The MPCpS® Methodology

Process Optimization

A Five-Stage Methodology for Characterizing Processes

Mario Perez-Wilson

Follow this step-by-step approach at your own pace, and teach yourself how to optimize processes.

You will be improving processes right away!

The M/PCpS® Methodology

Stage IV: Optimization

Mario Perez-Wilson

President
Advanced Systems Consultants

"The M/PCpS Methodology - Stage IV: Optimization"

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THE M/PCpS METHODOLOGY - STAGE IV: OPTIMIZATION

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When is Statistical Experimentation Important ?

There are many instances when the learning is so important it requires experimentation and the use of statistical methods.

Two important activities in which experimentation is important are:

1. Scientific Research, and
2. **Problem-Solving**

This book deals with the application of experimentation for complex problem-solving.

A Methodology - DOEx

In the process of experimentation for problem-solving, there is no one unique path to obtaining a solution to a problem. Many paths may lead to the solution. However, a strategically designed path comprised of logically selected steps may become a common path or methodology, providing an efficient way of converging to a possible solution every time it is followed. This book attempts to provide such a methodology, and it will be referred to as the DOEx methodology. DOEx stands for the "Design of Experiments - A Methodology".

Qualities Needed For Good Experimentation:

1. **Subject-matter Knowledge**
   - **Knowledge of:**
     - **Process**
     - **Problem**
     - **Physics**
2. **Intellect**
   - **Faculty of :**
     - **Understanding**
     - **Thinking**
     - **Acquiring Knowledge**
3. **Knowledge Of Strategy**
   - **Statistical Methods**
   - **DOEx**

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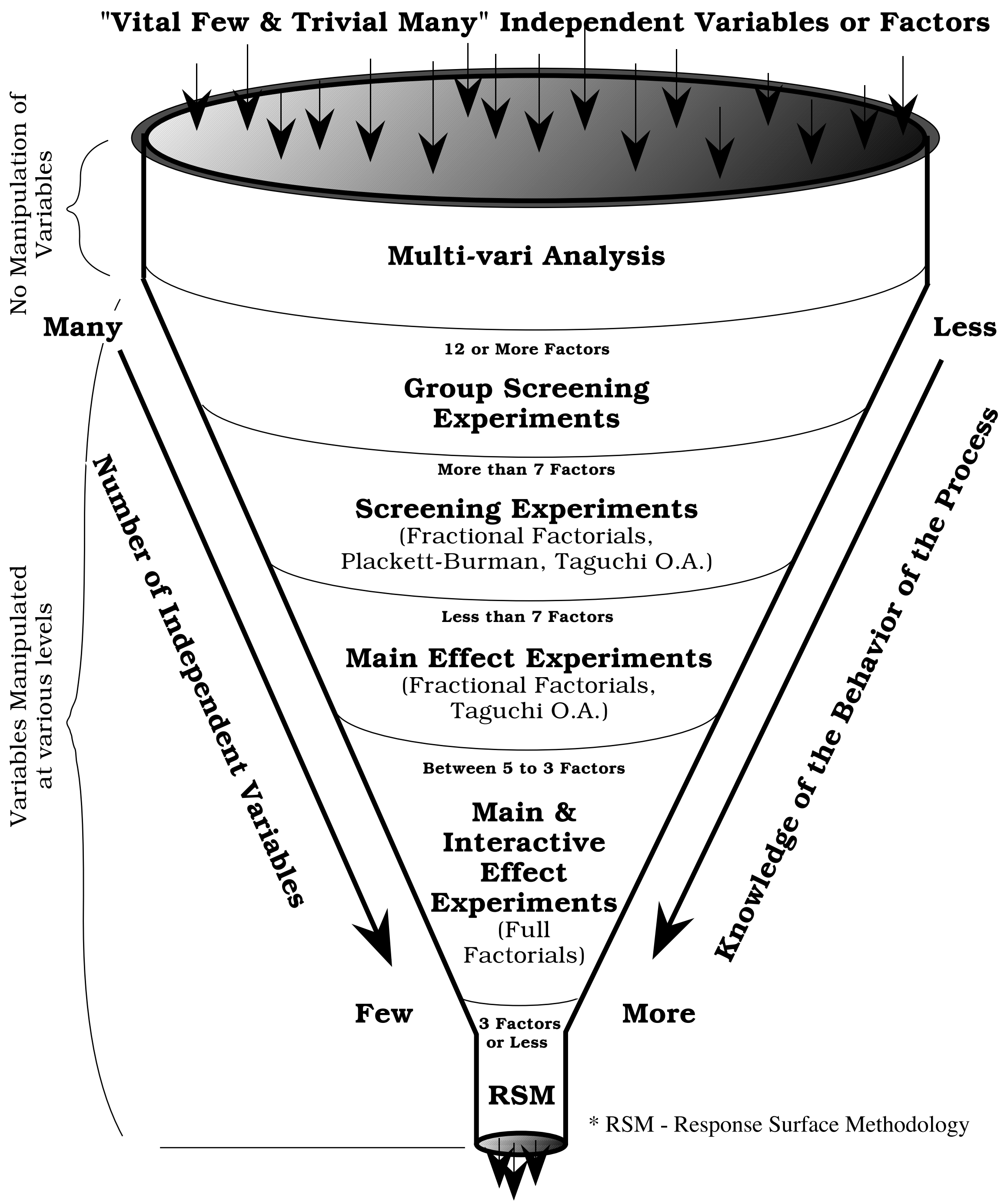
Experimental Design Funnel



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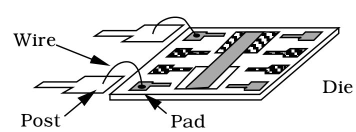
Let's use experimental data collected from a Wire Bonding process to describe the computations of the main and interactive effects in a 2^3 full factorial and to analyze the experiment.

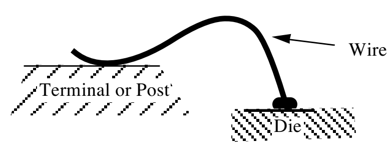
Wire Bonding

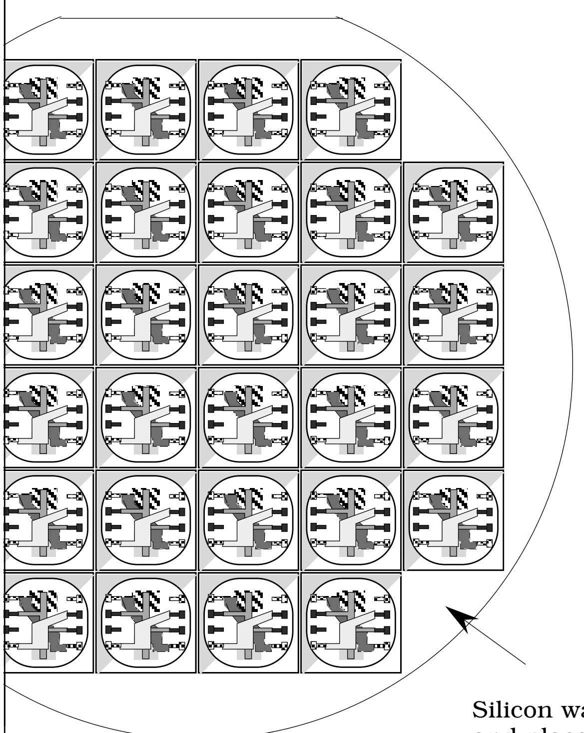
An Integrated Circuit (IC) wire bonding process makes wiring connections from wafer die bond pads to the leadframe posts. The bonding is an ultrasonic bonding process.

In a previous process step (die bonding), the die are singly picked from a silicon wafer by a pick-and-place robotic arm and accurately placed in a leadframe. The die are then bonded to the leadframes. Once the die are attached, the wire bonding process uses a gold wire to connect each die bond pad to a leadframe post by bonding the wire from the bond pad to its respective post. The bond on the pad appears as a ball formed by ultrasonic energy, making a good intermetallic formation between the ball-bond and the pad.

Some typical factors critically important in the wire bonding process are ***bond time***, ***bond power*** *and* ***bond temperature***.

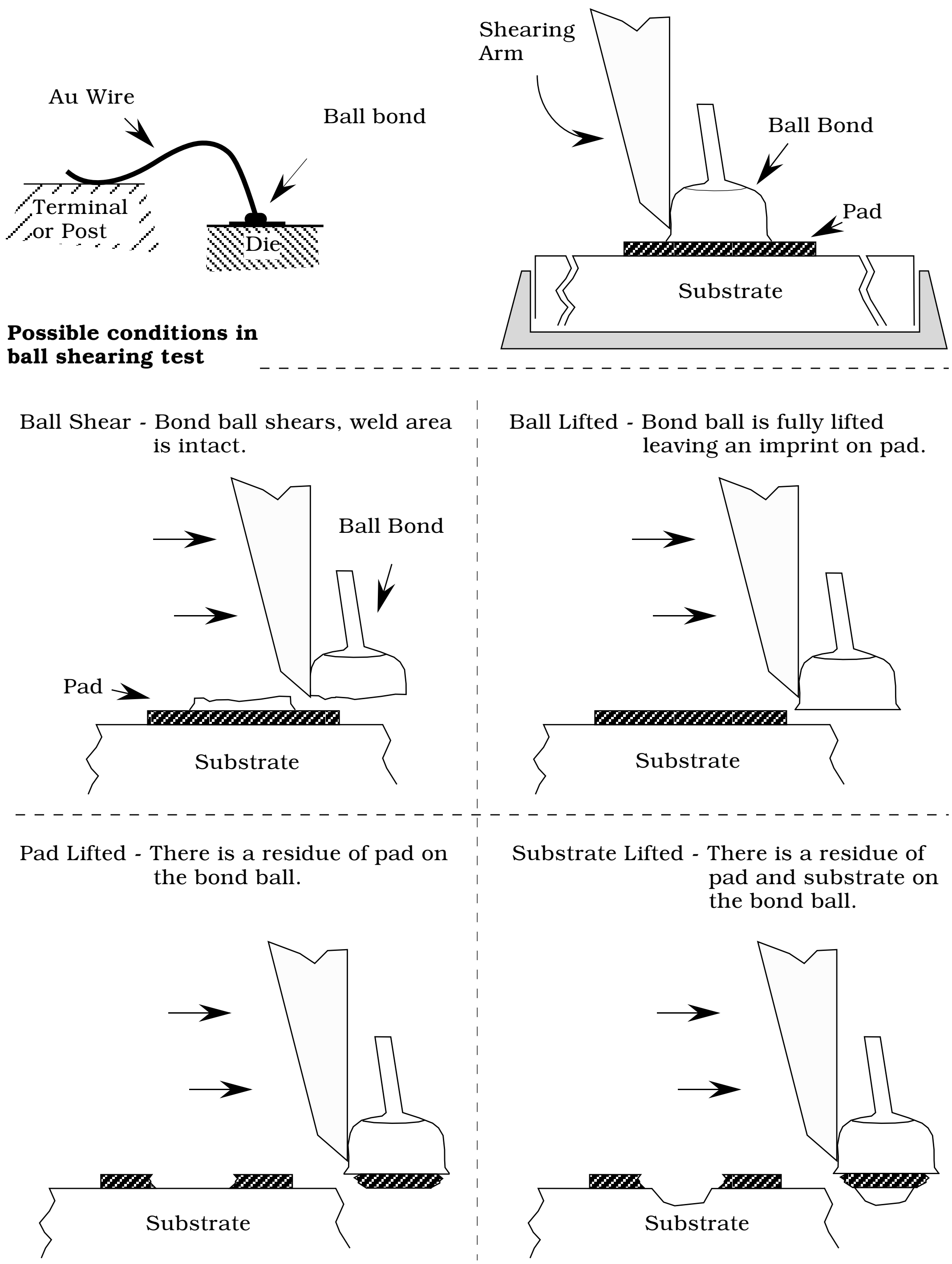






Silicon wafer with die ready to be picked and placed in leadframe for bonding.

A shearing arm swivels with an increasing force (grams) to shear the bond ball out of the bonding pad.



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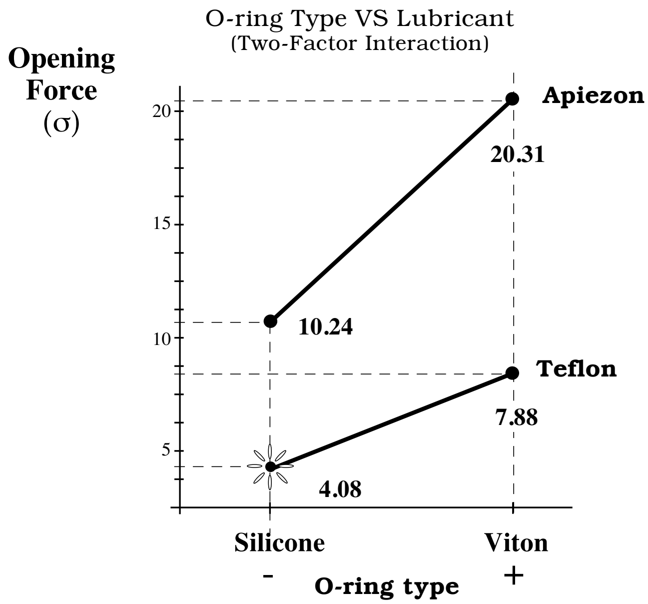
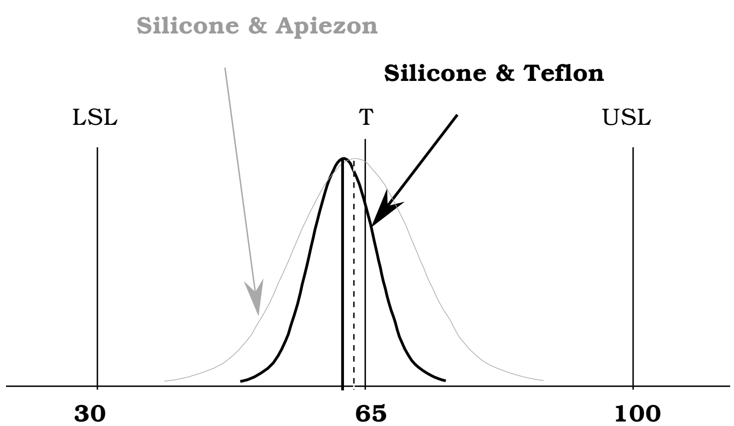


Plotting the standard deviations in an isolation plot, the standard deviation of silicone and teflon is 4.08, and is the lowest of all the other conditions. The apiezon appears to have more variation (standard deviation) than the teflon.



Setting the process with a Silicone o-ring and teflon as a lubricant appears to reduce the opening force average from 101.63 to about 61.5, and reduce the standard deviation from 34.58 to about 4.08. The new setting would improve the Cpk to about 2.57 and make the process **± 8.6 sigma**, obviously after testing for normality and stability.

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Let's go through an example of conducting a fractional factorial design experiment and of analyzing the data.

Integrated Circuit Molding Process

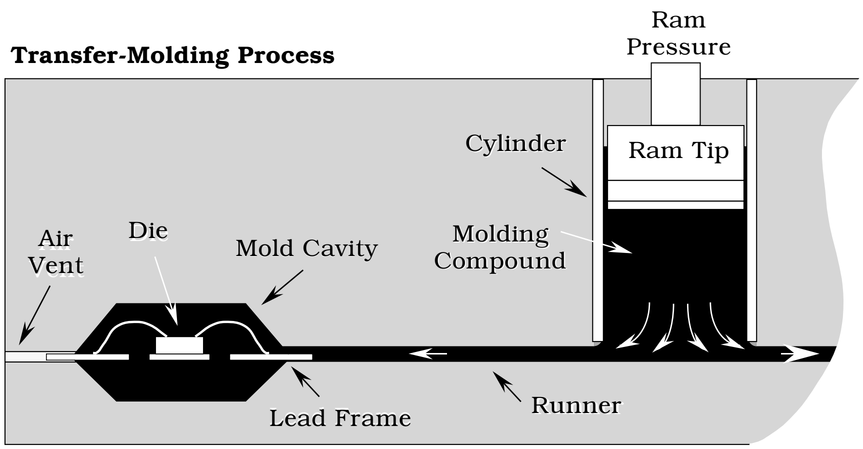
An integrated circuit molding process has been exhibiting some production quality problems and engineering has decided to conduct some experiments to determine the "vital few" independent variables controlling the process. The process has consistently exhibited a high number of voids in the IC components and various process changes have not yielded a stable improvement. Engineering has decided to conduct a screening experiment to determine the main effects of the following variables suspected to be influential in the reduction of voids.

The independent variables determined through a team brainstorming session are:

[A] ***Ram Tip Type***
[B] ***Pellet Preheat Time***
[C] ***Ram Transfer Time***
[D] ***Ram Transfer Pressure***
[E] ***Mold Curing Time***
[F] ***Mold Temperature***

The response variable is percent voids, and the current yield is at about 92%.

Transfer-Molding Process



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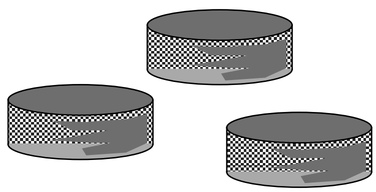
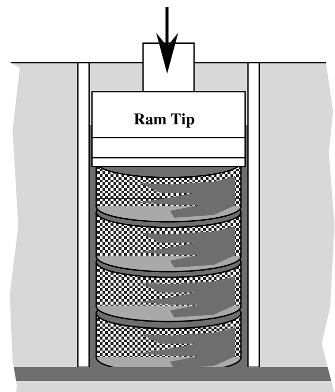
Integrated Circuit Molding Process Cont...

***Background**: Prior to the transfer molding process, plastic molding materials are compressed into small pellets of equal size, disk shape, density and weight. In the transfer molding process, molding pellets of 4.0 grams are placed into the pressure transfer chamber where they are later liquefied by heat and pressure. The mold is then closed and clamped by a press platen. The molding compound is then injected into the mold cavities as a hot liquid where the materials will be allowed to cure and harden.*



Molding Pellets



Step 1. Select the factors and levels for those factors.

Factor	Independent Variables	Low (-)	High (+)
A	Ram Tip Type	Taper	Straight
B	Pellet Preheat Time	5 Sec	10 Sec
C	Ram Transfer Time	5 Sec	10 Sec
D	Ram Transfer Pressure	20 Kg/cm^2	40 Kg/cm^2
E	Mold Curing Time	45 Sec	65 Sec
F	Mold Temperature	170 ˚ C	190 ˚ C

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