SAND2008-2401C

Joint DoD/DOE Munitions Program (JMP)
Five Year Plan
Predictive Materials Aging & Reliability
for FY09-13 Project Plans

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Sandia National Laboratories

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Predictive Materials Aging & Reliability
Five Year Plan for FY09-13

Performing Organization: Sandia National Laboratories
Project Lead: Rob Sorensen, MS0889, 505-844-5558, nrsoren@sandia.gov

Customer	**Collaboration**
Tom Erickson, Tom.erickson@us.army.mil, 256-876-0218 (Redstone)	*TCG XIV DoD customer.*
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Dan Kral, djkral@sandia.gov *505-844-4104*	*NNSA Satellite Programs (DoE) providing leveraged support for the 3-D package-on-package sub-task*
Picatinny Arsenal *(Army Corrosion Office)* *Jim Zunino, 973-724-7633, james.zunino@us.army.mil* *Don Skelton, 973-724-4071, donald.skelton@us.army.mil* *Robert Kuper, 201-572-4085, robert.kuper@us.army.mil*	*-MEMS Reliability Program* *-Development of specifications and standards directly applicable to MEMS devices*
Redstone Arsenal (AMRDEC) *Abdul Kudiya* *Dave Locker*	*-MEMS IMU for common guidance* *-Development of reliability analysis tools, e.g. MEMS reliability fault tree*
NSWC *Mike Bucher, 301-744-6174, michael.bucher@navy.mil* *Michael Deeds, 301-744-1933, michael.deeds@navy.mil*	*-NSWC S&A – Diagnostic Test structures, transitioning to accelerated aging structures and testing* *-First set of diagnostic designs to be submitted to NSWC lab 4/2008*

Predictive Materials Aging & Reliability
Five Year Plan for FY09-13

Customer	Collaboration
D. Locker, ARMDEC	**COTS component reliability**
Dr. W. Shankle, ARMDEC	**Developer of RRAPDS data logger and interrogator for long term dormant storage tests**
Steve Marotta, ARMDEC	**DoD Embedded Evaluation**
Alexander Steel, ARMDEC	*Army Corrosion / Materials*
Navy – China Lake *Dave Dunaj, david.dunajWnavy.mil* *951-204-4933*	*Rolling Air Frame Missile POC, steering group member*

Predictive Materials Aging & Reliability Funding

Planned:

FY09	FY10	FY11	FY12	FY13
$1,200K	$1,250K	$1,300K	$1,300K	$K

Historical:

prior FYs	FY04	FY05	FY06	FY07	FY08
	$1190K	$1056K	$1235K	$760K	$1,314K*

Values include the total of both DoD and DOE $s
*COTS task merged into Materials Aging projectin FY08

Project '*Name*' Funding by Task for FY09

Tasks *	Funding**
1. Solder Interconnect Reliability	$180K
2. Corrosion of Electronics	$190K
3. Degradation of Adhesives	$190K
4. MEMS Reliability	$170K
5. Military Use of COTS Electronics	$490K
Total FY09 Project Funding	$1,260K

*Indicate a new task as "(new start)" next to title
**Indicate any previous-year task that was terminated as $ 0K

Values include the total of both DoD and DOE $s
(Includes $20K project management)

Predictive Materials Aging & Reliability GOTChA

Goal: ------ Predict the effect of materials aging on system performance (solder, corrosion, adhesives, MEMS) --------

Objective: --- Develop physical-based models for key degradation processes. ------

Challenges: --

Solder
- Modeling the mass transport mechanisms of Sn-whiskering
- New technology (3-D packaging) requires new understanding

Corrosion
- Environment (micro & macro unknown)
- Corrosion is controlled by latent defects
- Electrical system model unavailable
- Validation data do not exist

Adhesives
- Measuring hydrolysis in ultrathin (~100 Å) silane films in adhesive joints
- Extrapolating to low temperature, low water content, and a range of pH
- Validating model for a range of silane chemistry

MEMS
- Test structures in surface polysilicon and LIGA only
- Mechanism-properties relationships do not exist
- No link to reliability of MEMS devices
- No mechanism for translating results into DOD/DOE device design.

Predictive Materials Aging & Reliability GOTChA

Approach: ---

Solder
- Use test techniques to determine kinetics important to Sn whiskering.
- Develop 3-D packaging test vehicles & aging parameters based on real failure mechanisms.

Corrosion
- Use engineered aging structures to monitor corrosion
- Develop corrosion model for known defects and degradation modes
- Generate a device-level failure criterion & model
- Validate with field returned units & dormant storage parts

Adhesives

Use finite element codes to predict failure of adhesive joints.

Start simple & progress to more complicated systems.

MEMS
- Start with SOI as MEMS (relevant to DOD/DOE missions)
- Design test structures that can be used to assess reliability
- Produce MEMS test structures with various fab locations and processes

Tasks: ---

Solder
- Obtain Sn diffusion rate kinetics by creep tests
- Evaluate 3-D package test vehicles
- Evaluate accelerated aging conditions.

Corrosion
- Complete bondpad model f([Cl], RH, T)
- Develop EAS structures for bondpad & connector corrosion
- Deploy EAS structures with tuned sensitivity in storage locations
- Perform failure analysis on field returns (database)

Adhesives
- Predict debonding in a NEAT system
- Predict debonding in an adhesive/primer system
- Predict debonding of a system with a silane coupling agent

MEMS
- Develop key mechanism-properties relationships in SOI
- Develop key mechanism-properties relationships in 2nd processing technology

Solder Interconnect Reliability

What are you trying to do in this task?

- Assess interface reactions (microstructure and rate kinetics) between Pb-free solders and Pd.
- Develop a computational model to predict Sn whisker growth.
- Investigate 3-D packaging technology for high-reliability applications.

What difference will it make?

- Understanding Sn-Ag-Cu/Pd reactions will minimize process defects and reliability concerns of Ni/Pd/Au finishes.
- A Sn whisker growth model will address reliability concerns with COTS parts having 100% Sn finishes.
- A reliability database will be the primary enabler of 3-D packaging technology for weapons, satellite,space, and other high-reliability applications.

What makes you think you can do it?

- Sandia has an extensive experience in the study of Pb-free interface reactions.
- Sn whisker model development is a joint effort between Sandia materials and computational engineers and materials scientists at U. of Rochester (NY).
- Contractor (ACI) and Sandia facilities are engaged in the test vehicle evaluation.
- *Partnering with other SNL programs jointly supporting Sn whisker model and 3-D packaging studies.*

What / When / To Whom Will You Deliver?

- Journal Article on Pd interface reactions posted to JMP website 06/08.
- Conference article on Sn whisker model posted to JMP website 03/08
- Journal article of 3-D packaging reliability on JMP website – 09/11.

Corrosion

What are you trying to do in this task?

- Produce a validated, physical based model of bondpad & connector corrosion
- Develop engineered aging structures (EAS) to TRL level 7.
- Use EAS deployed in real environments to obtain validation data for the corrosion model.

What makes you think you can do it?

- A first generation model of bondpad corrosion exists.
- Uncertainty quantification techniques are available
- Extensive SNL program on embedded surveillance (electronics, sensor, communication expertise)

What difference will it make?

- The corrosion model will allow us to make reliability predictions based on corrosion in PEM devices and connectors.

What / When Will You Deliver?

- Connector corrosion model (11/08)
- Integrated EAS / sensor package (1/09)
- Demonstration of SOHPAC – using EAS & sensor data in a reliability prediction (10/08, 6/09)
- Report on embedded evaluation efforts in DoD & DOE (11/09)

Adhesion

What are you trying to do in this task?

- Predict the critical stresses for adhesive debonding
- Predict the change in debonding stress with component age
- Relate the debonding stress to processing history

What makes you think you can do it?

- Leverages previous SNL-funded research on predicting adhesive strength
- Combines experimental and computational expertise
- Adhesion working group involves DOE and DoD members to focus activities and smooth transitions

What difference will it make?

- Component designs can be more robust if debonding stress margins are known
- Knowledge of aging mechanisms improve material selection for given environments
- Processes can be defined to improve adhesive strength

What / When / To Whom Will You Deliver?

- Deliverables are component specific, finite element based codes and procedures to predict debonding
- Delivery will be staged to provide capability on successively more difficult systems
- Four deliverables are proposed in the five year plan

MEMS Reliability

What are you trying to do in this task?

- Demonstrate a series MEMS diagnostic test structures in a DOD fabrication process
- Use test structures to address specific issues with NSWC S & A (adhesion etc.) and develop accelerated aging protocol

What makes you think you can do it?

- Experience designing reliability test structures
- Ability to draw from standardized accelerated aging protocols
- Flexible planning driven by MEMS steering group meetings

What difference will it make?

- Elucidate mechanisms of adhesion failure in NSWC S&A
- Accelerated aging study results on a series of diagnostic structures
- Foundational study for developing MEMS-based reliability standards

What / When / To Whom Will You Deliver?

- first series of designs to NSWC for a 4/2008 fab run
- Results from evaluating test structures to NSWC 1/2009
- proposed accelerated aging protocol 1/2009

Task *COTS* Four-Question Chart

What are you trying to do in this task?

- **Assess new Commercial Off the Shelf (COTS) technologies and assure the long term reliability of these technologies meet high-reliability environments**
- **Develop more efficient assessment processes and models for new technologies**

What makes you think you can do it?

- **Initial processes and models have been used to predict life of W76-1 components under accelerated temperature/humidity conditions.**

What difference will it make?

- **Confidence in COTS electronic components selected will meet design storage life requirements**

What / When / To Whom Will You Deliver?

- **New technology assessments shared between DOE and DoD FY09-F012**
- **Validated PC based code for reliability predictions of a limited number of current leaded and LCC SMT COTS components – FY09**
- **Life predictive models for new COTS technologies. – FY10**

Solder Interconnect Reliability Key Personnel

Name	Org	Role
Paul Vianco *ptvianc@sandia.gov* *505-844-3429*	*Sandia National Laboratories, Albuquerque, NM*	*Task Leader*
Tom Erickson *tom.erickson@rdec.redstone.army.mil* *256-876-2781*	*US Army RDECOM* *Redstone Arsenal, AL*	*Customer*
Professor: Dr. J.C.M. Li *li@me.rochester.edu* *Graduate student: Ms Jing Cheng* *jcheng@me.rochester.edu*	*University of Rochester, NY*	*Principle investigators on a portion of the Sn whisker modeling sub-task.*
Jeff Braithwaite *jwbrait@sandia.gov* *505-844-7749*	*Sandia National Laboratories, Albuquerque, NM*	*Enhanced Surveillance Campaign (DoE) providing leveraged support for the Sn whisker modeling sub-task.*
Dan Kral *djkral@sandia.gov* *505-844-4104*	*Sandia National Laboratories, Albuquerque, NM*	*NNSA Satellite Programs (DoE) providing leveraged support for the 3-D package-on-package sub-task*

Corrosion of Electronics
Key Personnel

Name	Org	Role
Rob Sorensen *nrsoren@sandia.gov* *505-844-5558*	*Sandia National Laboratories, Albuquerque, NM*	*Task Leader*
Tom Erickson *tom.erickson@rdec.redstone.army.mil* *256-876-2781*	*US Army RDECOM* *Redstone Arsenal, AL*	*Customer*
Lysle Serna *lmserna@sandia.gov, 505-284-4495*	*Sandia National Laboratories*	*PI on connector sulfidation effort.*
Harry Moffat *hkmoffa@sandia.gov, 844-6912*	*Sandia National Laboratories, Albuquerque, NM*	*Modeling of connector contact resistance.*
James Stamps	*Sandia National Laboratories CA*	*Electronics interface, testbed design, data bus*
Steve Marotta	*US Army RDECOM Redstone Arsenal, AL*	*DoD embedded evaluation*

Adhesion Task - Key Personnel

Name	Org	Role
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Mike Bucher (michael.bucher@navy.mil; 301-744-6174)	*Indian Head*	*TCG-XIV Navy Co-Chair*
Dave Dunaj (david.navy.mil; 951-204-4933)	*China Lake*	*Navy adhesion working group member*
Alexander Steel (alexander.steel@us.army.mil; 256-876-3867)	*RDECOM*	*Army adhesion working group member*

MEMS Reliability - Key Personnel

Name	Org	Role
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Brad Boyce *blboyce@sandia.gov* *(505)-845-7525*	*Dept. 1824* *Sandia Labs*	*Mechanical Properties*
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COTS - Key Personnel

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TCG XIV
Predictive Materials Aging & Reliability

Problem: Aging occurs at the materials level (not the component or system level).
Effective predictions of future age-induced performance changes must be based at some level on degradation physics.

COTS Reliability

Solder Fatigue
(interconnect reliability)

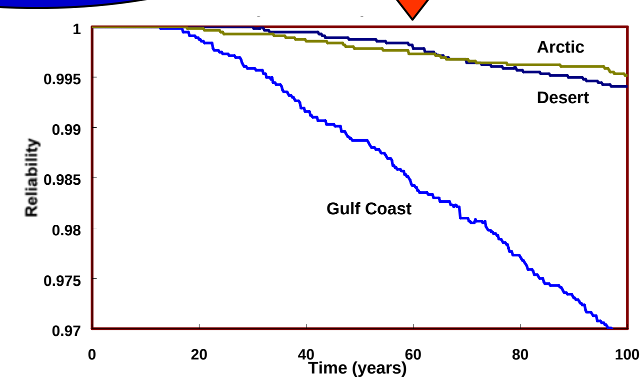
Corrosion

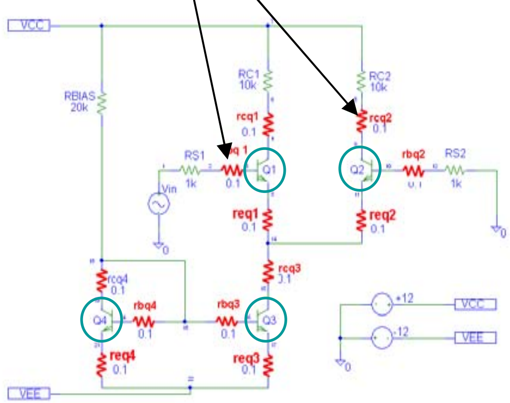
MEMS Reliability

Adhesives Degradation

Materials Degradation Model

System or Component Performance Model



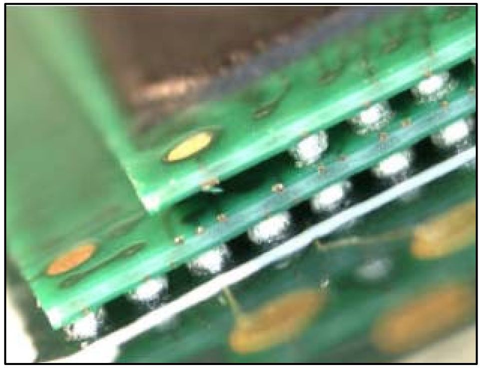


Sub-task: **3-D Packaging Technology**

- **Issue:**
  - **There is an increased need to reduce the size and weight of flight system electronics, while at the same time, increasing guidance, control, arming, and fusing functionality.**
  - **3-D packaging - stacked die or package-on-package (PoP) - offers the next step in advanced electronic package that can effectively address this need.**

- **Objective**

  Assess the reliability of advanced 3-D packaging technologies, which integrate the functions of stand-alone components, for flight and ground military systems.

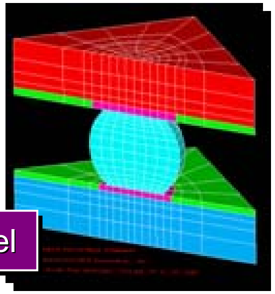


Solder Interconnect Reliability

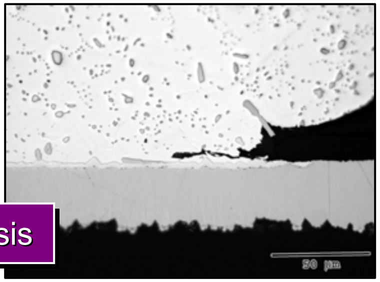
Sub-task: **3-D Packaging Technology**

- **Technical approach:**
  - **The focus will be on package-on-package (PoP) as this technology has a wider utilization base in the electronics assembly community (OEMs and contract manufacturing).**

1. **Identify suitable test vehicle(s) and accelerated aging protocols.**
2. **Utilize computational modeling to predict long-term reliability.**
3. **Perform accelerated aging experiments.**
4. **Compile solder interconnection lifetime data and failure mode analysis results.**
5. **Validation of computational model(s).**
6. **Develop utilization guidelines.**



Model



Failure mode analysis

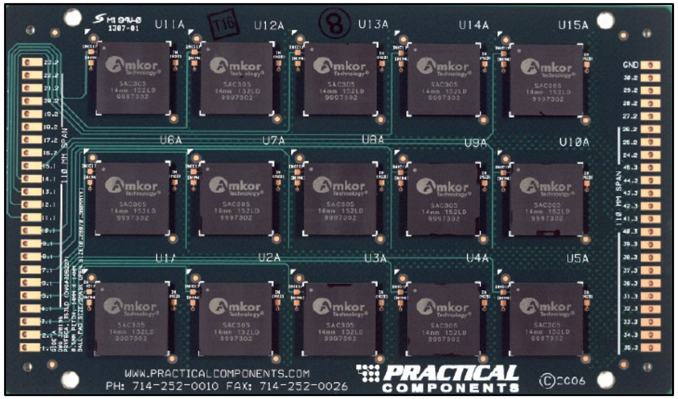
Solder Interconnect Reliability

Sub-task: **3-D Packaging Technology**

- **Accomplishments:**

1. **The American Competitiveness Institute (Philadelphia, PA) assembled all of the test vehicle printed wiring assemblies.**

   - **Top package:** **152 I/O BGA; 0.65 mm pitch; SAC305* solder balls**
   - **Bottom package:** **353 I/O BGA; 0.50 mm pitch; SAC305 solder balls.**
   - **Circuit board finish:** **Organic solderability preservative (OSP).**
   - **Assembly processes:** **SAC305 (Pb-free) … Qty. = 50**
Sn-Pb (backwards compatibility) … Qty. = 50
   - **One-half of each group (Qty. = 25) had the BGAs underfilled to address potential shock-and-vibration requirements.**



***SAC305 is the Pb-free solder 95.5Sn-3.0Ag-0.5Cu.**

Solder Interconnect Reliability

Sub-task: **3-D Packaging Technology**

- **Accomplishments:**
  - **Started accelerated aging:**
    -55°C/125°C, 10 min holds, 20C/min
  - **Cycles ……… 0, 500, 1000, 1500, 2000, 2500, 3000, 4000, and 5000.** } **968 cycles** *(02/27/08)*

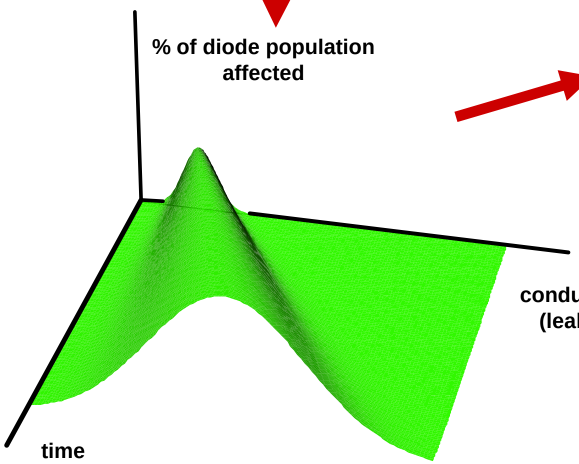
Results to date:

1. **Mixed SnPb/SAC; underfill of both top and bottom joints:**
   2x failures: 500 TC
2. **Mixed SnPb/SAC; underfill of only the bottom joints:**
   2x failures: 500 TC
   1x failure: 771 TC
3. **SAC only solder joints, underfill of both top and bottom joints:**
   1x failure: 500 TC

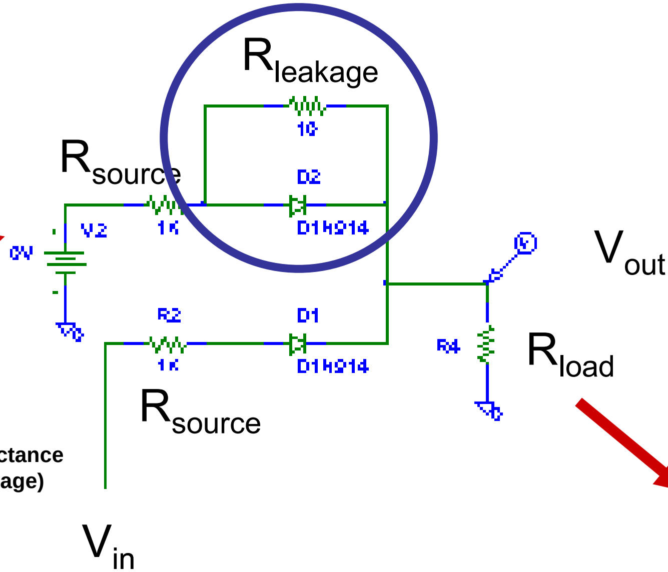
Knowledge, environmental and EAS information are the critical inputs to state-of-health predictions

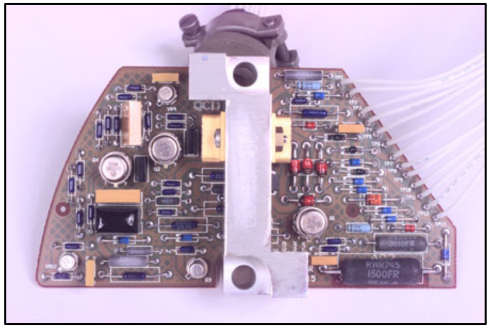
Materials Model

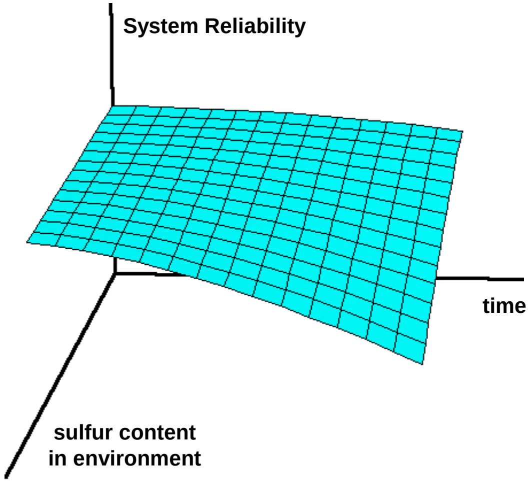
$$R_{cs} = \frac{dQ_{cs}}{dt} = \frac{5k_{sr}\varepsilon}{vol} Q_v = 5k_{sr}\varepsilon P_{H_2S}$$



Component Electrical System Model

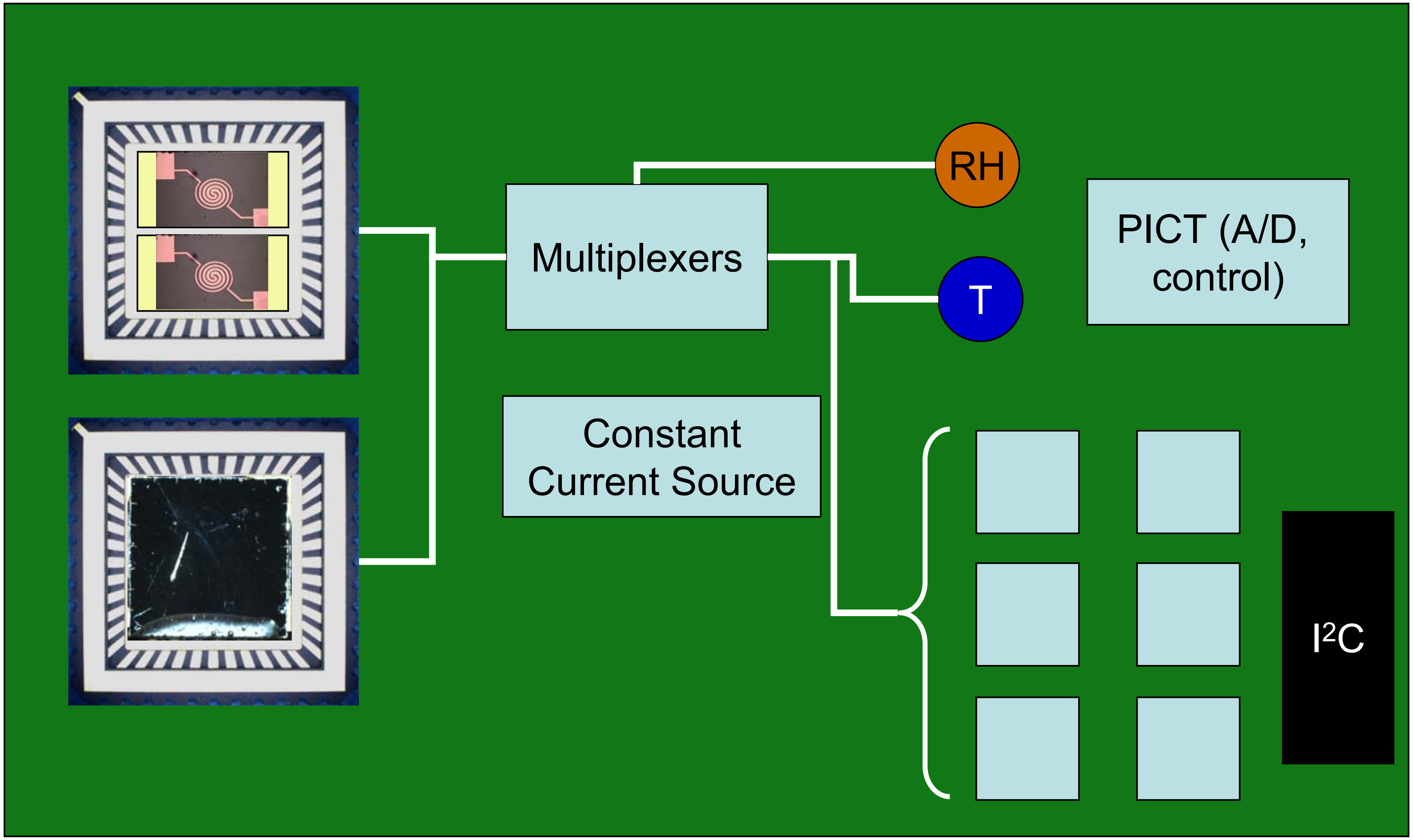




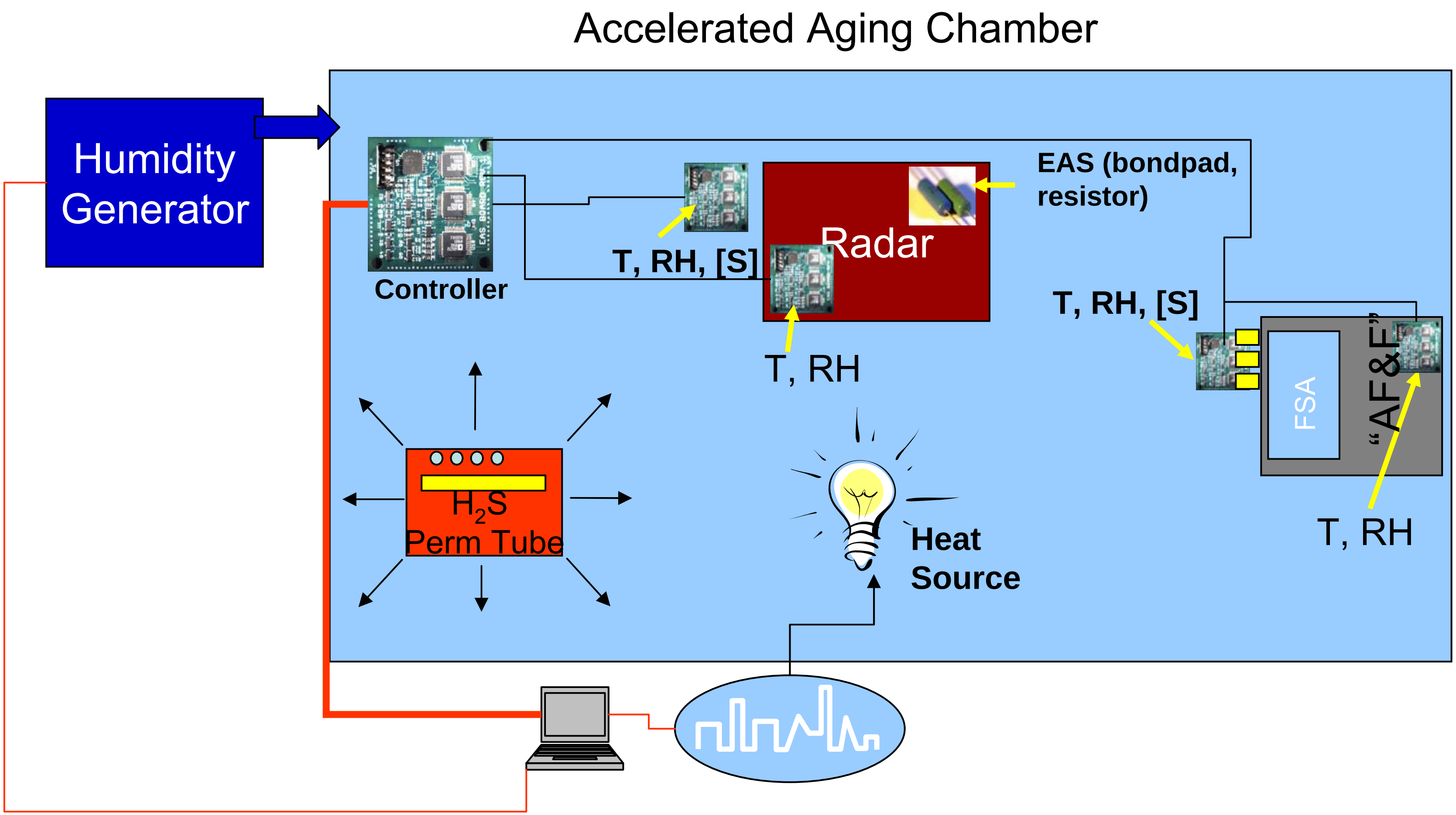


- The materials aging model provides a time-dependent distribution of resistance.
- The electrical system model is used to calculate age-related performance changes

The current generation board will contain EAS structures & environmental sensors



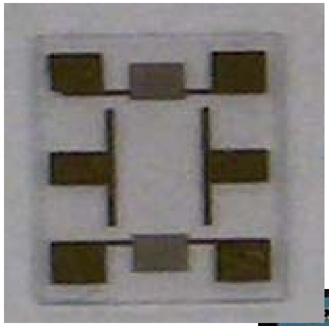
Embedded Evaluation Testbed



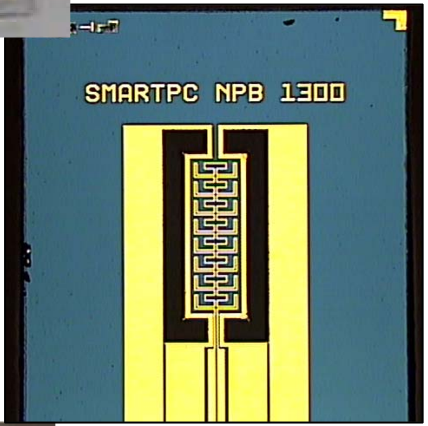
- Incorporate EE instrumentaion electronics into a nested assembly that will permit multiple types of accelerated-aging exposures (e.g., localized heat source, contaminated atmosphere)
- Locate the required sensors and EAS's on 2 types of weapon external structures: (1) clamshell radar assembly, and (2) potted AFS board.

Three different sensor technologies are currently being evaluated for connector EAS

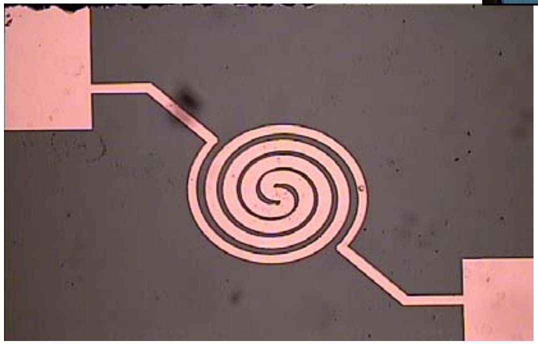
- **Copper InterDigitated Electrodes (IDEs)**
  - **Sulfidation changes electrical impedance**



- **Copper plated resonator**
  - **Gravimetric measurement of mass change due to sulfidation**

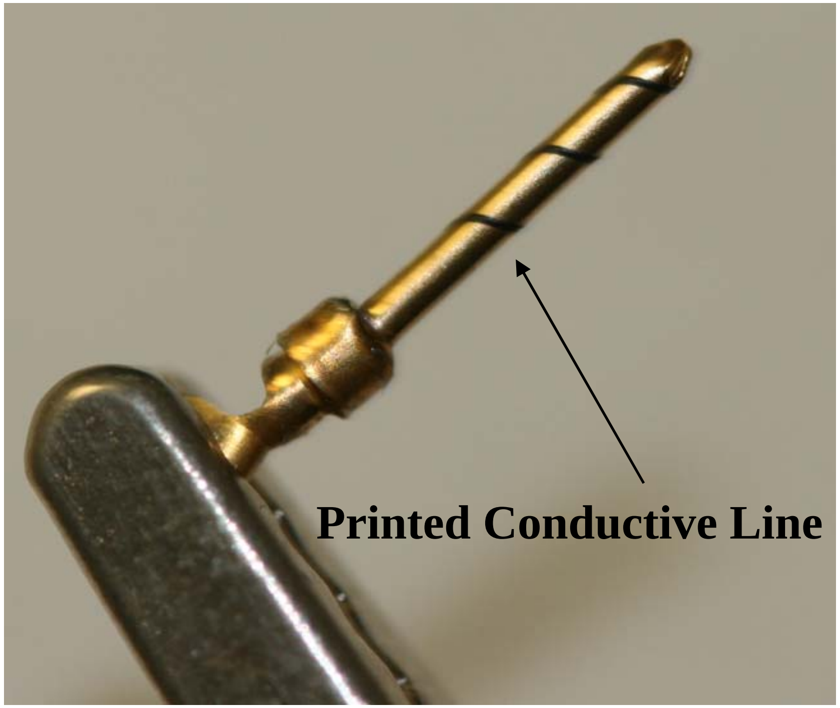


- **Copper serpentine coils**
  - **Sulfidation changes resistance**



Possible Connector EAS (Build EAS onto an Artificial Connector Pin)

- Idea: Replace unused connector pins with phony pins that have a built-on EAS structure (like the Cu serpentine)
- Motivations
  - Statistically impossible to evaluate the connector pins themselves
  - Monitor DC resistive changes
  - Monitors connector's local environment

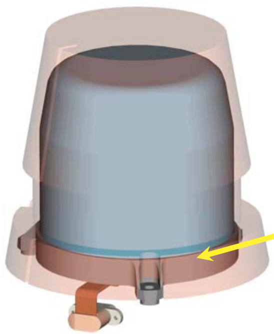


Adhesion Task – Details

phase 1 is the simplest system (typical for SNL but not for DoD):

- initiation of debonding in "as-designed" component vs. propagation from known, pre-existing interfacial separation
- adhesive to substrate without primers
- no moisture ingress

time frame for completion: Sept '08



problem statement:
when will this battery bracket adhesive fail?

phase 2 is an adhesive/primer system :

- primer mechanism does not involve "adhesive chemistry" (i.e., not a silane coupling agent but a wetting promoter, corrosion inhibitor, etc.)
- no moisture ingress
- examples: primers with chromium complexes, metallic zinc, and low viscosity for use with film adhesives

time frame for completion: Sept '10

Adhesion Task – Details

phase 3 is an adhesive with silane coupling agent aging in a humid environment:

- assumption is that polymer is saturated with water (bulk and interface)
- debonding occurs when applied stresses exceed silane interfacial strength

time frame for completion: Sept ‘12

phase 4 is an adhesive aging in a humid environment

time frame for completion: post Sept ‘13

Task *MEMS Reliability* – Details

- **Diagnostic Tests and Structures for NSWC fab run**

Diagnostic Test	Diagnostic Structures
surface adhesion residual stress resonant frequency	Array of Cantilever beams Pointer Device
XPS surface roughness	Pad location
sidewall roughness	"Beam in Well"
mechanical properties	Pull-Tabs
friction sidewall adhesion contact resistance	Friction test structure
Device characterization	Thermal actuator with load cell engagement tab

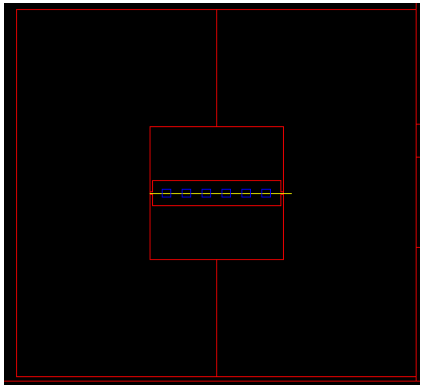
TRL readiness level:

3. Analytical and experimental critical function and/or characteristic proof of concept.

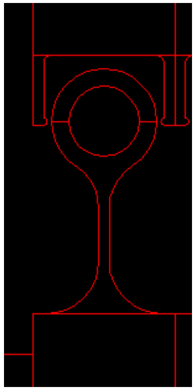
Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.

Task *MEMS Reliability* – Details

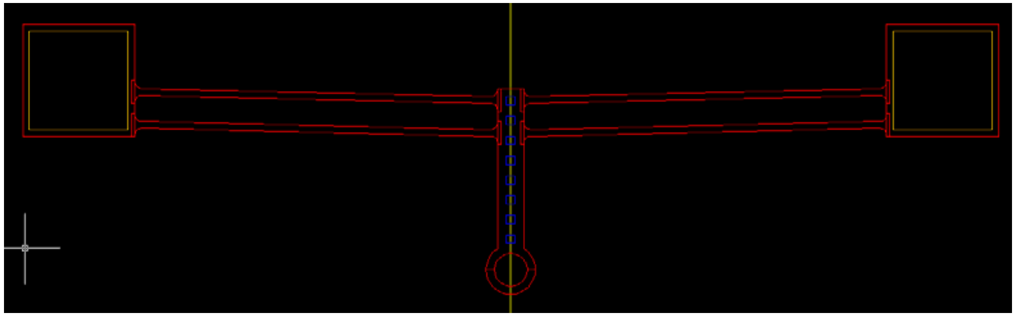
Selected Diagnostic Test Structure Designs in "NSWC fab run"



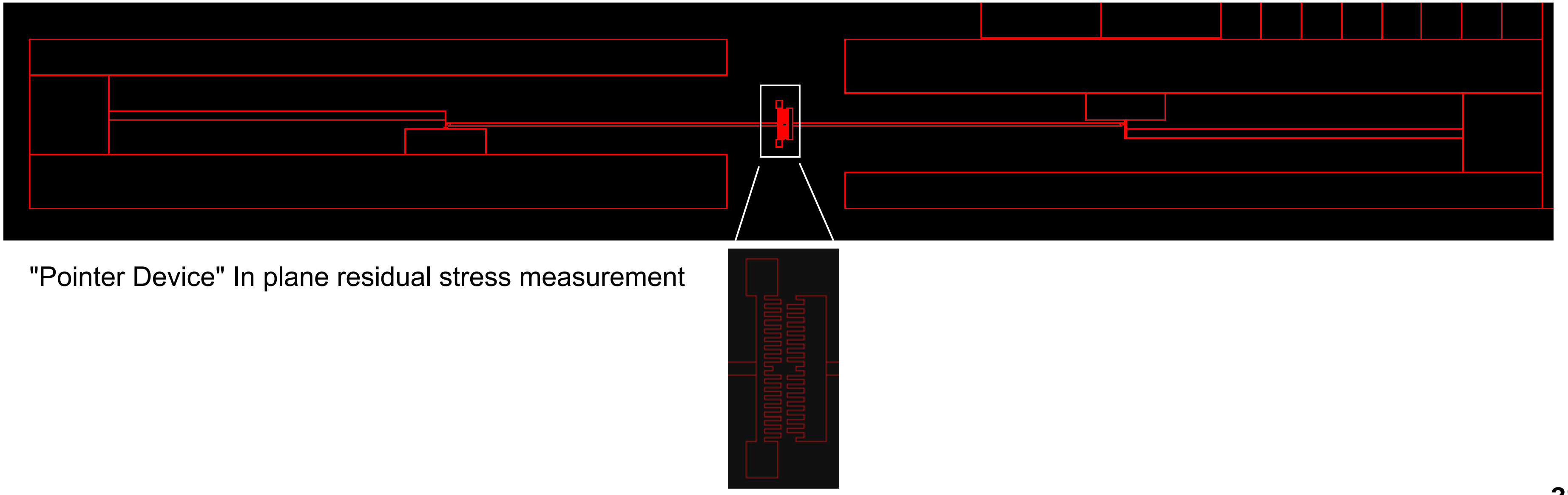
"Beam in well"
sidewall characterization



"pull tab"
mechanical
characterization



Thermal actuator with load cell engagement tab



"Pointer Device" In plane residual stress measurement

Materials Aging & Reliability Current & Prior FY Results

- **Deliverables**
  - **Journal Article on Pd interface reaction (6/08)**
- **Milestones**
  - **First version of Sn whisker model (6/08)**
  - **First version of connector corrosion model (9/08)**
  - **Report on Health Monitoring/Condition Based Maintenance current status (11/08)**
- **Accomplishments**
  - **Completed analysis of 3rd year storage data – no unpredicted failures**
  - **Steering groups formed & functioning**
  - **3-D packaging effort ahead of schedule (parts being tested)**
  - **Model geometries designed & being tested for validation of chemistry-induced adhesion failure**
  - **Engineered aging structures produced (currently being evaluated)**
  - **Comprehensive EAS / sensor package designed**
- **Outcomes**
  - **Direction change for Adhesives task – based on mechanical behavior & FEA**
- **Transitions**
  - **MEMS characterization / aging test structure designs provided to NWSC**

Materials Aging & Reliability Milestones/Deliverables for FY09-13

Project Milestones/Deliverables ***(What is to be delivered to the customers?)*** ***Suggestion: 1-3 for FY09, and 1-3 for balance of the planning period***			
Milestones/Deliverables	**Date**	**TCG-I & M&SI Taxonomy ID***	**DoD / DOE Linkage**
Predict debonding in a neat adhesive system	***12/08***		
Accelerated aging completed for the PoP reliability test vehicle.	***09/09***		
Demonstrate use of embedded evaluation data in a system prediction	***1/09***		
Assess the accuracy of current metrics for chemistry-induced adhesion failure	***9/09***		
Present results from evaluating NWSC test structures	***1/09***		
Complete failure mode analysis of PoP TVs	***06/10***		
Predict debonding in a primer / adhesive system	***9/10***		

Solder Interconnect Reliability Outcomes/Accomplishments for FY09-13

Task Outcomes /Accomplishments				
Task	**Outcomes/ Accomplishments**	**Date**	**TCG-I & M&SI Taxonomy ID***	**Task Dependencies**
Task 1	*Consistent materials model for predicting Sn whisker growth.*	*03/09*	*P*	*Experimental data on Sn whisker growth as a function of test conditions.*
Task 2	*Event detector data compiled into a Weibull failure distribution plot for the PoP TVs.*	*09/09*	*P*	*Completion of the accelerated testing*
Task 3 *Task 4*	*Test data showing the rate of whisker growth as a funtion of stress, temperature, etc.* *Correlation between the failures and damage to the PoP solder joints.*	*03/10* *09/10*	*P* *P*	*Success with developing a suitable test vehicle* *There cannot be any interruptions in the accelerated aging schedule.*

Corrosion Outcomes/Accomplishments for FY09-13

Task Outcomes /Accomplishments				
Task	**Outcomes/ Accomplishments**	**Date**	**TCG-I & M&SI Taxonomy ID***	**Task Dependencies**
1	*Explore EAS structures needed for DoD applications*	*3/09*		*Depends on funding at Redstone*
2	*Demonstrate EAS response in environmental testbed*	*12/09*		
3	*Demonstrate corrosion connector model*	*1/10*		
4	*Deploy EE system in dormant storage*	*3/10*		

Adhesion Outcomes/Accomplishments for FY09-13

Task Outcomes /Accomplishments				
Task	**Outcomes/ Accomplishments**	**Date**	**TCG-I & M&SI Taxonomy ID***	**Task Dependencies**
Phase 1	***predicting debonding in a neat adhesive system***	***12/08***		
Phase 2	***predicting debonding in a primer/adhesive system***	***9/10***		***requires completion of Phase 1***
Phase 3	***predicting degradation of adhesion in a silane primer due to temperature and moisture***	***9/12***		***requires completion of Phase 2***

MEMS Reliability
Outcomes/Accomplishments for FY09-13

Task Outcomes /Accomplishments ***(What are the intermediate accomplishments required to achieve project milestones / deliverables?)*** ***Suggestion: 1-3 per task***				
Task	**Outcomes/ Accomplishments**	**Date**	**TCG-I & M&SI Taxonomy ID***	**Task Dependencies**
Task 1	***# 1*** **First series of designs to NSWC** ***# 2*** **Results from evaluating test structures to NSWC 1/2009**	***4/2008*** ***1/2009***	***DD***	**NSWC S&A platform**
Task 2	***# 3*** **Verified Accelerated aging protocol**	***10/2010***	***DD***	

*TCG-I & Modeling & Simulation Initiative (M&SI) Required Parameter-Taxonomy ID: P = Physics, N = Numerics, DP = Databases/Phenomenology, DC = Databases/Calibration, DM = Databases/Model Validation, DD = Databases/Diagnostics, V = Validation. These are required descriptors for all tasks in TCG-I and those that participate in the M&SI.

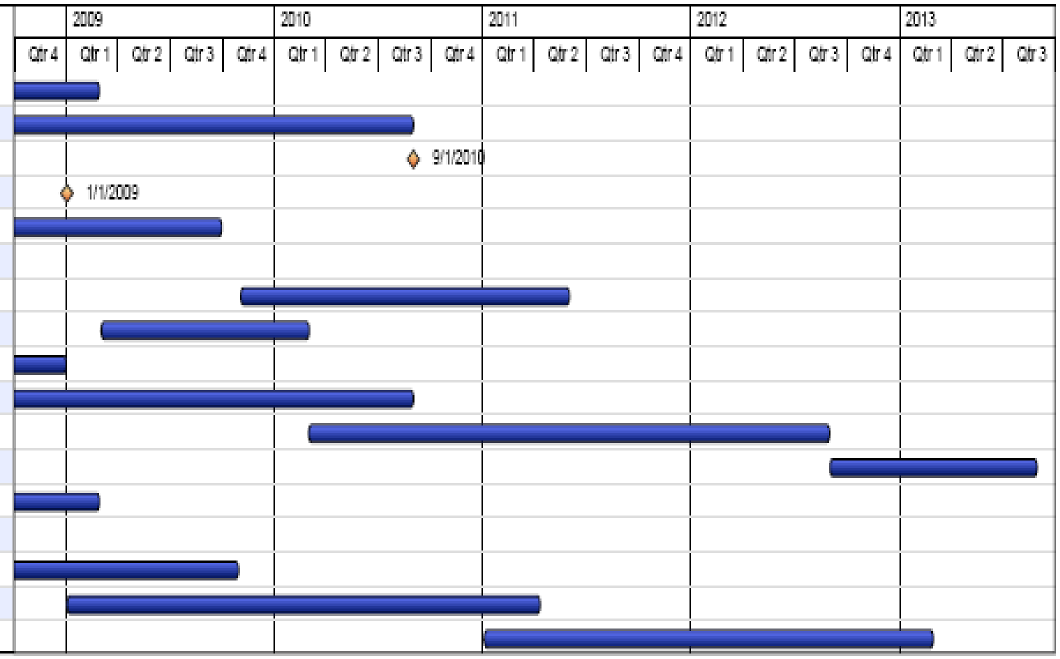
<u>Other TCG's may want to use other categories or leave blank</u>**.**

Project ‘*Name*’ Metrics & Exit Criteria for FY09-13

Project Milestone/Deliverable	Metrics or Exit Criteria (Typically 1 per Milestone/Deliverable)
(Copy Milestone or Deliverables from above)	*(Identify metric or characteristic being used to measure progress or identify successful completion of milestone or deliverable. Relate to TRLs as appropriate)*
Predict debonding in a neat adhesive system	*Output from finite element based codes that predict debonding of a specific component*
Accelerated aging completed for the PoP reliability test vehicle.	*Failures in accelerated test mimic field failures*
Demonstrate use of embedded evaluation data in a system prediction	*System reliability prediction using testbed data from EASs and environmental sensors*
Assess the accuracy of current metrics for chemistry-induced adhesion failure	
Present results from evaluating NWSC test structures	
Complete failure mode analysis of PoP TVs	
Predict debonding in a primer / adhesive system	*Use FEM codes to predict failure of a specific geometry (to be chosen later)*

Predictive Materials Aging and Reliability

#	Name
1	Consistent materials model for predicting Sn whicker growth
2	Accelerated aging tests on PoP test vehicles
3	Correlation between failures and damage to PoP solder joints
4	Demonstrate use of embedded evaluation in a system prediction
5	Explore possible EAS structures neede for DoD applications
6	Develop 1st generation corrosion model
7	Integrate embedded evaluation into DoD hardware
8	Deploy EE system in dormant storage
9	Predict debonding in a neat adhesive system
10	Predict deponding in a primer / adhesive system
11	Predict degradation of adhesion in a silane primer due to temperature & moisture
12	Predict adhesive aging in a humid environment
13	Strength, Friction, Faigue studies on 2nd gen SOI design
14	Identify 2nd MEMS processing technology
15	Strength, Friction, Faigue studies on 2nd technology
16	Aging & Reliability studies for predictive model development usng diagnostic test structures
17	Correlation between aging & reliability failures in prototype devices



Task ‘*MEMS Reliability*’ – Issues

the steering group meetings

Objectives FY2007:

- Design, fabricate and characterize test structures to measure *process diagnostics*, strength, friction and fatigue response in various MEMS processing technologies
- Use test structures and post mortem characterizations to develop mechanism-properties relationships
- Design and perform series of experiments which isolate the effects of aging and environment on the performance of MEMS materials

Redefined objectives FY2007-2008 Steering group meetings:

- DOD/DOE MEMS Catalog
- A Standard MEMS “Discovery Platform” for reliability evaluation
- A Fault Tree for MEMS reliability.

TCG tech. review did not like these objectives

This deliverable looks a lot like our original objectives

Issues:

- The steering group meetings have been extremely useful and informative, and they have generated a good and open exchange between DOD and DOE representatives in this task
- Many diverse interests are represented at these meeting, thus many very different directions which the task should take are proposed, which forces the task to lose focus.