# SEMICONDUCTOR – YIELD DURING PILOT MANUFACTURING

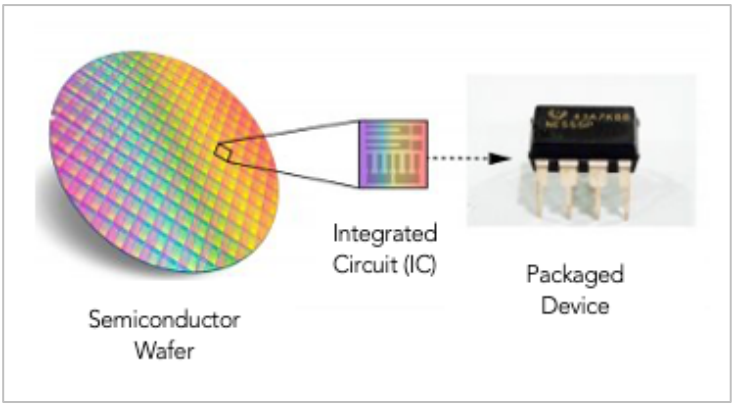
## RELEVANT JMP PLATFORMS AND STATISTICAL TECHNIQUES

**Distribution :** Bar Chart, Summary Statistics, Confidence Interval for a proportion, Confidence Interval for difference in proportions, confidence interval for ratio of proportions.

**Graph Builder :** Mosaic Plot, Heat Map

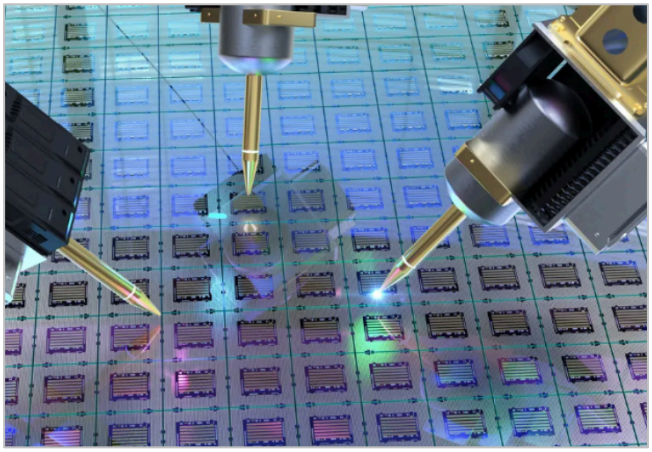
## PROBLEM STATEMENT

In the semiconductor manufacturing process, a silicon wafer undergoes various stages of processing to create integrated circuit (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. 25 of them were produced using method A and 25 were produced using method B – 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 analysis will be to examine the yield identifying if there is significant changes between the two methods, between the wafer within a method, and within the location on the wafer.

## DATA SET

Semiconductor_IC_Yield_During_Pilot_Manufacturing.jmp

| | |
|---|---|
| **Method** | The two different method used to produce each batch of 25 wafers |
| **Wafer** | Wafer produced within each method (1,…,25) |
| **Method-Wafer-IC** | Identification for each IC |
| **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 electronic 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:* *Use 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 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:* *We will make two versions of this graph.*
>
> *1. Use 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. Use 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.*

6. Can you think of any other outcome data that would be useful to have available for analysis beyond just “Passed” or “Failed” the electrical testing?