Usage of Water Contact Angle to Step Up Six Sigma in Cleanliness and Adhesion Functions.

New tools and methodologies to apply Lean Manufacturing and Six Sigma to bonding, coating, cleaning, and sealing processes

Brighton Science

Usage of Water Contact Angle to step up Six Sigma in **cleanliness and adhesion functions.**

Originally associated with Japanese management and manufacturing techniques, quality circles are a participatory management technique that enlists the help of employees in solving problems related to their job. Through the teaching of thought leaders like Taiichi Ohno, Shigeo Shingo or Kiichiro Toyoda, and with the emergence of the well-known "Toyota Production System" (TPS), generations of green and black belt engineers have used the concepts of Lean Manufacturing and Six Sigma to improve quality, efficiency and reduce the financial burden of Taylorism approach in their industries.

Every sector of manufacturing for which the safety, quality and performance are paramount to the success of enterprises have undergone this transformation, including the automotive, medical device, aerospace and consumer goods industries. More recently, chemical processing industries and services have started to implement Lean and Six Sigma, demonstrating the universality of the concepts.

The master themes of this transformation are the elimination of every part, component or activity not delivering added value. It happens through a series of simple actions from the shop floor to the engineering offices.

The differences between Lean and Six Sigma can be confusing. They pursue different goals and their combination delivers a long list of incredibly powerful results, including increased throughput, defect elimination, reduction of rework or inspections, reduction of material waste (scrap), equipment reliability and availability, workforce efficiency and involvement. But what are the differences, specifically?

Lean manufacturing reduces waste by streamlining manufacturing processes. The primary focus is on waste reduction in materials, movements, flows and operations by clearly distinguishing between added value (seen by the customer) and wasted energy. Lean manufacturing focuses also on optimizing flows by reducing inventory, producing only what is necessary while maintaining quality and low defect rate.

Six Sigma reduces defects with effective problem solving. In a Six Sigma world, "variation is the enemy." The study of stable process results through statistical methods and in-depth root cause analysis helps eliminate problems and minimize re-occurrence. In this world, a master theme could be "measure, measure, measure." We often talk about Six Sigma organizations as an "ideal" to reach. In fact, the number of Sigma will define a proceeses' ability to deliver reliable results.

The chart below shows commonly used indicators and how they correspond with the number of sigma.

- ppm: defect per million of part produced
- Cpk: process capability (variation and center)

Sigma	Defect (ppm)	Cpk
1	317,000	0.33
2	45,500	0.67
3	2,700	1.00
4	63	1.33
5	0.6	1.67
6	0.002	2.00

In the current manufacturing world, successful companies perform in the range of 5 sigma, meaning less than 1 defect per million and a process capability larger than 1.5.

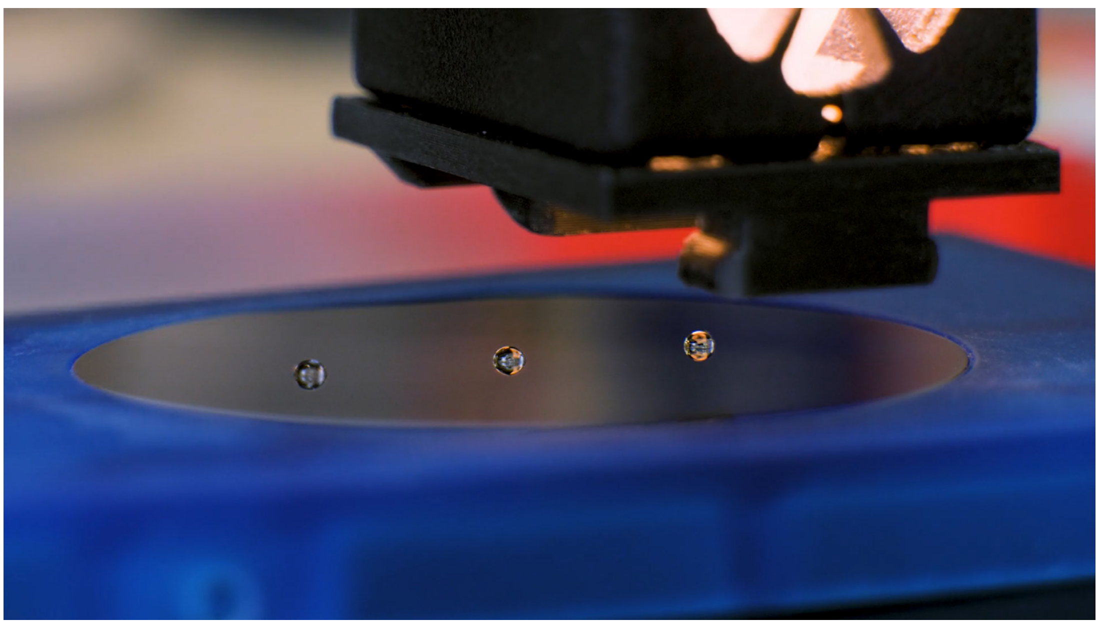
Bonding, cleaning, and coating are common to all manufacturers, from those that produce microchips to those designing spaceships. When a bonding failure occurs, it's most often attributed to one of two causes: selecting the wrong material or choosing materials that don't meet quality standards. However, it's much more likely that the problem lies at the surface during the point of bonding.

If Lean Manufacturing and Six Sigma processes are so efficient in resolving issues and improving overall results, why aren't they more widely used in the world of cleanliness and adhesion?

There are multiple answers, but the most likely reason is that companies in this environment is still using empirical methods and lack "defined data."

What prevents companies from employing more widely used technologies that would allow a perfect qualification of processes and products?

In high-speed automated manufacturing as well as production requiring hands-on work of skilled technicians, adhesion failure is a leading cause of product failure. Yet, the requirements for an effective bond are not well understood and controlling bond quality is seldom tracked on a control chart. However, appreciating the importance of surface readiness in ensuring a high-quality bond unlocks significant opportunity for companies focused on Lean process improvements.

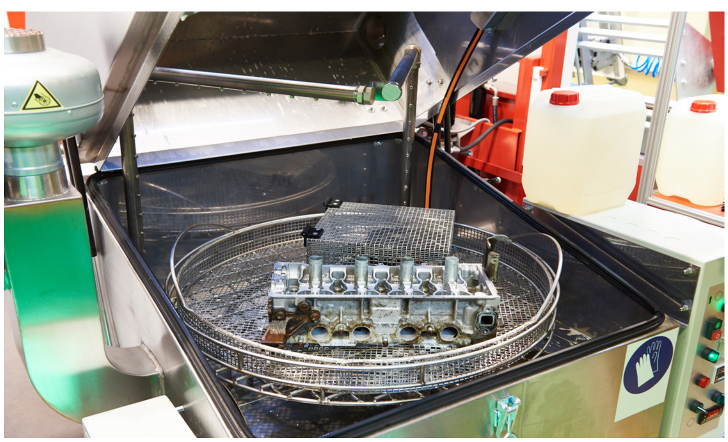


A manufacturer has set standards for measuring surface readiness at multiple points on a silicon wafer.

Across hundreds of companies and thousands of cases, Brighton Science has been identifying the following root causes:

- The request for more "defined" data often comes AFTER the problem occurs. The quality or process engineers focus primarily on the composition of the materials being used rather than considering the surface readiness preparation or the impact of process and environment. At that point, significant changes to the product design or process can become extremely lengthy and costly. Additionally, if chemicals are not the proven issue nor solution, then the blame is placed on the supplier, logistics or operators rather than the lack of mastership in surface preparation.
- There is a lack of knowledge about the difference between mechanical surface preparation and chemical surface preparation. This is coupled with a lack of understanding that surface readiness is largely attributed to the 3 to 5 first molecular levels of the material and therefore not visible nor detectable with microscopes, and even less so with simpler tools.
- Engineering teams should carefully consider the measurement methodology when working on lean projects. Sensitivity to the right variables, allowing for the appropriate measurement frequency (with something easy, fast, and non-destructive), and making measurement part of ongoing Continuous Improvement will allow improvement in Cpk values. Currently many manufacturers are utilizing methods that are not sensitive, are destructive, and are implemented at the end of the assembly. An example would be performing bond tests a few parts per shift. This is not only expensive but makes it difficult to determine Root Cause and implement corrective actions. Bond tests are also difficult to analyze digitally as failure MODE is more indicative of performance than failure LOAD.

Standard methods of surface preparation are not in control and can fail to prepare the surface due to human, material, or mechanical error. Due to many subtle factors, invisible variation goes undetected, leading to production problems, warranty claims, and perhaps even the potential for injury or loss of life. Better standards for surface readiness are needed.

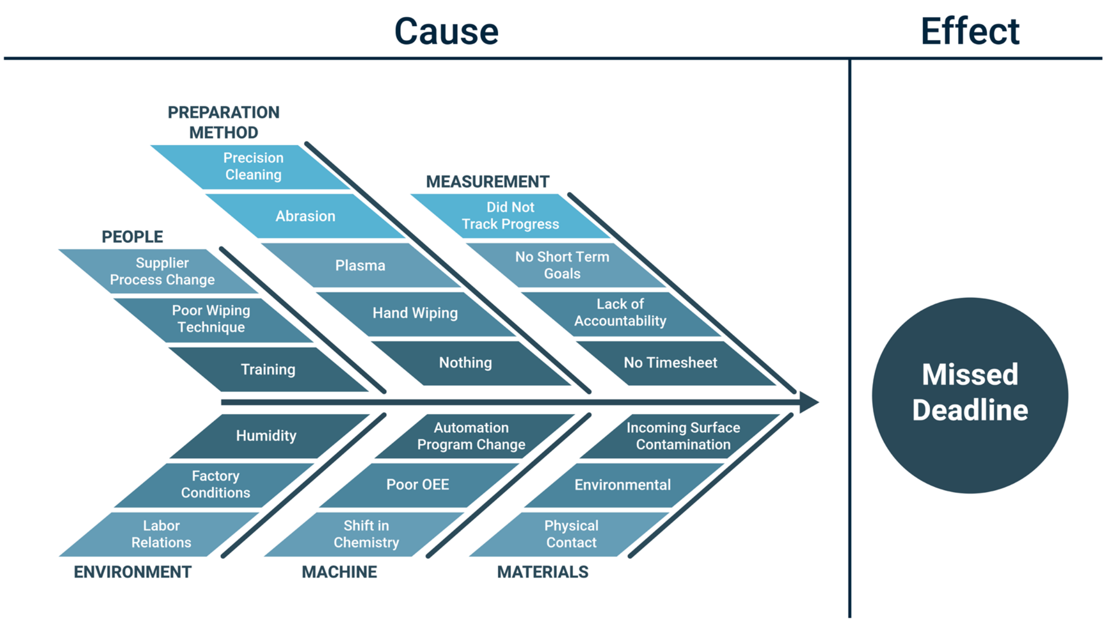


Even the most stringent cleaning processes impose risks due to unpredictable variables and contaminates.

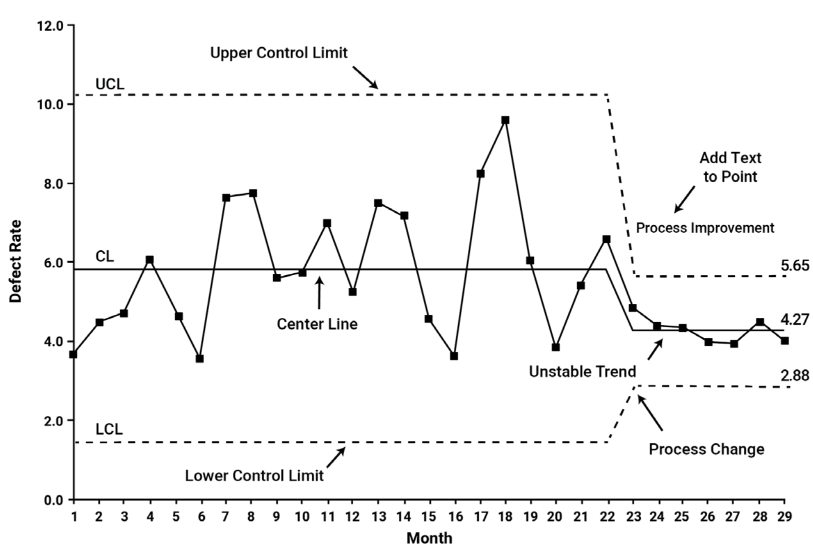
Combined, these causes result in a significant waste of time, energy and efficiency while still not diagnosing the actual causes of the problem and, therefore, the solution to fix it.

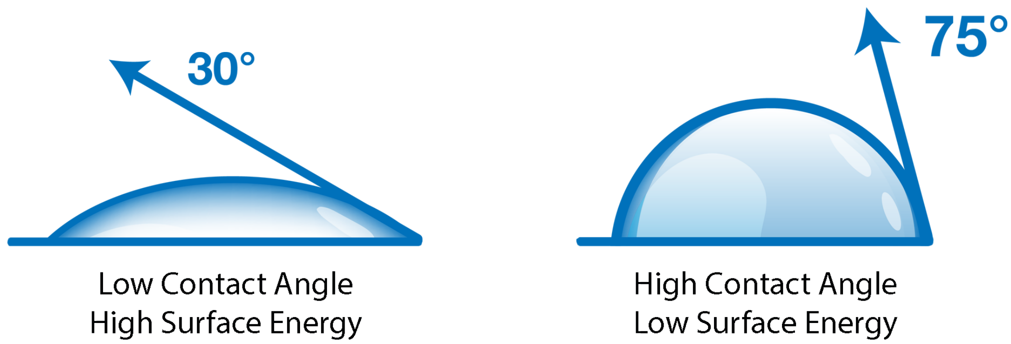
To address the cause and fix the issue, a Sig Sigma approach will need data and Root Cause Analysis tools (see below for examples).

Fishbone Diagram



Control Chart



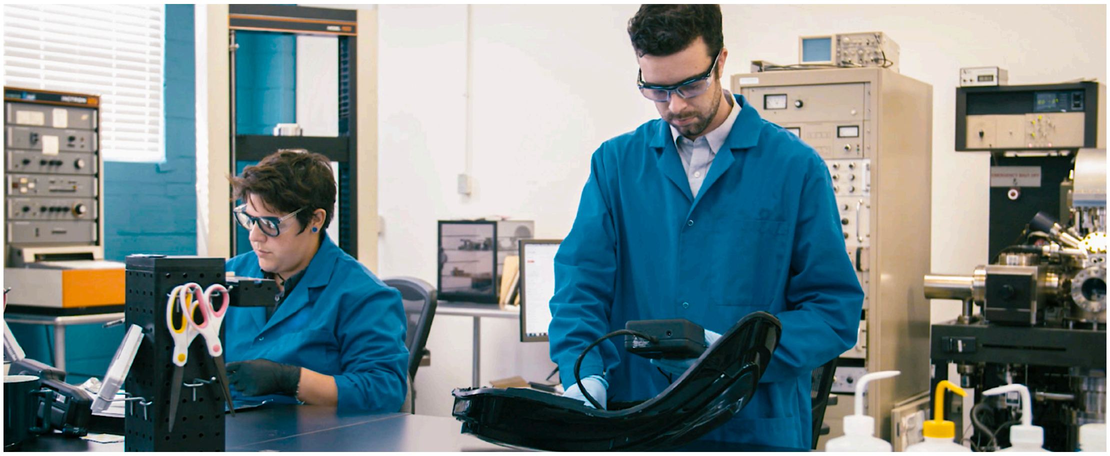


Source: Brighton Science

This is where Water Contact Angle (WCA) technology will play a major role in establishing surface intelligence. By measuring the angle that the perimeter of a water drop forms while in contact with a surface, you can determine the state of your surface.

This technology has been in use in laboratories for decades and allows a perfect understanding of the issues. However, the necessary equipment is only available at the laboratory level and is difficult to transport to production settings, and therefore is not scalable.

Returning to the Six Sigma concept, the WCA methodology offers a solid set of data, creates a common language as well as a data-based solution.



Over the years, Brighton Science has developed equipment and methods that allow full scalability of the WCA methodology, including:

- A portable device allowing measurement precisely at the contact point and in the exact environment.
- The ability to measure the impact of fabrication, storage, and transportation processes throughout the product life cycle.
- The accuracy of results combined with the speed of tests (2 seconds) allows automation (versus other empirical processes that can take 30 to 120 seconds without delivering accuracy).
- The permanent availability offering the opportunity to control 100% of the parts before treatment (robotic solutions exist) or to create control cards for statistical process control (SPC).
- The opportunity to control process and environment influence even before developing a product, resulting in more efficient designs while also avoiding the randomness of multiple tests.
- Measuring change and process evolution, establishing a well-defined threshold to qualify any new process or product design.

Finally, offering the science of Water Contact Angle in a compact and scalable solution can dramatically improve the Lean Six Sigma approach related to cleanliness or adhesion solutions.

The Brighton Science Story

More than twenty years ago, Brighton Science began as a development lab for plasma polymerized coatings. Through research and development work led by Chief Scientist and Founder Dr. Giles Dillingham, Brighton Science made great strides in the field of material science and adhesives in manufacturing. It was during this time that Brighton Science developed the Surface Analyst, the first hand-held contact angle measurement device used in the development of adhesive bonding for the F-35 Joint Strike Fighter program.

Since those early days, Brighton Science has helped some of the world's largest companies build better products and develop reliable adhesion processes. Let our experts advise you on specific solutions you can put to work immediately or build into your optimization processes.

Let's talk about what we can do for you. **Contact us.**

Brighton Science

sales@brighton-science.com
brighton-science.com
513-469-1800

4914 Gray Road
Cincinnati, OH 45232