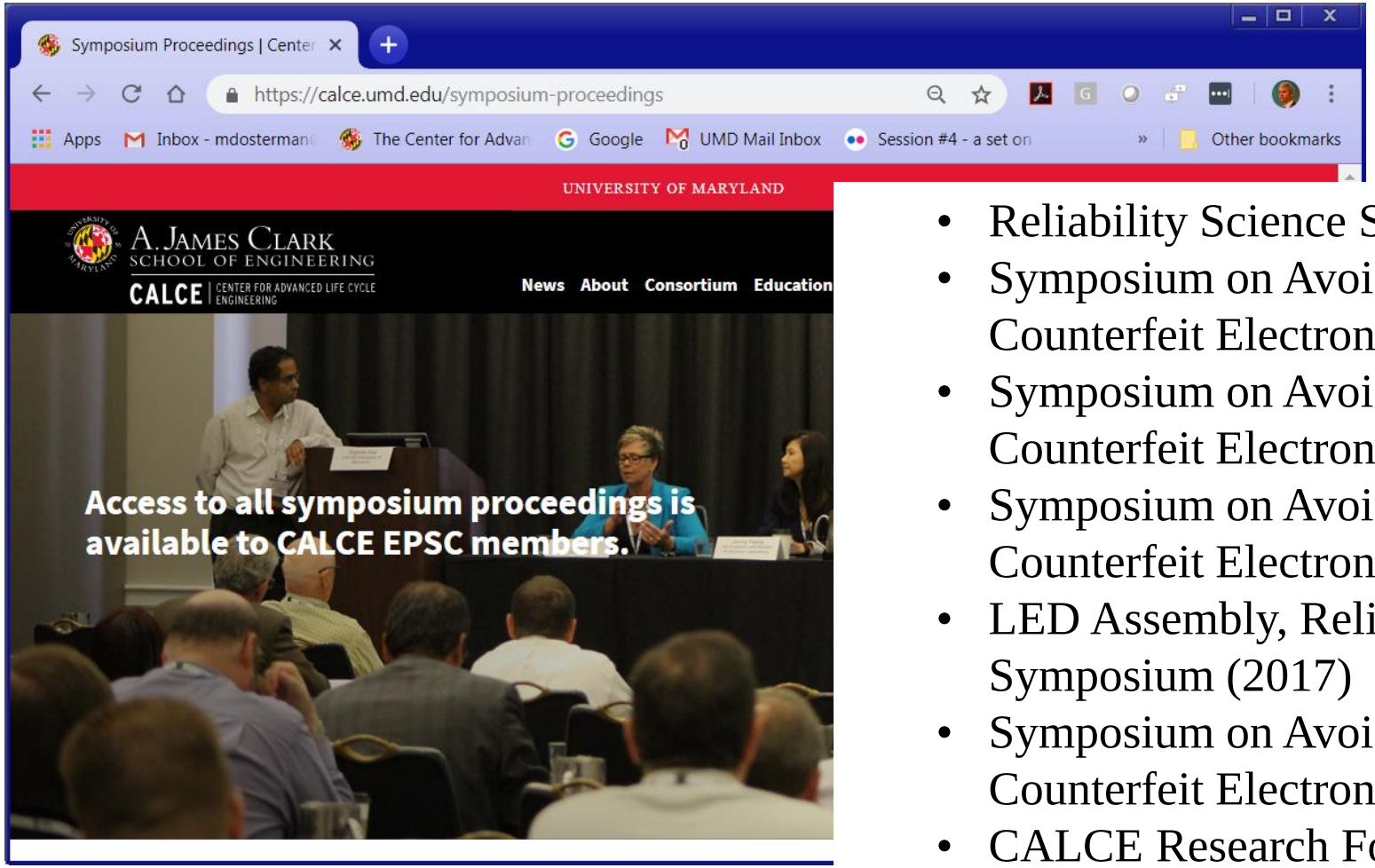
On January 12, 2021, Michael Azarian presented **Are You Getting The Most Out Of Your System? - Prognostics and Health Management**

On December 8, 2020, Qian Jiang presented **Are We Modeling Solder Joints Correctly? A Grain-Scale Modeling Approach**

On November 17, 2020, Abhijit Dasgupta presented **Printed Hybrid Electronics (PHEs): Are They Really Ready for Deployment?**

CALCE Symposium Proceedings

https://calce.umd.edu/symposium-proceedings

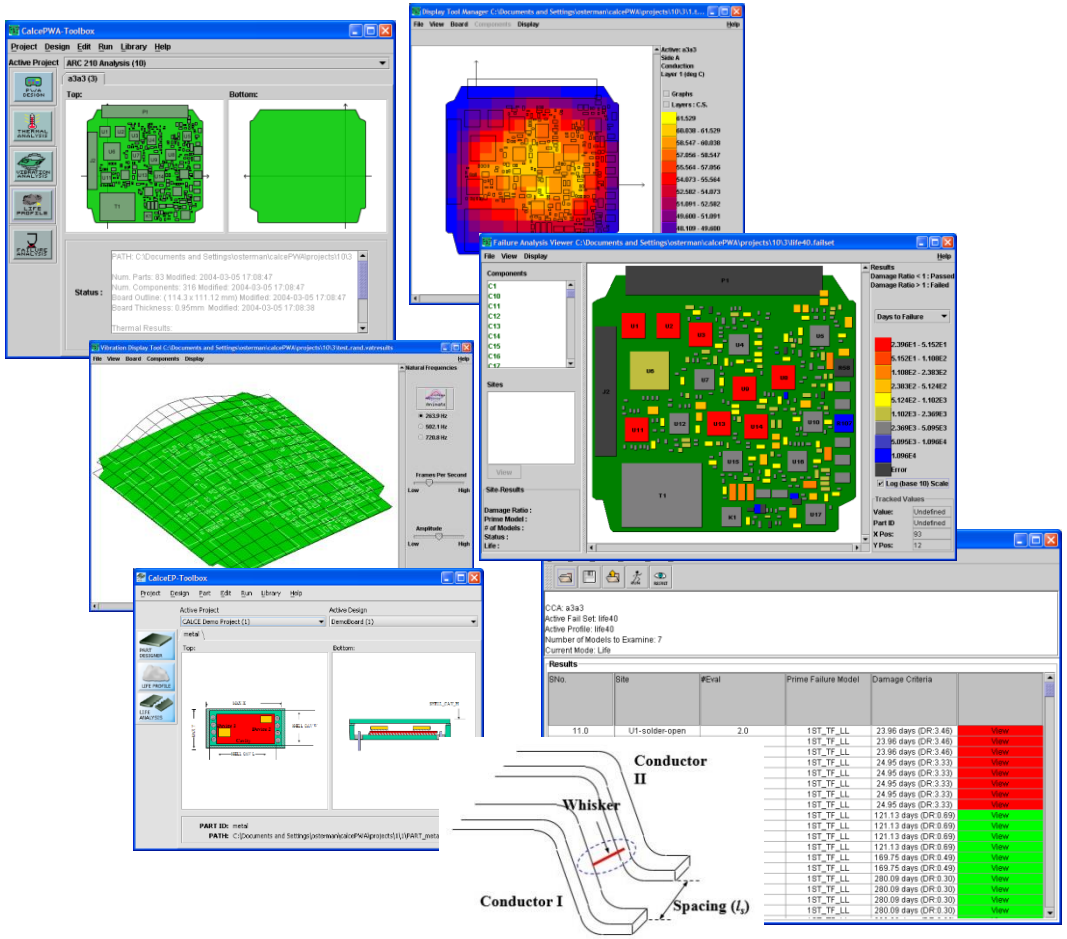


- Reliability Science Symposium Spring 2021
- Symposium on Avoiding, Detecting, and Preventing Counterfeit Electronic Parts (2020)
- Symposium on Avoiding, Detecting, and Preventing Counterfeit Electronic Parts (2019)
- Symposium on Avoiding, Detecting, and Preventing Counterfeit Electronic Parts (2018)
- LED Assembly, Reliability, and Testing (A.R.T.) Symposium (2017)
- Symposium on Avoiding, Detecting, and Preventing Counterfeit Electronic Parts (2017)
- CALCE Research Forum (2017)

Access to symposium proceedings available at this location.

CALCE Simulation Assisted Reliability Assessment Software

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



Assembly, Package and Device Failure Assessment Modules

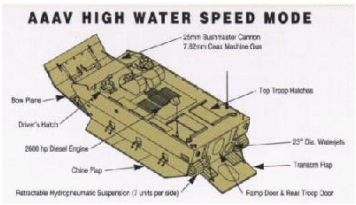
GM

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

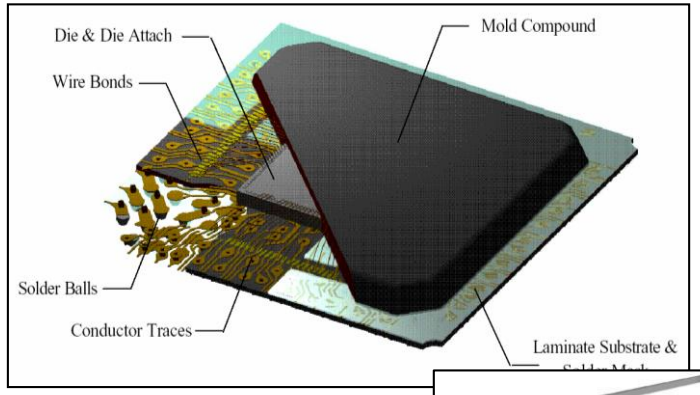
Rockwell Collins

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

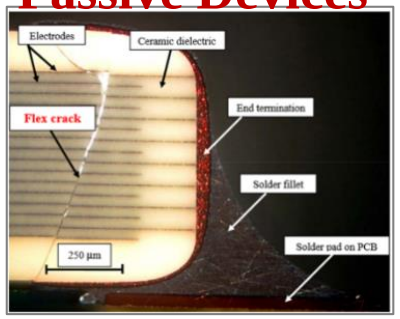
Reliability of Electronic Devices and Interconnects

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

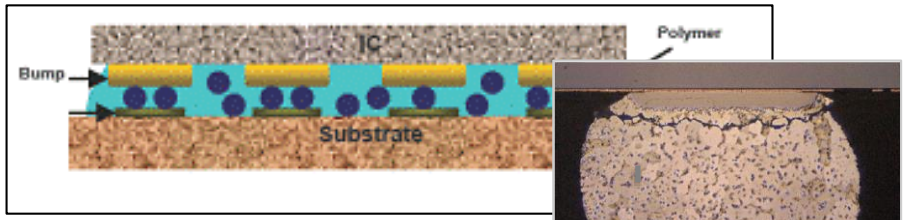
Active Devices

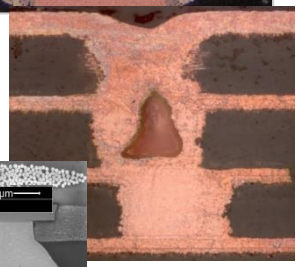


Passive Devices



Interconnects



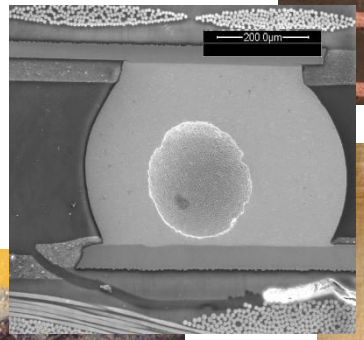


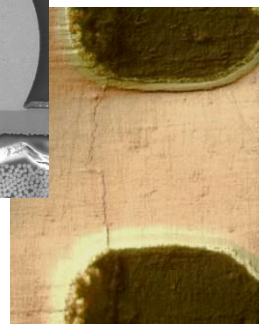
Reliability models and acceleration models can use physics-based and data-based models

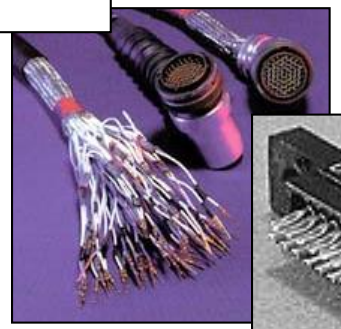
Adhesives

Batteries

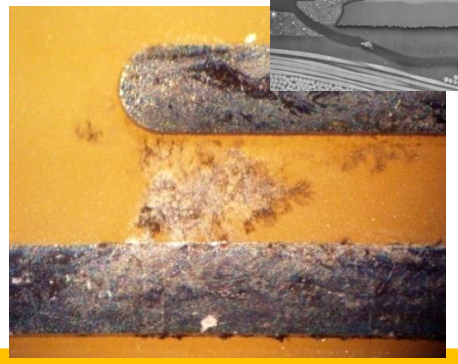
Printed Electronics







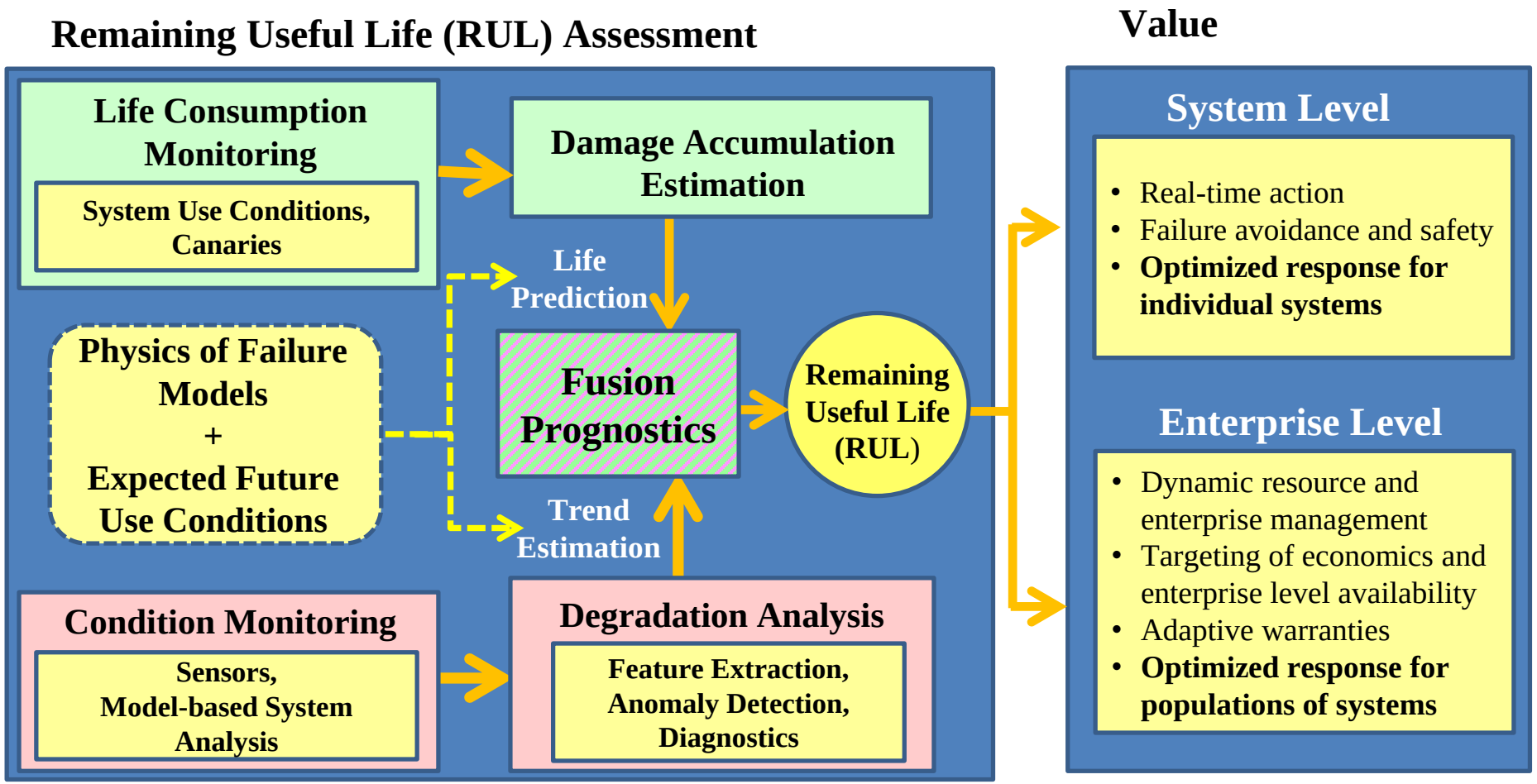
Cables & Connectors



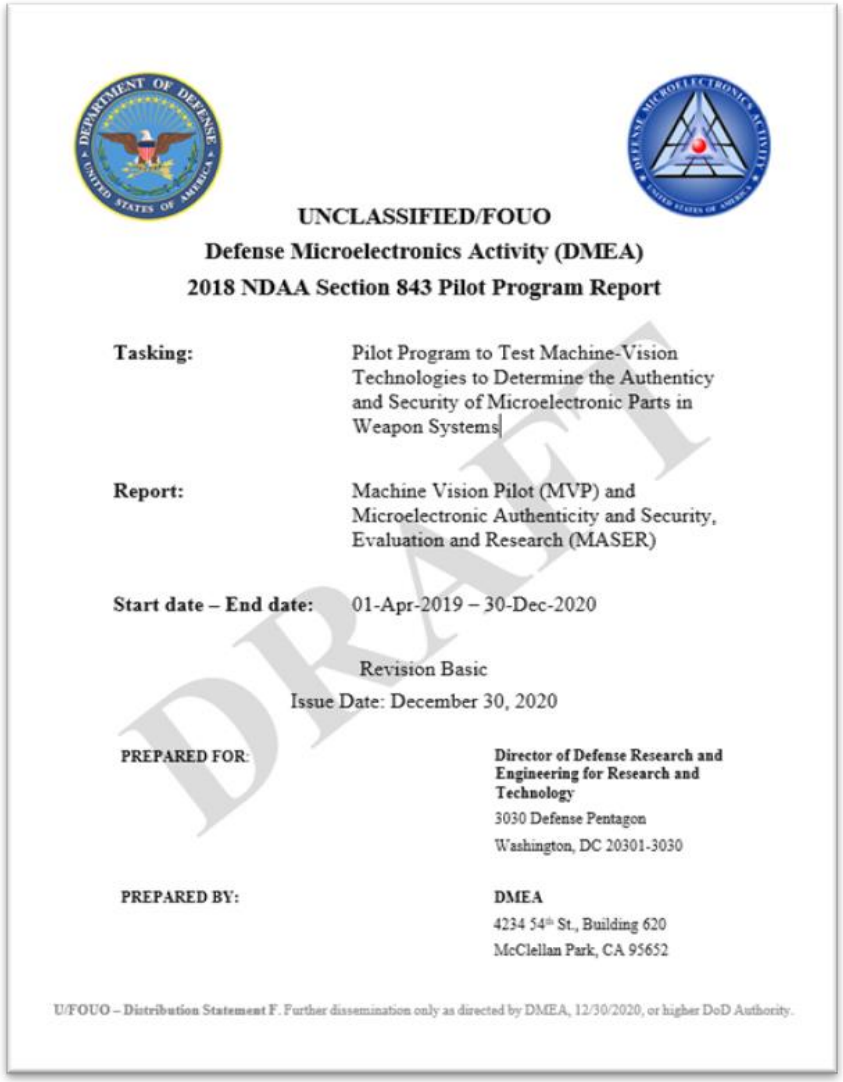
High-Density Substrates

Prognostics and Health Management

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



CALCE Concludes Machine Vision Pilot Study for DoD



UNCLASSIFIED/FOUO

Defense Microelectronics Activity (DMEA)

2018 NDAA Section 843 Pilot Program Report

Tasking: Pilot Program to Test Machine-Vision Technologies to Determine the Authenticy and Security of Microelectronic Parts in Weapon Systems

Report: Machine Vision Pilot (MVP) and Microelectronic Authenticity and Security, Evaluation and Research (MASER)

Start date – End date: 01-Apr-2019 – 30-Dec-2020

Revision Basic

Issue Date: December 30, 2020

PREPARED FOR: **Director of Defense Research and Engineering for Research and Technology**
3030 Defense Pentagon
Washington, DC 20301-3030

PREPARED BY: **DMEA**
4234 54th St., Building 620
McClellan Park, CA 95652

U/FOUO – Distribution Statement F. Further dissemination only as directed by DMEA, 12/30/2020, or higher DoD Authority.

DRAFT

- CALCE performed a 21 month study in 2019-20 for the Defense Microelectronics Activity (DMEA). The study included:
  - Review of emerging counterfeit detection systems and technologies, and comparison with SAE AS6171 standards-based testing, with a blind study of effectiveness with real counterfeits, including clones.
  - Review of existing legislation, standards, requirements, and policies (led by University of Maryland Carey School of Law)
- CALCE worked with ten technology organizations and SMT Corporation to assess the maturity of their technologies and their ability to detect counterfeit parts.
- The study provided a set of long and short term recommendations to the US DoD regarding technology adoption and procurement policies.
- Contact Dr. Azarian (mazarian@umd.edu) or Dr. Das (diganta@umd.edu) for more information.

JHU-APL Partners with CALCE for Interstellar Probe Study

- CALCE received an award from The Johns Hopkins University Applied Physics Laboratory (JHU-APL) for its work on the Interstellar Probe Study (ISP) initiative. This initiative aims to study the environment well beyond the Heliosphere by being able to reach distances of up to 1,000 AU and operate for 50 years or longer.
- This task will identify the processes for both the flight system, the supporting ground infrastructure, and mission staffing to assure a successful outcome when mission success requires 50 plus years of successful operation.
- It will also perform a gap analysis of current status of electronics degradation models and the needs for the interstellar missions.
- Contact Prof. Pecht (pecht@umd.edu) or Dr. Das (diganta@umd.edu) for more information.

USPAE DoD Lead-Free Solder Performance and Reliability Assurance Project

AUBURN UNIVERSITY

PURDUE UNIVERSITY

UNIVERSITY OF MARYLAND

- **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

Compromised Additive Manufacturing Supply Chain Workshop: June 16, 2021

- As part of the NSF project on "*Enterprise Network Models to Disrupt the Operations of Illicit Counterfeit Part Supply Chains for Critical Systems*," led by Prof. Sandborn and Dr. Diganta Das, MChESS will host a virtual workshop on "Compromised Additive Manufacturing Supply Chain."
- The workshop will identify the unique issues posed by compromised additive manufacturing parts and components and how they can be mitigated.
- Participants will include academics, industry practitioners, and stakeholders from the security community whose concern is disruption and compromise of the supply chain for critical systems.
- Contact Prof. Sandborn (sandborn@umd.edu) or Dr. Das (diganta@umd.edu) if you are interested.

2021 Symposium on Counterfeit Parts and Materials: Virtual Event on August 3-5 (https://smta.org/counterfeit)

- This long-running symposium 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: Friday, April 23, 2021
- Contact Dr. Das (diganta@umd.edu) if for more information.

Electronic Products and Systems Consortium Membership Fee

For less than the cost of an entry engineer, get the CALCE Research Team on your side

- $65K per year for regular membership
  - Benefits conferred to a single business location.
  - $15K per year for each additional business location
  - $25K initiation fee.
- $125K per year for enterprise level membership
  - Benefits conferred to all identified participating business locations.
  - $25K one time initiation fee.

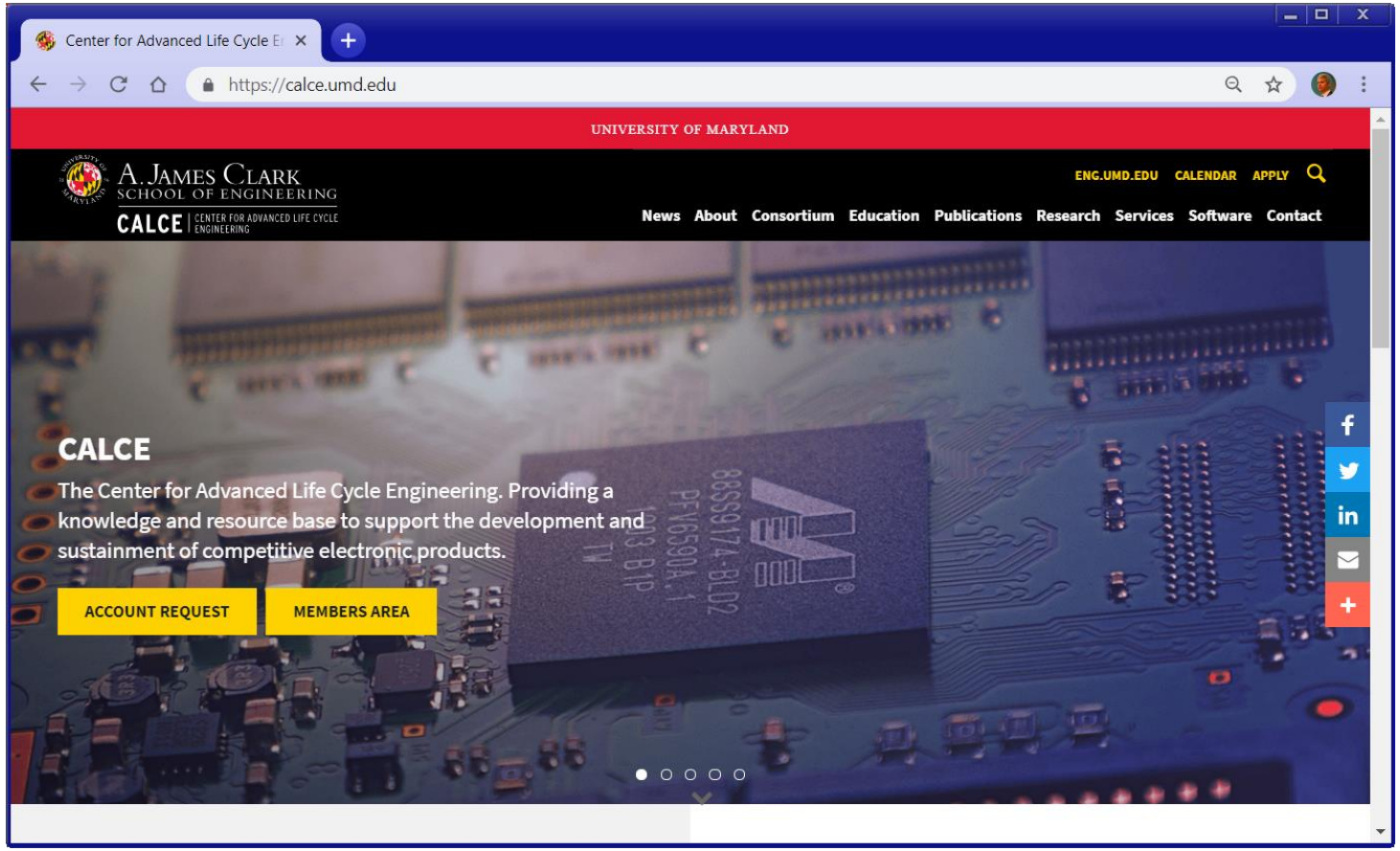
Learn more at https://calce.umd.edu/join-calce-eps-consortium

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

Questions



https://calce.umd.edu/

Michael Osterman
osterman@umd.edu

https://web.calce.umd.edu/symposiums/RS/2021/Spring/

CALCE Reliability Science Symposium Spring 2021

On Tuesday, March 16, 2021, the Center for Advanced Life Cycle Engineering will conduct its bi-annual Reliability Science symposium. This meeting will be conducted virtually and will include an overview of CALCE research activities with several detailed research project presentations. The meeting will open to CALCE members and those individuals interested in learning more about CALCE research. Registration Links are provide below. Presentation links are expected to be active prior to the meeting. However, please note, presentations will only be available to individuals with CALCE Member Web Accounts.

Registration

Download Agenda

March 16, 2021 (Wednesday)

8:45 am - Opening Presentation

9:00 am - Session I (Feedback)

- Solder Interconnect Reliability Studies: Low Temperature Bismuth Tin Solder Alloys and Third Generation Bismuth/Antimony SAC Solder Alloys(Member's Only)
- Modeling Methods for Response of Grain-scale Solder Interconnects to Multiaxial Loading, to Support Virtual Testing and Digital Twin (Member's Only)
- The Durability of IMC and Copper Traces under Vibration & TC loads(Member's Only)
- Viscoplastic Mechanical Properties of Sintered Silver using Indentation Methods(Member's Only)
- Multi-Degree of Freedom Vibration Durability in Electronic Assemblies(Member's Only)

Copies of presentations are limited to CALCE Members

Feedback Is Appreciated!

9:00 am - Session I (Feedback)

Solder Interconnect Reliab

Reliability Science Symposium Feedback Form

Name/Company:

Solder Interconnect Reliability Studies: Low Temperature Bismuth Tin Solder Alloys and Third Generation Bismuth/Antimony SAC Solder Alloys

Interest In Topic (5 being excellent): ○ 1 ○ 2 ○ 3 ○ 4 ○ 5

Quality of Presentation (5 being excellent):: ○ 1 ○ 2 ○ 3 ○ 4 ○ 5

Comments and Suggestions: