JMP Instructional data set 015

Semiconductor IC Yield During Pilot Manufacturing

JMP STATISTICAL DISCOVERY

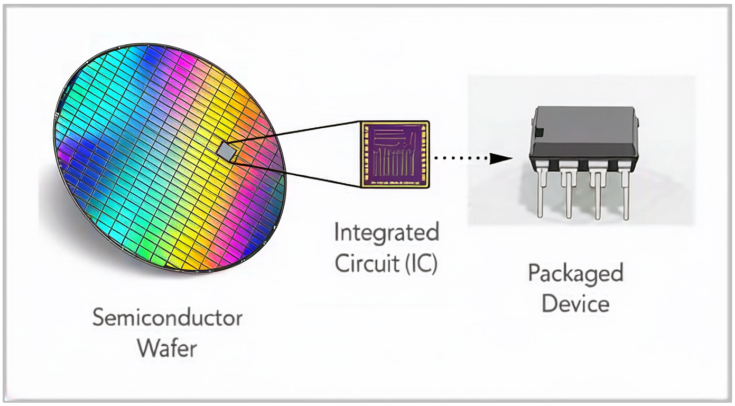
JMP platforms and statistical methods

Distribution: Bar chart; summary statistics; confidence intervals for a proportion, difference in proportions, and ratio of proportions

Graph Builder: Mosaic plot; shape-based heat map

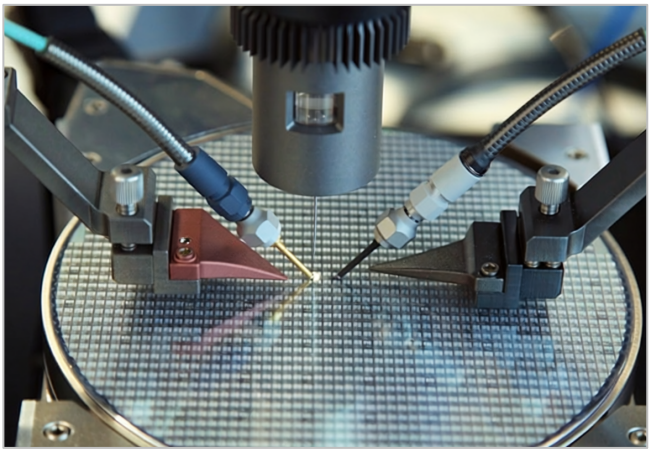
Problem Statement

In the semiconductor manufacturing process, a silicon wafer undergoes various stages of processing to create integrated circuits (ICs) – complex electrical interconnections to perform the intended functions of the final product. Depending upon the size of the wafer and the types of ICs being formed, a wafer may contain a few hundred to thousands of individual ICs. Each of these is cut from the wafer and packaged into a device to be used in electronic products.



In the early development stage of a new IC design, the yield (percentage of functional ICs from all the ICs produced) can often be quite low. As the process matures, the yield will improve, eventually reaching a point where full-scale manufacturing of the ICs can take place.

In this example, an engineering team has run a pilot study on a new IC design by producing a total of 50 semiconductor wafers, with half of them produced using Method A and half produced with Method B, which is a quicker and less expensive process. Each wafer contains 1,300 ICs for a total of 50 x 1,300 = 65,000. Each IC undergoes a series of electrical tests to determine if it functions properly. The outcome is a binary variable indicating if the IC passed or failed the electrical testing.



The objective of the analyses will be to use graphical methods and confidence intervals for proportions to describe and compare the yield of the electronic testing to identify if there are significant differences in outcomes between the two methods, between the wafers within a method, and across the location of the ICs on the wafers.

Data

IDS_015.jmp

Methods	The two different methods (A,B) used to produce each batch of 25 wafers
Wafer	ID of wafers produced within each method (1,2,…,25) and the simulated years in the accelerated tester
IC	ID of the 1,300 integrated circuits on each wafer
Method-Wafer-IC	Unique ID for each of the 65,000 integrated circuits
X Coordinate	Location of the IC on the wafer in the X dimension
Y Coordinate	Location of the IC on the wafer in the Y dimension
Test Result	Results of the electrical testing (“Passed” or “Failed)

Exercises

1. Graphically and numerically summarize the Yield for each of the two methods. Provide a brief interpretation of the results.

   Instructions:
   Choose Analyze > Distribution. Place the variable ‘Test Result’ in the Y, Columns role. Place ‘Batch’ in the By role. Click OK.

2. Create 95% confidence intervals estimating the Yield for each method if it was applied to full scale manufacturing without further modifications. Provide an interpretaton of these intervals. Do you believe there to be a significant difference in Yield between the two methods? What characteristic of these data is determining the very narrow margin of error in these confidence intervals?

   Instructions:
   In the Distribution report, select Confidence Interval > 0.95 from the red triangles next to ‘Test Result’ title for each method.

3. Create 95% confidence interval estimating the difference in the Yields between the two methods. Provide an interpretaton of this interval. Create 95% confidence interval estimating the ratio of the Yields between the two methods. Provide an interpretaton of this interval. Do you have a preference on which technique you feel is better at describing the difference in Yields between the two methods?

   Instructions:
   Choose Analyze > Fit Y by X. Place ‘Test Result’ in the Y, Response role and ‘Method’ in the X, Factor role. Click OK.
   1. For difference in Yields: Select Two Sample Test for Proportions under the top red triangle.
   2. For ratio of the Yields: Select Relative Risk under the top red triangle. Choose to report Passed and Method B in the denominator.

4. Create a graph that displays the Yield separately for each of the 50 wafers. Is the Yield relatively consistent across the wafers within each method?

Instructions:
Graph > Graph Builder. Place the variable 'Test Result' on the Y axis, 'Wafer' on the X, and 'Method' on the Group X. Choose the Mosaic Plot icon  *from the graph palette.*

Float cursor over any of the bars to see the Yield for each wafer.
Note: You can change the colors of the bars by right-clicking on the legend to the right of the graph (e.g., red for "Failed" and green for "Passed").

5. Create a shaped based heat map displaying the Test Result for each of the 1,300 ICs for all 50 wafers. Describe the features/patterns this heat map reveals regarding the locations/areas on the wafers where Yield is highest/lowest.

Instructions:
Two versions of the visualization will be made.

1. Graph > Graph Builder. Place the variable 'Y Coordinate' on the Y axis, and 'X Coordinate' on the X. Right-click on the graph and choose Graph > Size/Scale > Size to Isometric. This makes the shape a symmetric circle. You can also do this manually by clicking the corner of the graph and dragging to create the desired size and shape. Place the variable 'Test Result' in the color role. Right-click on the elements in the legend on the right to change "Passed" to green and "Failed" to red. Select Local Data Filter under the red triangle next to the Graph Builder title and choose the variables 'Method' and 'Wafer'. Select "+" symbol. Now any one of the 50 individual wafers can be selected and the test results for the 1,300 ICs on the chosen wafer will be shown.

2. Graph > Graph Builder. Place the variable 'Y Coordinate' on the Y axis, and 'X Coordinate' on the X. Place the variable 'Test Result' in the color role. Right-click on the elements in the legend on the right to change "Passed" to green and "Failed" to red. Place 'Wafer' in the Wrap role and 'Method' in the Group Y role. Right-click on the graph and choose Graph > Size/Scale > Size to Isometric so all the wafers are shown as symmetric circles. This graph shows the test results for all 65,000 ICs (1,300 on each of the 50 wafers). Note: you can choose the arrangement of how many wafers are shown in each row of the graph by right-clicking on the 'Wafer' variable name at the top and choose Levels > Lever per Row. Suggest using 10.

6. What other outcome data would be useful to have available for analysis beyond just "Passed" or "Failed" the electrical testing?