

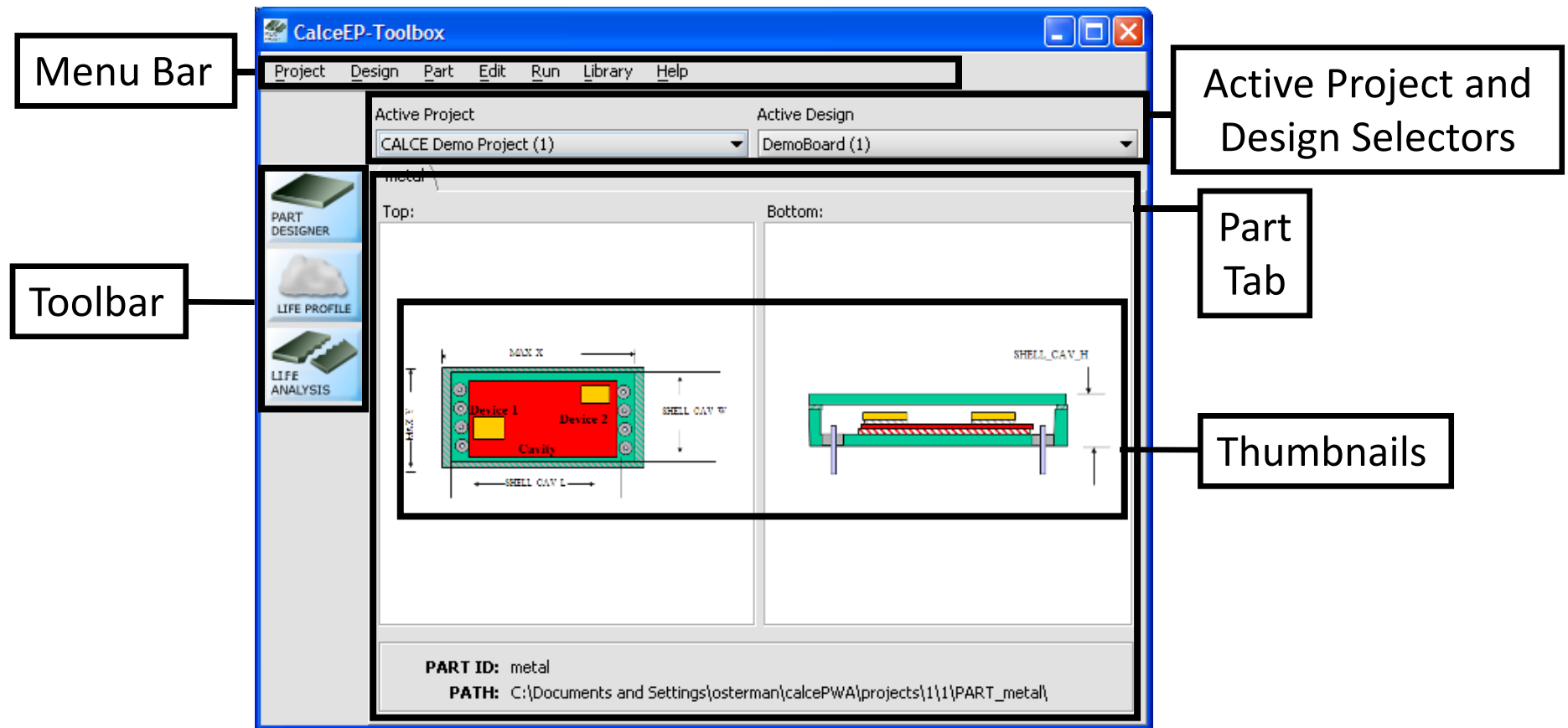


calceEP



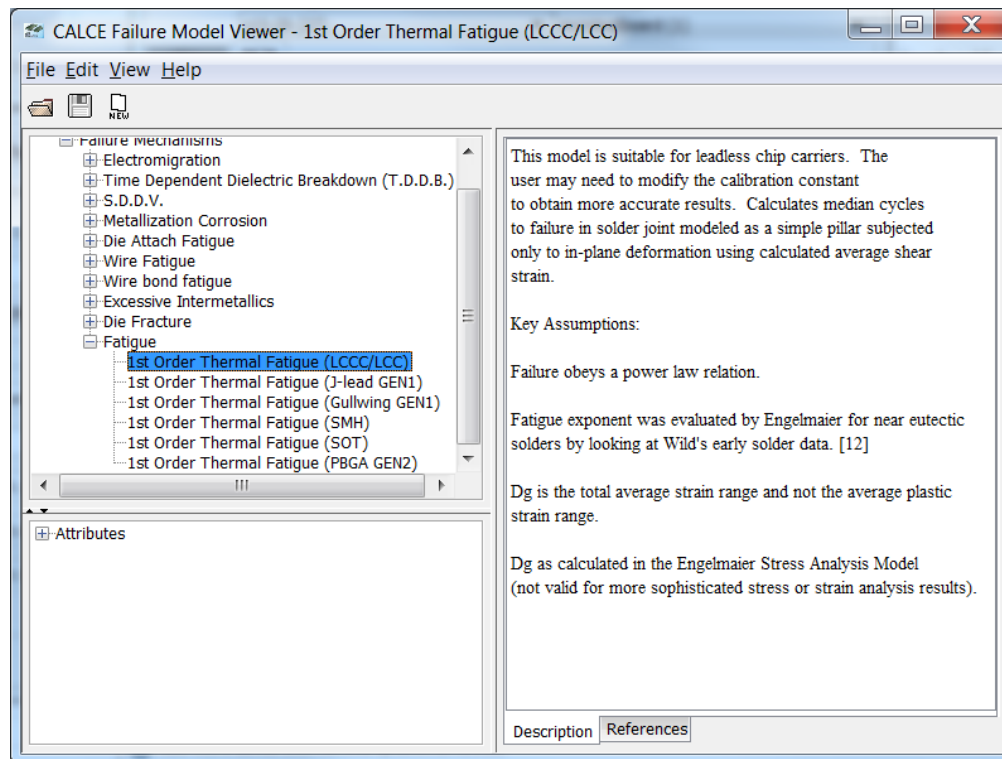
CalceEP is a modeling and analysis environment for package and devices in the calceSARA software.

calceEP Toolbox



The calceEP Toolbox uses the current calcePWA file system. The software can be used to create and edit parts under an existing calcePWA design and works in a modal fashion: design and assessment tools apply to the active part.

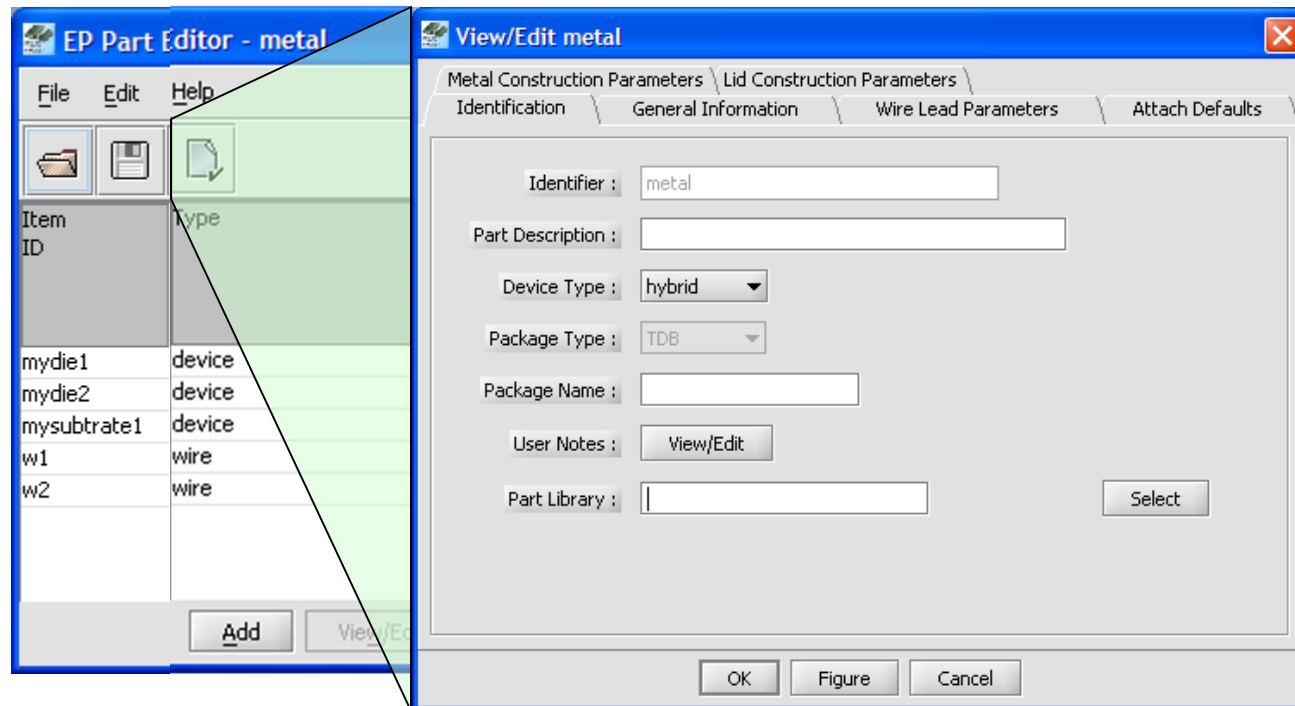
Added Failure Mechanism Model



- Surface Mount Solder Interconnect Failure Models have been added to the calceEP failure mechanism list. This change allows users to access temperature cycling induced surface mount solder interconnection failures in calceEP.



EP Part Editor



The **EP Part Editor** is used to define the package geometry and materials as well as to define devices (instances of parts) and wire bond interconnects within the part. The overall part geometry and features are defined by the package template chosen for the part.



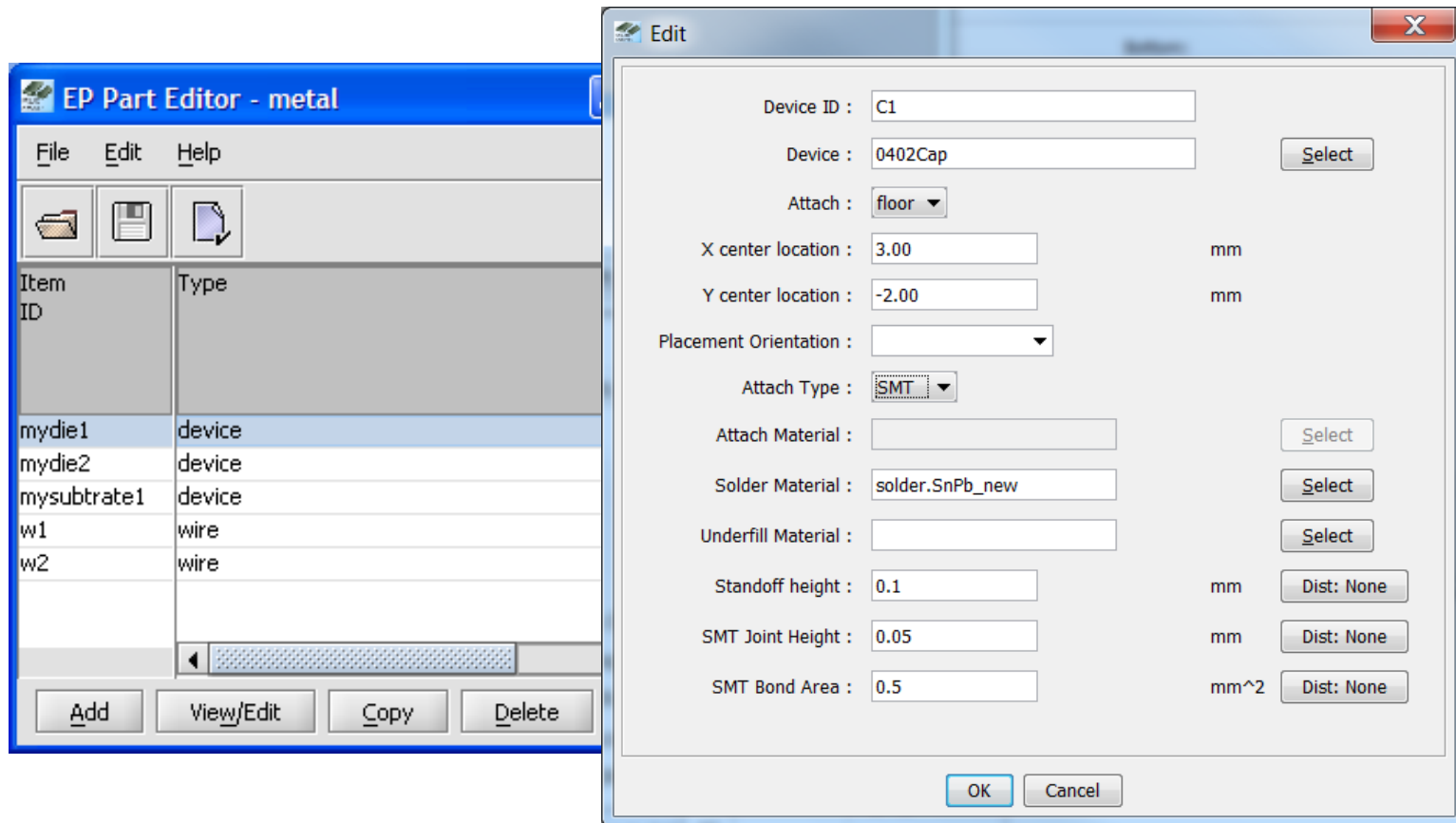
Supported Package Templates

calceEP supports five common package formats:

ID	Description	Side View	Interconnect
PLCC	Plastic Leaded Chip Carrier		J-Lead
PQFP	Plastic Quad Flat Package		Gullwing
PBGA	Plastic Ball Grid Array		Solder ball
Metal	Metal		Pin
LCCC	Leadless Ceramic Chip Carrier		NA



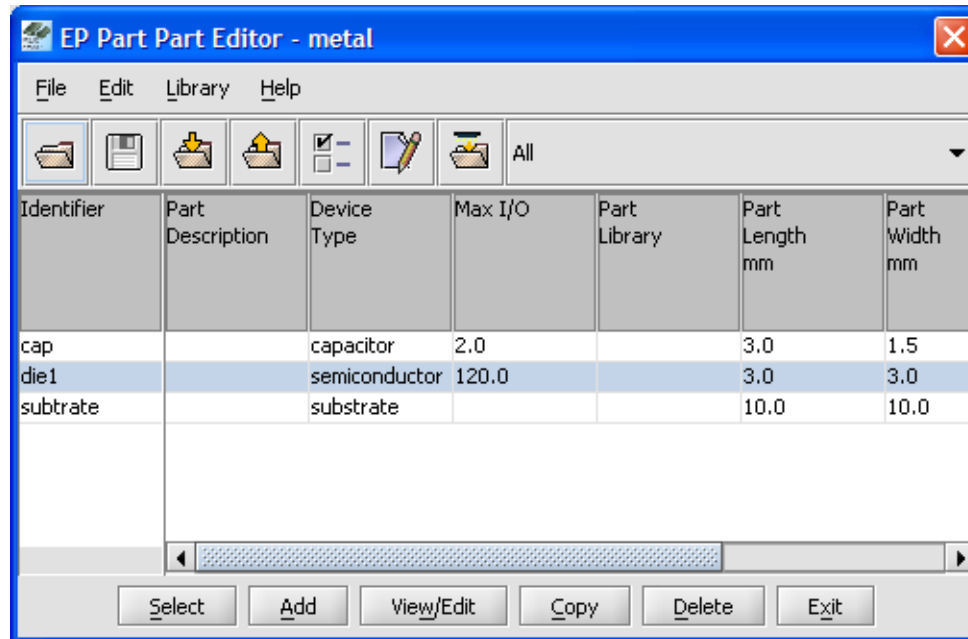
Modeling Part Devices



A device is an instance of one part located within another part. A device definition includes a unique identifier, a *reference* to a predefined part, a location relative to the containing part, and attachment properties.



EP Part Part Editor

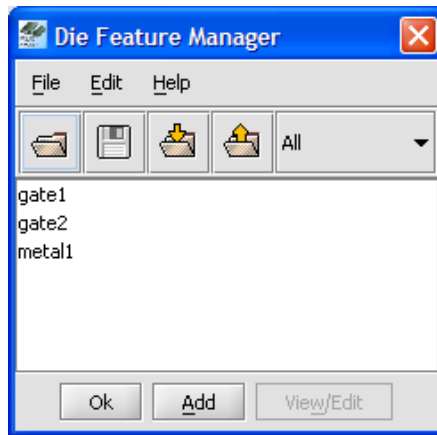


The **EP Part Part Editor** is used to manage part models that are referenced by devices within a calceEP part. A part model provides the physical description of those devices that reference that part. Use the **EP Part Part Editor** to create parts, view/edit part parameters, add/modify/edit part features, and import/export parts to the CALCE Parts Library.

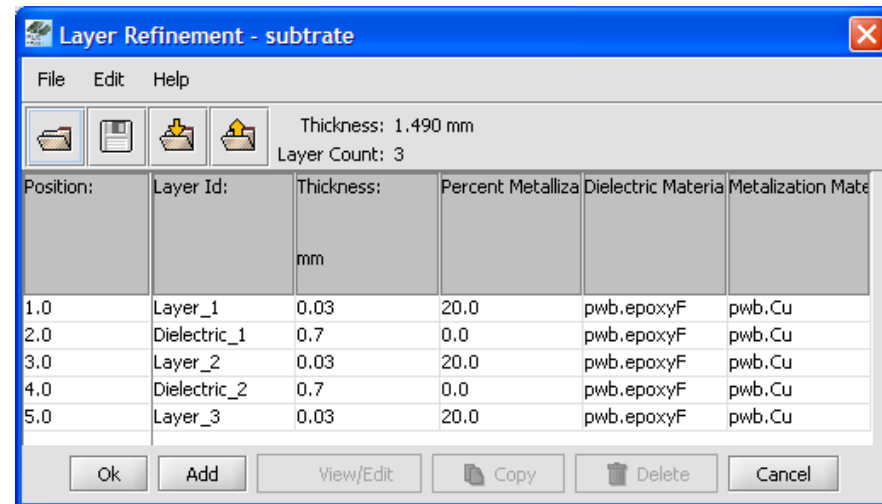


Part Features

Additional data items, called *part features*, define further information for certain classes of parts.



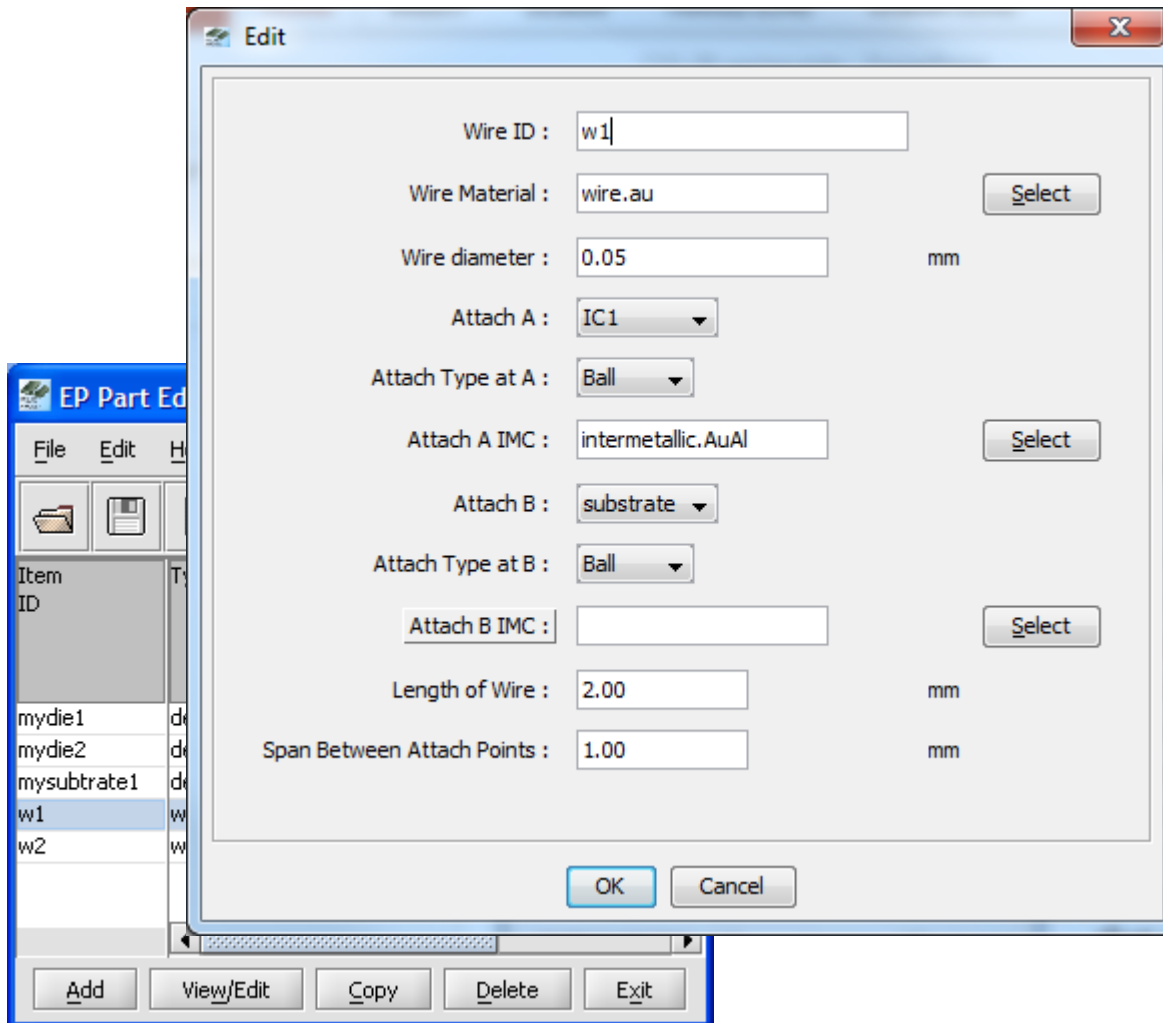
Die features include metal oxide, gate and die metallization.



Substrate feature allows you to define a multiple-layer material composite.



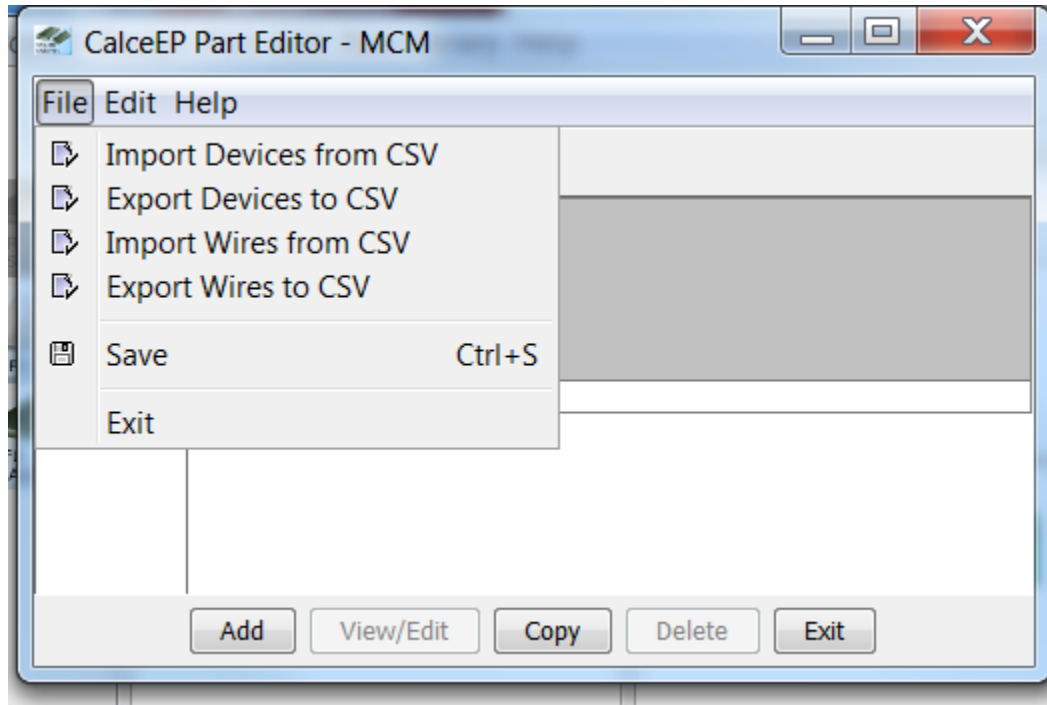
Wire Bonds



In addition to devices, the **EP Part Editor** allows you to defined multiple wirebonds within a part. The wirebond definition includes wire material, wire diameter, wire length, and interconnection span.

Wire and wire bond failure mechanism models are included to evaluate life expectancy under temperature cycling loading conditions.

Enhanced Import/Export

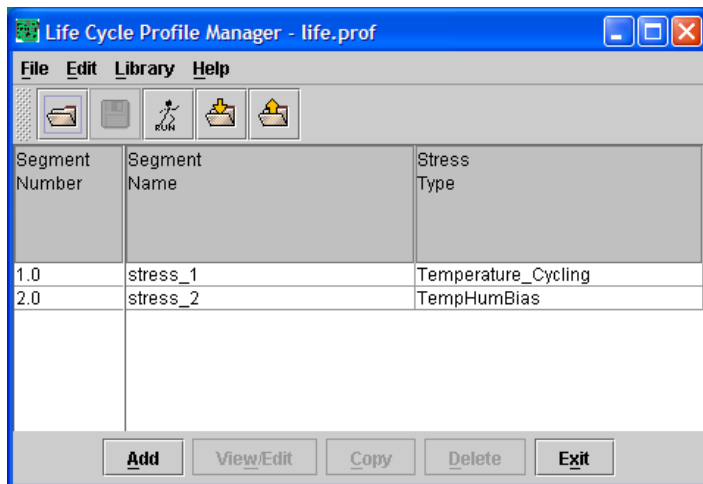


- To facilitate data entry into the calceEP tool, facilities to import and export comma separated variables (.csv) files were added to the part modeling module.
- The import export included devices as well as wires.

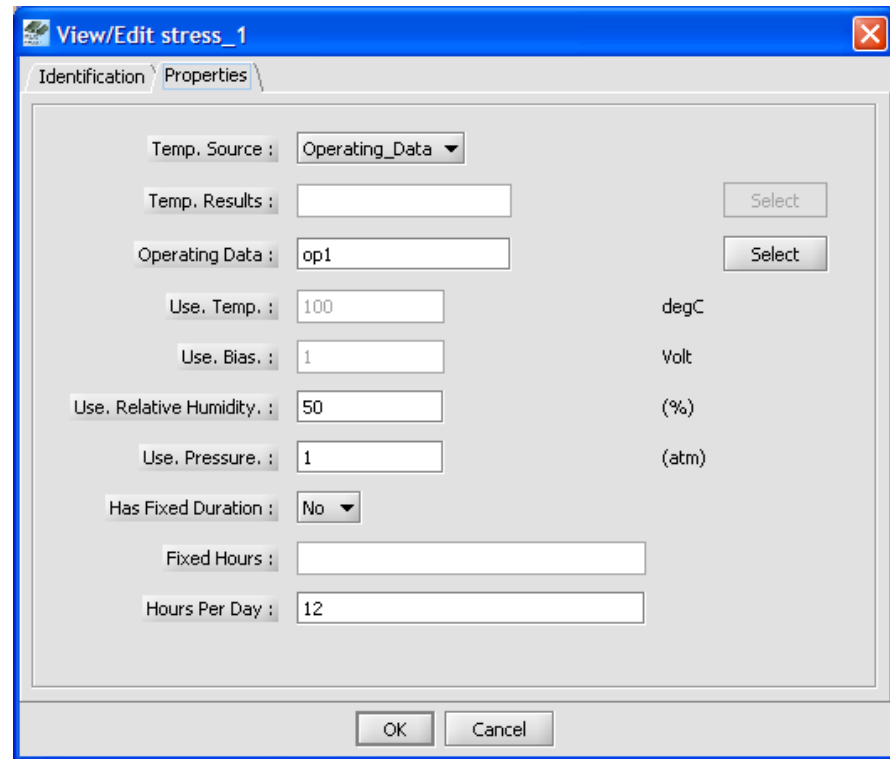


calceEP – Life Cycle Profile

The life assessment process requires that anticipated loading to which the part is subjected be modeled. This task is achieved with the Life Cycle Profile Manager.



Life Profile Manager



- Temperature Cycling
- Sustained Temperature/Humidity/Bias



Assigning Operating Data

The screenshot displays the CALCE EP Operational Part Data Manager interface. The main window shows a table of part segments with their respective operating temperatures. An 'Edit' dialog box is open, allowing the user to assign specific operating data to a selected segment.

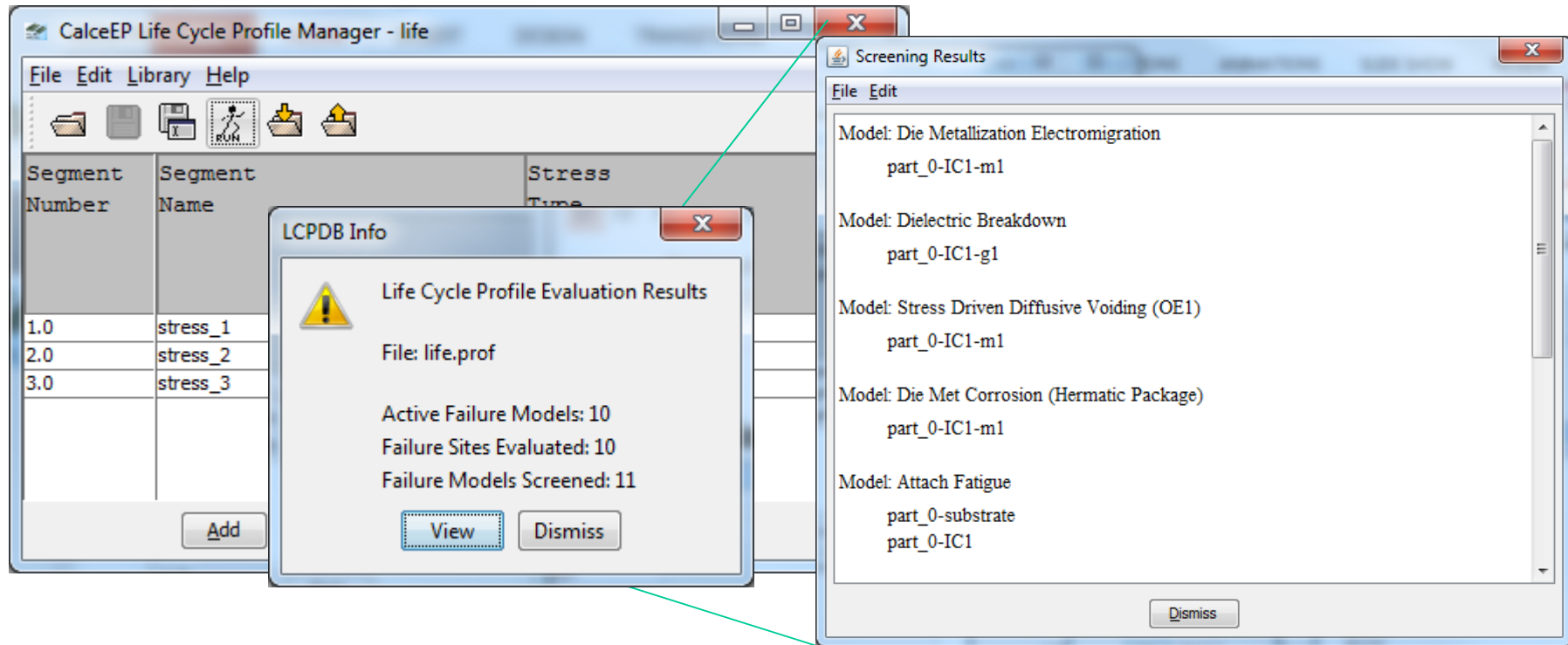
Ref ID	Operating Temp degC
part_0	70.0
part_0-mydie1	78.0
part_0-mydie1-mypdie1	83.0
part_0-mydie1-gate1	78.0
part_0-mydie1-gate2	78.0
part_0-mydie1-metal1	78.0
part_0-mydie2	75.0
part_0-mydie2-mypdie1	80.0
part_0-mydie2-gate1	75.0
part_0-mydie2-gate2	75.0
part_0-mydie2-metal1	75.0
part_0-mysubstrate1	70.0
part_0-w1	70.0
part_0-w2	70.0

The 'Edit' dialog box contains the following fields:

- Ref ID: part_0-mydie1-mypdie1
- Operating Temperature: 83 degC
- Operating Voltage: 1 V
- Operating Current: 1 A

The calceEP software allows you to define operational data for the devices modeled within the part through the **CALCE EP Operational Part Data Manager**, which is accessed from the **Life Cycle Profile Manager**. With this tool, you have the ability to assign temperature, voltage, and current data. You can create multiple operating definitions and reference them when defining a loading segment.

Life Cycle Profile Screening Display



As part of the software update, the ability to examine the active failure models and failure sites for a particular life cycle profile has been added through the addition of the “View” button on the LCPDB Info dialog.



Failure Models

Failure models are based on those available in open literature, as well as those internally developed at CALCE. Supported failure mechanisms include:

- Electromigration
- Stress-Driven Diffusive Voiding (SDDV)
- Time-Dependent Dielectric Breakdown (TDDB)
- Metallization Corrosion
- Electrolytic Breakdown
- Dielectric Breakdown
- Die Attach Thermal Fatigue
- Wire Bond Thermal Fatigue
- **SMT Solder Interconnect Temperature Cycling Fatigue**
- **Excessive IMC**



Failure Assessment Manager

SNo.	Site	#Eval	Prime Failure Model	Damage Criteria	View
1.0	part_0-mydie1-metal1-tra...	3.0	Hermetic_Met_Corrosion	13.26 days (DR:137.67)	View
2.0	part_0-mydie2-metal1-tra...	3.0	Hermetic_Met_Corrosion	13.26 days (DR:137.67)	View
3.0	part_0-mydie1-gate1-trac...	2.0	Hermetic_Met_Corrosion	13.26 days (DR:137.67)	View
4.0	part_0-mydie2-gate1-trac...	2.0	Hermetic_Met_Corrosion	13.26 days (DR:137.67)	View
5.0	part_0-w2-wire-open	1.0	Wire_Fatigue	> 30 years (DR:0.05)	View
6.0	part_0-mydie1-dieattach-...	1.0	Die_Attach_Fatigue	> 30 years (DR:0.01)	View
7.0	part_0-mydie2-dieattach-...	1.0	Die_Attach_Fatigue	> 30 years (DR:0.00)	View
8.0	part_0-w1-wire-open	1.0	Wire_Fatigue	> 30 years (DR:0.00)	View
9.0	part_0-mydie2-gate1-gat...	2.0	TDDB_1overE_Model	> 30 years (DR:0.00)	View
10.0	part_0-mydie2-gate2-gat...	2.0	TDDB_1overE_Model	> 30 years (DR:0.00)	View
11.0	part_0-mydie1-gate1-gat...	2.0	TDDB_1overE_Model	> 30 years (DR:0.00)	View
12.0	part_0-mydie1-gate2-gat...	2.0	TDDB_1overE_Model	> 30 years (DR:0.00)	View
13.0	part_0-w1-a-open	2.0	Wire_Shear_Fatigue	> 30 years (DR:0.00)	View
14.0	part_0-w2-a-open	2.0	Wire_Shear_Fatigue	> 30 years (DR:0.00)	View
15.0	part_0-w2-b-open	2.0	Wire_Shear_Fatigue	> 30 years (DR:0.00)	View

Ranked Failure List

The failure assessment is used to select from defined loading scenarios and evaluate the life expectancy of the part based on a set of automatically chosen applicable failure models. The evaluation results are presented in a table with life expectancy sorted in ascending order. You may inspect the results of the individual evaluations by selecting items from within the results table.

Inspection of Failure Sites and Mechanism

The screenshot displays the CalceEP Life Assessment Manager interface. The main window shows a table of failure results for part_0-IC1-m1. A red arrow points from the 'View' button in the table to a detailed view window titled 'Results for part_0-IC1-m1:Electromigration'. A second red arrow points from the 'View' button in the 'Failure Results for part_0-IC1-...' dialog to the same detailed view window.

SNo.	Site-Mode	#Eval	Prime Failure Mode	Damage Criteria	
1	part_0-IC1-m1-trace-open	6	Electromigration	326.32 days (DR:5.60)	View
2	part_0-IC1-die-fracture	1	Die_Cracking	> 30 years (DR:0.01)	View
3	part_0-w1-wire-open	1	Wire_Fatigue	> 30 years (DR:0.01)	View
4	part_0-w1-a-bond-open	2	Bond_IMC	> 30 years (DR:0.01)	View
5	part_0-substrate-attach-o...	1	Attach_Fatigue	> 30 years (DR:0.00)	View
6	part_0-IC1-attach-open	1	Attach_Fatigue	> 30 years (DR:0.00)	View
7	part_0-IC1-g1-gate-open	2	TDD8_EModel	> 30 years (DR:0.00)	View
8	part_0-w1-a-open	2	Wire_Shear	> 30 years (DR:0.00)	View

Failure Results for part_0-IC1-...

- Electromigration - 2
- SDDVOE1 - 2
- Hermetic_Met_Corrosion - 2
- Hermetic_Met_Corrosion - 3
- SDDVOE1 - 3
- Electromigration - 3

Results for part_0-IC1-m1:Electromigration

Electromigration - Blacks Model

Part Id: part_0-IC1-m1
Condition Name: stress_2
Condition Number: 2
Time to Failure: 7.02E3 Hours

Die Attributes

Metallization width on die: 500e-9 (meter)
Metallization thickness on die: 500e-9 (meter)
Current density of metallization strip: 400000000.000000 (ampere per meter²)
Activation energy of metallization material: 6.0000e-001 (eV)

Environment Attributes

Operating temperature of the device: 423.15 (K)

Buttons: Graphs, Show Input, Dismiss

The failure model results can be inspected for each failure site and load segment.