IC KNOWLEDGE LLC

Packaging Cost and Price Model User Manual

IC Knowledge LLC, PO Box 20, Georgetown, MA 01833
Tx: (978) 352 – 7610, Fx: (978) 352 – 3870, email: info@icknowledge.com

Version 2018 model

Introduction

This manual presents an overview of the Packaging Cost and Price Model and the basic workings of the model.

Model description

The Packaging Cost and Price Model is designed to easily calculate the cost and price of most low power semiconductor packages. Examples of specific package types covered in the model are leadframe packages, organic substrate packages including EMIB, wafer level packaging and InFO.

Please note that our cost models are cost of goods sold (COGS) models and do not include below the line costs such as research and development (R&D) or selling, general and administration costs (SG&A). Our pricing calculations are cost plus gross margin (GM). R&D and SG&A costs are absorbed in GM as well as profits.

Support and updates

As a licensee to the Packaging Cost and Price Model you will receive all updates made to the model for twelve months from the date of purchase emailed to your email address of record. If you change your email address it is your responsibility to notify us. Reasonable levels of phone and email support will be provided for twelve months from the date of purchase of the model. On-site or other forms of support are not provided. For more information, please see our Support Policy.

Our "Support Policy" and other model support information is available in the gray bar on the right side of the Packaging Cost and Price Model page here:
http://www.icknowledge.com/products/packagingmodel.html

Known Excel bugs and limitations

- We occasionally see issues with dropdown menus not working properly in the model. If you click on a dropdown menu and can't see the dropdown list, right click in the cell, choose "Pick from Drop Down list" and then left click in the cell and the dropdown should appear. This is an Excel bug and not something we can address ourselves.
- Number formatting must use a decimal point to indicate decimals, e.g. 1.0. If you set up Excel to use a coma to indicate a decimal, e.g. 1,0 the model will not function correctly. This setting is an Excel option under advanced and you can set "Use system separators" for a "Decimal separator" to be a . or ,. It is common practice in Europe to use a , but that will prevent the model from working correctly.
- We use a lot of dropdown lists in the model. Excel 2007 does not support dropdown lists that reference other sheets in the model. We have currently designed the model to work around this

issue but at some point we will cease to support Excel 2007 because there is a lot of overhead involved in accommodating this.

Model conventions

There are several conventions used throughput the model.

The gray areas on each model sheet contain the model inputs and outputs. The inputs that can be directly changed by the user are white areas within the gray, the gray areas are labels and model driven outputs and cannot be directly changed by the user.

Throughout the model there are red dots indicating comments. Moving the cursor over the red dots displays information explaining input or outputs.

In this manual, regular, bold and underlined text describe the model and model features. Italic text provides background on the inner workings of the model.

Common Questions

- How do I model an SOC - we get this question a lot. There is a perception that SOC specifies what something is, it doesn't. SOC stands for System On a Chip and is vaguely defined industry buzz word that can be applied to many different types of devices. Things like cell phone applications processors are commonly referred to as SOCs, but most microprocessors, most microcontrollers and many other products meet the definition of SOC as well. You can model an SOC in the model but you need to model the product based on what it is.
- What package do I select for Chip Scale Packages (CSP) - this is similar to SOC described above, CSP basically means a package is roughly the size of the die or chip it contains. Many package types can be CSPs, simply select the package type of interested, BGA, QFN, etc.

Worksheet overview

The following is a brief description of the model worksheets and the purpose of each sheet. The sheet tabs are color coded, gray is informational (these sheets may in some cases be editable but do not drive the model results), red are the main drivers (these sheets are editable), brown are results (these sheets are not editable), blue modifies the processes or performs comparisons or calculations (these sheets are editable).

Please note that there are many sheets in the model and scrolling between them can be a slow process. If you right click in the area where the scrolling arrows are (bottom left part of Excel) you will get a sheet list and you can directly select the sheet you want to go to.

- License (Gray tab) – the model software license. This sheet is not editable.
- Introduction (Gray tab) – a brief introduction to IC Knowledge and our cost modeling product line as well as disclaimer and warrantee information. This sheet is not editable.
- HELP (Gray tab) – a listing of the various ways to get help with the model. This sheet is not editable.
- Global Values (red tab) – configures the overall model. This sheet is user editable.
- Packaging (blue tab) - this is the sheet that defines the packaging process and displays some costs.
- Cost Summary - a summary of the model results.
- Materials Usage - a summary of the material quantities and costs used for the defined package.
- Yearly Data (brown tab) - sets utility, labor, material and margins by year, company and country.
- Revision (grey tab) - lists the changes in the current version of the model.
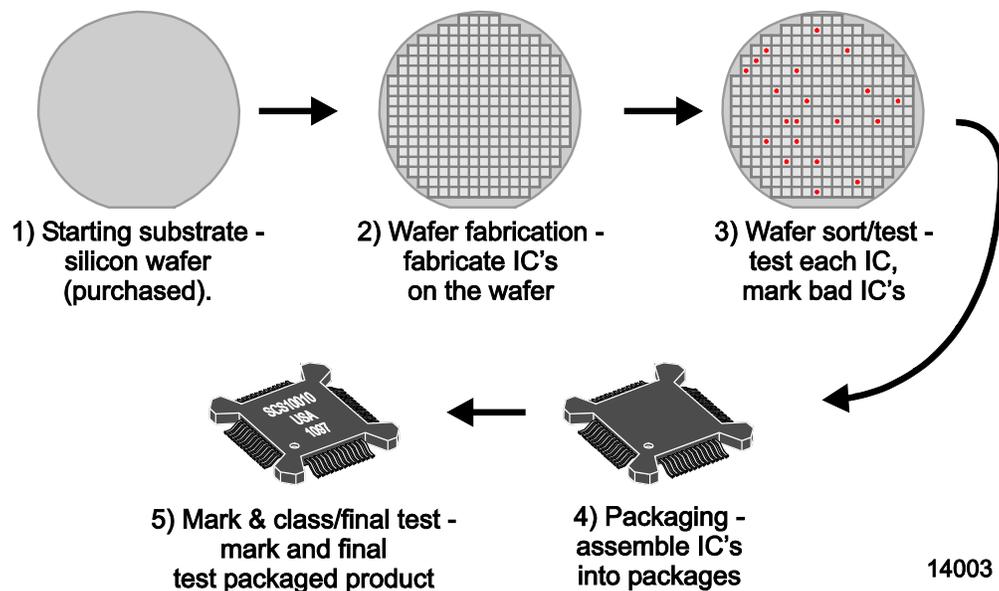
Detailed worksheet descriptions

In this section the "active" worksheets are described in more detail. Worksheet such as 'License', 'Introduction', 'Help', 'Revision History' worksheets are expected to be self-explanatory.

The following are the main steps in the IC manufacturing flow:

- _Starting wafer – this is purchased by all IC manufacturers. Wafers come in a variety of sizes and types. When you select a process the appropriate wafer size and type is automatically selected._
- _Wafer fabrication – anywhere between tens to tens of thousands of integrated circuits are fabricated on the surface of the wafer. The wafer yield is the number of wafers that complete fabrication process divided by the number of wafers started into the fab._
- _Wafer sort (also called wafer test or wafer probe) – the ICs on the wafer surface are tested and the bad ICs are mark with an ink dot or in an electronic map so they won't be packaged. Die yield is the number of die that pass wafer sort divided by the total number of die on the wafer. Wafer sort may be a single pass test or may include multiple passes at different temperatures, or before and after bakes and burn-ins._
- _Packaging – the individual ICs on the wafer are cut up and put into protective packages that provide electrical connections to the IC._
- _Class test (also called final test) – the packaged ICs are tested to insure the ICs were correctly packaged without damage. For some ICs they can't be fully tested until they are packaged and this may be the first full test. Class test may be a single pass test or may include multiple passes at different temperatures, or before and after bakes and burn-ins._

1) Starting substrate -
silicon wafer
(purchased).

2) Wafer fabrication -
fabricate IC's
on the wafer

3) Wafer sort/test -
test each IC,
mark bad IC's

5) Mark & class/final test -
mark and final
test packaged product

4) Packaging -
assemble IC's
into packages

14003

IC Manufacturing Flow

Global Values (red tab)

These values configure the overall model.

- OSAT (cell B1) - sets the outsourced assembly and test provider running the packaging process. This selection determines the country and sets the default gross margin. The country and gross margin can be overridden to model OSATs or packaging locations not available in this list.

For the rest of the page for each item column C is the default value, column C selects default or override values and column D presents the value being modeled.

- Year being modeled (row 3) - year being modeled is used to select the yearly values on the 'YearlyData' sheet and also is compared to the year the equipment came on line value to determine if equipment is still depreciating.
- Country (row 4) - the country the packaging facility is located in. The default is set by the selected OSAT. The country selected sets what labor and utility rates to use from the 'YearlyData' sheet.
- Volume/margin (row 5) - when you select an OSAT in row 1 and average gross margin fill in as the default. You can override the gross margin by selecting "Very low", "Low", "Average", "High" or "Very High" here in in each case an override margin will fill in based on the volume selected and OSAT. You can also select a margin %.
- Street width (row 6) - the street is the space between die left for sawing (see the Background on die size and number of die per wafer information below).
- Edge exclusion (row 7) - the width of the area at the wafers edge where no good or whole die are printed (see the Background on die size and number of die per wafer information below).
- Oversaw (row 8) - when sawing up a wafer the saw travels past the edges of the wafer, this is called oversaw and the amount of oversaw effects the wafer sawing time.
- Equipment set years to depreciate over (row 9) - sets the depreciation rate for equipment.
- Equipment depreciation (display only) (row 10) - displays the equipment depreciation rate (one divided by the years to depreciate the equipment over).
- Year the facility was built (row 11) - by default this is set to 5 years before the date being modeled so the facility is still depreciating.
- Building systems years to depreciate over (row 12) - the number of years to depreciate the building systems over. Building systems make up 70% of the facility construction costs and are the HVAC systems, high purity piping systems, cleanroom, etc.
- Building years to depreciate over (row 13) - the number of years to depreciate the building over. the building makes up 30% of the facility construction cost.
- Building system depreciation rate (display only) (row 14) - displays the depreciation rate being applied to the building systems. If the year to model minus the year the facility was built is greater than the years to depreciate the building systems over this is 0. If the year to model minus the year the facility was built is less than or equal to the years to depreciate the building systems over this is set to one divided by the years to depreciate the building systems over.
- Building depreciation rate (display only) (row 15) - displays the depreciation rate being applied to the building. If the year to model minus the year the facility was built is greater than the years to depreciate the building over this is 0. If the year to model minus the year the facility was built is less than or equal to the years to depreciate the building over this is set to one divided by the years to depreciate the building over.
- Hours per week of operation (row 16) - by default 168 hours (24 hours a day 7 days a week).
- Weeks per year of operation (row 17) - by default 52 weeks per year.
- Uptime (%) (row 18) - the average percentage of time the equipment is up and available for use.

- <u>Utilization (%) (row 19)</u> - the average percentage of time that equipment is being used when it is up.
- <u>Calculated machine hours (hrs/yr) (row 21)</u> - this is the hours per week multiplied by the weeks per year multiplied by the uptime multiplied by the utilization and represents the productive machine hours per year.

<u>Background on die size and number of die per wafer</u>

When entering the die size – the die width and height in millimeters should be entered. The model takes the die size, adds street width and calculates the number of die that will fit onto a wafer based on wafer size and edge exclusion. If a supplier will not tell you the die size (this is very unusual) and x-ray of the package can be performed, or the package can be decapped to measure the die size. We recommend TechInisght for this service.

There is more than one way to describe die size and it is important to understand the differences. The following figure illustrates three die in a row on a wafer. Notice that there is the physical die size and then between each die there is a blank "street". The street provides an area for the saw cut used to separate the finished die. The model assumes that the die size that is entered is the physical die size of the die and by default the model adds a 75 micron street width when calculating the whole die on a wafer. Sometimes die sizes are specified using the stepping distance from the middle of a street to the middle of the next street. In this case you need to override the street width and set it to zero. Another situation that you may encounter is where a die size is measured after sawing, you need to make sure the measurement is the die only and not some remnant of the street still attached to the side of the die. The street is made wider than a typical saw cut to leave some room for misalignment and saw damage around the cut.

Die Size
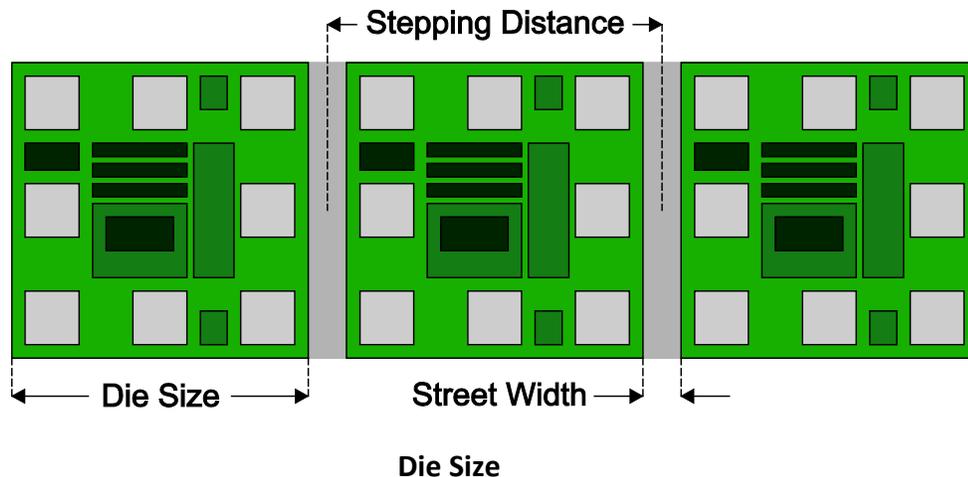
Other factors to take into when determining the number of whole die on a wafer are the edge exclusion.

- *Edge Exclusion – due to issues with maintaining prefect process uniformity all the way to the edge of a wafer there is an edge exclusion area at the edge of the die where no good die exist. By default the model leaves a 2mm edge exclusion but you can override that if necessary on the 'Global Values' sheet.*

Background – Cost Accounting

Cost accounting practices break out manufacturing costs in three categories:

1. *Material – material only includes materials that become part of the final product that is shipped. Materials consumed in product are included in overhead and do not count as materials.*
2. *Labor – labor only include direct or "touch" labor, basically the operators who make the product. Indirect labor such as engineers, technicians, managers and supervisors are included in overhead.*
3. *Overhead – everything else.*

The following table summarizes what is included in each category for different phases of IC production.

Category	*Wafer Fabrication*	*Packaging*	*Test*
Material	*Starting Wafer*	*Substrates, Leadframes, Wire, Mold Compound*	*None*
Labor	*Operators*	*Operators*	*Operators*
Overhead	*Depreciation, Equipment maintenance, Indirect labor, Monitor wafers, Facilities costs, Consumables*	*Depreciation, Equipment maintenance, Indirect labor, Facilities costs, Consumables*	*Depreciation, Equipment maintenance, Indirect labor, Facilities costs, Consumables*

Packaging (blue tab)
This is the main sheet of the model and is where the package is defined.

At a high level, columns A through AD are the wafer level operations and columns AF through BN are the die/package level operations. Rows 4 through 15 define the operations and rows 16 through 28 present the costs.

Rows 5 through 10 allow the user to define input wafers and select how the wafers are processed (columns B through AD).

Rows 11 through 15 are predefined wafers with limited ability for the user to edit how they are processed. In columns B through AD some selections are set and cannot be edited by the user (grey background) and some can be edited by the user (white background).

The predefined wafers supported in the model are:
1. Bridge die wafer - bridge die are used to connect die together in the Intel EMIB process.
2. InFO wafer - TSMC process where a wafer is used as a package for one or more die.
3. Integrated passive device - typically used in cell phones, resistors, capacitors and inductors are integrated on a single device.
4. Interposer - no TSV - interposer wafers without TSVs.
5. Interposer - TSV - interposer wafers with TSVs.

Working left to right and top to bottom the following is the detail of the sheet operation.

Wafer processing
This section defines the wafer level processing and costs. The results of this section may be used by themselves and, or to feed into the die/package process section:
- Wafer # and description - The model allows for up to 6 user defined wafers and 5 pre-defined wafer types to be used in the packaging process. Each wafer can supply 1 die per package or many die per package. Cells A5 through A15 number the wafers 1 through 11 and cells B5 through B15 describe the wafers. Cells B5 through B10 are user editable and you can enter whatever wafer description you want, cells B11 through B15 are predefined wafer types and cannot be edited.
- Wafer size - cells C5 through C10 allow the user to select a wafer size for the user defined wafers. For any wafers you aren't using you should set this to "NA". The predefined wafers have wafer sizes set in cells C11 through C15 and these are not user editable.
- Wafer type - cells D5 through D10 allow the user to select a wafer type for the user defined wafers. The predefined wafers have wafer types set in cells D11 through D15 and these are not user editable. The wafer type drives sawing speed.
- Die size - the die width and die height are set in cells E5 through F15. You must fill this in for any wafer you are using and **should be left blank for any wafer you are not using**. For the user defined wafers if you select a wafer size other than NA these matching die size cells will turn red unless you enter die size values. See the " Background on die size and number of die per wafer" for information on die size.
- Gross die - cells G5 through G15 display the calculated whole gross die per wafer based on the wafer size selected in column C, die sizes from columns E and F and street width and edge exclusion set on the 'Global Values' sheet.

- Die yield - enter a die yield in cells H5 through H15 for any wafer types being used.
- Net die - the gross die multiplied by the die yield is displayed in cells I5 through I15.
- Backgrind - in cells J5 through J15 set whether the wafers are going through Backgrind. In cells J17 through J27 the cost per wafer for Backgrind is displayed.
- Wafer thickness (mm) - in cells K5 through K15 enter the die thickness after Backgrind. This thickness is used to determine mold epoxy thickness to cover the die.
- RDL - Redistribution Layer used to route bond pads to wafer bumps for flip chip. In cells L5 through L10 you can select whether to perform RDL or not. RDL is off for the predefined wafers and is not user editable. In cells L17 through L27 the RDL cost per wafer is displayed.
- Integrated Passive Wafer - integrated passive devices are being increasingly used in cell phones and combine passive devices such as resistors, capacitors and inductors onto a single device. Although the fabrication of these devices uses technologies you would normally see in a wafer fab, OSATs such as STATS ChipPAC have started fabricating these devices. In cells M5 through M15 the processing for integrated passive devices is on for integrated passive devices wafers and is off for everything else. This is not user editable.
- Frontside wafer bumping - in cells N5 through N15 select NA if no frontside bumping is done or copper for copper bumping or solder for solder bumping. Bumping includes under bump layers. Cells M17 through M27 display the cost per wafer from frontside wafer bumping.
- Backside solder balls - in cells O5 through O10 and O12 enter the number of solder balls applied for backside wafer bumping. In cells N11 through N15 solder balls is off by default for certain predefined wafers and is not user editable. In cells N17 through N27 the cost per wafer for solder ball bumping is displayed.
- Copper pillar formation - copper pillars are used for the InFO process and are off for all other wafers by default and not user editable. For InFO you can turn on or off copper pillars in cell P12. Copper pillars are an option in the InFO process to provide interconnect to die mounted to the backside of the InFO package. The cost per wafer to form copper pillars is displayed in cells O17 through O27.
- Wafer coating - a protective wafer coating is sometimes used on bumped die. Select yes or no for wafer coating in cells Q5 though Q10. Wafer coating is off by default for the predefined wafers and is not user editable. The cost per wafer for wafer coating is displayed in cells P17 through P27.
- Wafer level buildup layers - wafer level buildup layers are used for interconnect for the InFO process and off by default for all other wafer types and not user editable. In cell R12 enter the number of buildup layers for the InFO wafer. The cost per wafer for the selected buildup layers is displayed in calls Q17 through Q27.
- Wafer mold - wafer mold is used for the InFO process and off by default for all other wafer types and not user editable. Select "Yes" in cell S12 to activate wafer mold for the InFO wafer. The cost per wafer for wafer mold is displayed in calls R17 through R27.
- Planarize - planarize is used to expose electrical contacts after wafer mold for the InFO process. Planarize is off by default and not user editable for all non-InFO wafers. In cell T12 you can turn planarize off and on for InFO. Cells S17 through S27 display the cost per wafer for the planarize step.
- Carrier removal - a carrier is used for the InFO process and then removed. Carrier removal is off by default and not user editable for all non-InFO wafers. You can turn carrier removal off or on for InFO in cell U12. Cells T17 through T27 display the cost per wafer for the carrier removal step.

- First pass - selects "Yes" or "No" to turn on or off the first pass wafer sawing. Cells V5 through V15 select first pass sawing for each wafer. Cells V11 and V13 through V15 are on by default and not user editable. Cells V17 through V27 display the wafer cost for sawing for each wafer.
- Second pass - selects "Yes" or "No" to turn on or off the second pass wafer sawing. Cells W5 through W15 select second pass sawing for each wafer. Cells W11 and W13 through V15 are off by default and not user editable. Cells W17 through W27 display the wafer cost for sawing for each wafer.
- Saw type - select "1 spindle", "2 spindle" or "3 spindle" standard saw or laser (single head) for the saw type in cells X5 through X15. Cells X11 and X13 through X13 are set to "2 spindle" by default and are not user editable. The selections in these cells are used for both first and second pass sawing of applicable.
- Reconstruct wafer - after test only good die are picked and placed onto a frame to create a new wafer of all good die. Select "Yes" or "No" to activate or inactivate reconstructed wafer in cells Y5 through Y15. Reconstruct wafer is off by default for the predefined wafers and is not user editable. The cost per wafer for reconstruct is displayed in cells Y17 through Y25.
- Wafer backside laser mark - backside laser marking of die that will be wafer level packaged. Select "Yes" or "No" to activate or inactivate backside laser marking in cells Z5 through Z15. Wafer backside laser mark is off by default for the predefined wafers and is not user editable. The cost per wafer for wafer backside laser mark is displayed in cells Z17 through Z25.
- Tape and reel - tape and reel of die that will be wafer level packaged. Select "Yes" or "No" to activate or inactivate tape and reel in cells AA5 through AA15. Tape and reel is off by default for the predefined wafers and is not user editable. The cost per wafer for wafer backside laser mark is displayed in cells AA17 through AA25.
- Visual inspect - select "1 times", "2 times" or "3 times" for 1, 2 or 3 wafer visual inspections respectively or "NA" for no inspection in cells AB5 through AB15. By default many of the predefined wafers are set to 1 and it is not user editable.
- Wafer cost - in cells AC17 through AC27 the total cost for processing of each wafer type is displayed. This is a summary of columns J though AB.
- Die cost - in cells AD17 through AD27 the cost per die for wafer processing is displayed. This is the wafer costs from column AC divided by the net die for each wafer from cells I5 through I15.

Die/package processing

This section defines the die/package processes and costs. The die costs from the wafer level section feed into this section.

- Die usage - cells AF5 through AF15 define how many die are used from each wafer defined in the wafer processing section. If 0 is entered here the costs from the wafer on that row in the wafer processing section will not be included in the die/package calculations. For packages with multiple die from various wafers you can use as many die from each wafer as you want. For example for a leadframe package you might have 2 die from wafer 1. For an organic substrate with EMIB die you might have 1 die from wafer 1, 1 die from wafer 2 and 6 die from the EMIB wafer to interconnect them. For an InFO part you would have 1 InFO die and then multiple die you are attaching to it. Cells AF17 through AF27 display the total cost for die from each respective wafer type. This is the die cost from cells AD17 through AD27 multiplied by the number of times each die is used in cells AF5 through AF15. In cell AF28 a total of all of the die costs for the die being used is displayed.

- Type - select InFO, Leadframe or Organic Substrate to set the package type for this section. Wafer level packaging is not an option here because it is completed in the wafer level processing section. You select the package type in Cell AG5.
- Leadframe - if you select "Leadframe" in cell AG5 then cells AH5 through AJ15 turn white so you can define the leadframe. Cell AH5 is a dropdown where you select the leadframe. For "InFO" or "Organic Substrate" packages this section is inactive.
- Etched or stamped - for Leadframe packages you select "Etched" or "Stamped" for the leadframe type in cell AI5.
- Alloy - in cell AJ5 you select the alloy type used to make the leadframe.
- Stamped plated - for stamped leadframes you can select whether to spot plate it in cell AK5. In cell AH17 the cost for the leadframe based on the leadframe defining selections is displayed. This cost also appears in cell AH28 for the total of the entire package process.
- Width - if cell AG5 is set to "Organic Substrate" then cells AL5 through AQ15 turn white so you can define the organic substrate package. In cell AL5 you enter the organic substrate package width in millimeters.
- Height - in cell AM5 you enter the organic substrate height in millimeters.
- Core layers - in cell AN5 you enter the number of core layers for the organic substrate.
- I/O - in cell AO5 you enter the number of input/outputs for the organic substrate
- Buildup layers - in cell AP5 enter the number of buildup layers for the organic substrate.
- EMIB processing - if you enter a number greater than 0 for the EMIB wafer (Bridge die wafer) die used in cell AF11, then cell AQ5 will display a "Yes' to indicate additional organic substrate processing is active for EMIB die. In cell AN17 the cost for the organic substrate is displayed and it is also added into cell AN28 for the package total.
- Type - select the die attach type for each of the user defined wafer/die types in cells AR5 through AR10. If you select "Flip chip" here then wire bonding is disabled from that die. Also supported are "Epoxy", Gold Eutectic" and Solder. Cells AR17 through AR22 display the die attach cost for each die. Cell AR28 displays the total die attach costs and adds into the overall package cost.
- Cure - if any active die are epoxy mounted then cure is automatically turned on in cell AS5. The cure cost is displayed in cell AS17 and added into cell AS28 for the total package cost.
- Capacitors - in cells AT5 through AT10 you can enter the number of bypass capacitors used on the packages and in cells AU5 through AU10 you can enter the number of power supply capacitors used on the package. The cost for bypass capacitors is displayed in cells AT17 through AT and summarized in cell AT28 and the cost for power supply capacitors is displayed in cells AU17 through AU22 and summarized in cell AU28.
- Aluminum heat spreader - in cells AV5 though AV10 you can turn on aluminum heat spreaders, for each row that you turn on aluminum heat spreaders the corresponding width (column AW) and height (column AX) cells will turn white and you need to enter the height and width. The aluminum heat spreader cost for each die is displayed in cells AV17 to AV22 and the total cost is displayed in cell AV28.
- Plasma clean - in cell AY5 you can select "Yes" or "No" to activate or deactivate plasma cleaning. The cost for plasma clean is displayed in cell AY17 and added into cell AY28 for the total package cost.
- Wire type - in cells AZ5 through AZ10 select the wire type for wire bond with "Aluminum", "Copper" and "Gold" options. Wire bond is disabled for any die where "Flip chip" is selected for die attached or where 0 is entered for number of die in column AF.

- Number of bond wires - in cells BA5 through BA10 enter the number of wire bonds for each die. Wire bond is disabled for any die where "Flip chip" is selected for die attached or where 0 is entered for number of die in column AF.
- Wire length - in cells BB5 through BB10 enter the length of the wire bonds for each die. Wire bond is disabled for any die where "Flip chip" is selected for die attached or where 0 is entered for number of die in column AF. Cells BB17 through BB22 display the cost for wire bond for each die and cell BB28 totals up the wire bond cost for the final package costs.
- Inspect - in cells BC5 through BC10 select "Yes' to enable visual inspection and select "No" to disable visual inspection. The cost for visual inspection for each die is displayed in cells BC17 through BC22 and added together in cell BC28 for the package cost.
- Mold - select "Yes" in cell BD5 to enable molding and "No" to disable mold. If you disable mold then the thermal lid definition cells will turn white and allow you to define a thermal lid. Cell BD17 displays the molding cost and it is added into cell BD28 for the package cost.
- Used - if mold is turned off in cell BD5, then you will have the option to turn on a thermal lid by selecting "Yes' in cell BE5.
- Width - if a thermal lid is used enter the lid width in millimeters in cell BF5.
- Height - if a thermal lid is used enter the lid height in millimeters in cell BG5. Cell BG17 displays the cost of the thermal lid and the cost is added into cell BG28 for the package cost.
- Singulate - for leadframe packages you can select Singulate in cell BH5. InFO and organic substrates are sawn up and that is defied in the wafer section for InFO or incorporated into the substrate formation process for organic substrates. The cost for singulation is shown in cell BH17 and added into cell BH28 for the package cost.
- Laser mark - select "Yes" in cell BI5 to add laser mark to the package. The cost for laser mark is displayed in cell BI17 and added into cell BI28 for the package cost.
- Tape and reel - select "Yes" in cell BJ5 to add laser mark to the package. The cost for laser mark is displayed in cell BJ17 and added into cell BJ28 for the package cost.
- Inspect - select "Yes" in cell BK5 to add a visual inspection step. The cost is displayed in cell BK17 and added into cell BK28 for the package cost.
- Open/short test time - to add open/short testing enter the open/short test time in cell BL5. The cost for open/short testing is displayed cell BL17 and added into cell BL28 for the package cost.
- Total package cost - cell BM28 sums up all of the packaging costs to get a total package cost.
- Total package price - cell BN28 displays the package selling price after applying the gross margin from the 'Global Values' sheet.

<u>Cost Summary (brown tab)</u>

This sheet presents all the wafer level and package/die costs and summarizes them into a total package cost and selling price. This sheet is not user editable and is driven by the 'Global Values', 'Packaging' and 'Yearly Data' sheet entries/selections.

Material Usage (brown tab)

This tab displays the material usage for packaging. This sheet is not user editable and is driven by the 'Global Values', 'Packaging' and 'Yearly Data' sheet entries/selections.

- Column B lists every material type supported by the model.
- Column C displays whether the usage is per part, per wafer or a combination of the two.
- Column D displays the amount of usage.
- Column E displays the units of usage.
- Column F displays the cost of the material, this is based on the material and the current year and comes from the 'Yearly Data' sheet.
- Column G displays the units for pricing, for example a material might be used in grams but bought in kilograms.
- Column H displays the material cost, this is the usage multiplied by the price after adjusting for differences in usage and purchasing units.

<u>Yearly Value (brown tab)</u>

This sheet presents user editable values by year from 2010 for 2025 for the following input factors:

- Direct labor rate by country.
- Electric rate by country.
- Engineers salary by country.
- Margin by OSAT provider.
- Material costs by material type.