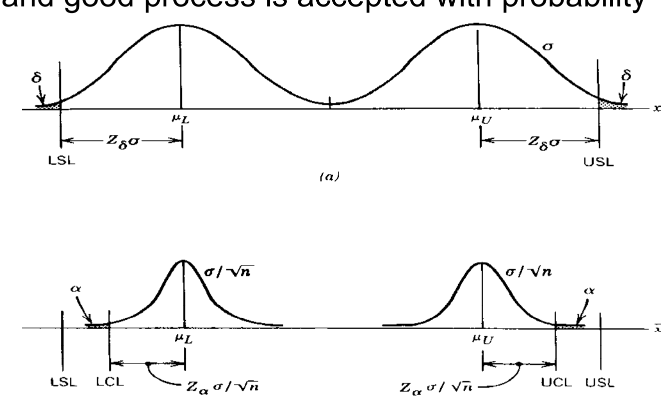
Control Charts and Data Integration

The acceptance chart and other control alternatives. Examples on SPC applications

Modified Charts

If C_{pk} >> 1 we set control limits so that the fraction non-conf. is < δ and good process is accepted with probability 1-α.



$$UCL = \mu_u + \frac{Z_{\alpha/2}\sigma}{\sqrt{n}} = USL - \left(Z_\delta - \frac{Z_{\alpha/2}}{\sqrt{n}}\right)\sigma$$

$$LCL = \mu_L - \frac{Z_{\alpha/2}\sigma}{\sqrt{n}} = LSL + \left(Z_\delta - \frac{Z_{\alpha/2}}{\sqrt{n}}\right)\sigma$$

Modified Charts (cont.)

When C_{pk} >> 1, then we can also set control limits so that that the fraction non-conforming is < γ.

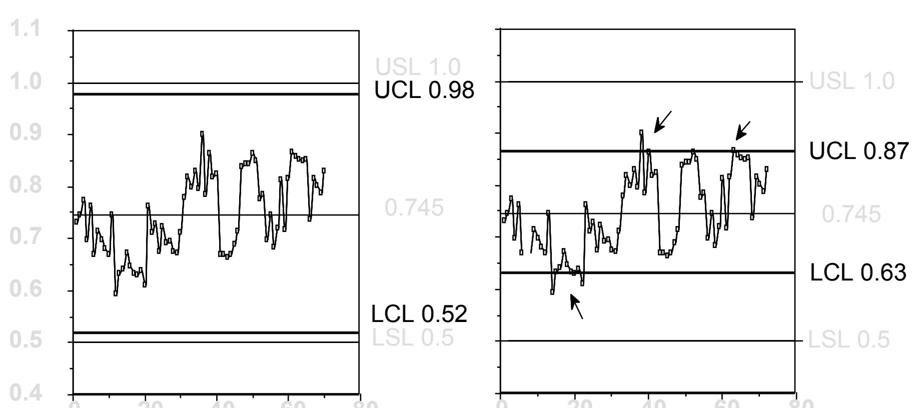
The <u>acceptance chart</u> is defined so that a bad process will be rejected with at least 1-β probability.

$$UCL = \mu_u - \frac{Z_\beta \sigma}{\sqrt{n}} = USL - (Z_\gamma + \frac{Z_\beta}{\sqrt{n}})\,\sigma$$
$$LCL = \mu_L + \frac{Z_\beta \sigma}{\sqrt{n}} = LSL + (Z_\gamma + \frac{Z_\beta}{\sqrt{n}})\,\sigma$$

Modified Chart (Example)

(Line-width control) with n=5, δ,γ =5%, Z=1.645, σ = 0.07

To accept with α = 0.0027 To reject with β = 0.8



Modified Charts (cont.)

It is also possible to choose a sample size n so that specific values of δ, α, γ and β are obtained:

$$USL-\left(Z_\delta - \frac{Z_{\alpha/2}}{\sqrt{n}}\right)\sigma = USL-\left(Z_\gamma + \frac{Z_\beta}{\sqrt{n}}\right)\sigma$$

$$n = \left(\frac{Z_{\alpha/2} + Z_\beta}{Z_\delta - Z_\gamma}\right)^2$$

For example, to accept a process at a level $\alpha = 0.0027$, when the yield is at least 90% ($\delta = 0.1$) and to reject the process 90% of the time ($\beta = 0.1$) when the yield is less than 80% ($\gamma = 0.2$), then the line width sample size should be:

$$n = \left(\frac{3.00 + 1.25}{1.25 - 0.85}\right)^2 = 113$$

Basic SPC Issues Covered so far

- Attribute Charts (P,C,U).
- Variable Charts ($\bar{x}$-R, $\bar{x}$-s).
- Process Capability.
- Acceptance Charts.
- Rate of false and missed alarms.
- Average run lengths.

In Conclusion...

SPC is a tool that will help keep the process free of non-random disturbances.

SPC reacts to a systematic disturbance in an objective and consistent way.

Solid process understanding is necessary in order to find and eliminate assignable causes.

In a modern clean room, the ability to explore production-wide data is also important

Case Study - Wafer Tracking Capability

Problem

In a high volume clean room, wafers are processed in batches.

Sometimes assignable causes are related to the position of the wafer in the batch.

During processing, wafers are mixed and matched in a batch in many different ways.

Solution

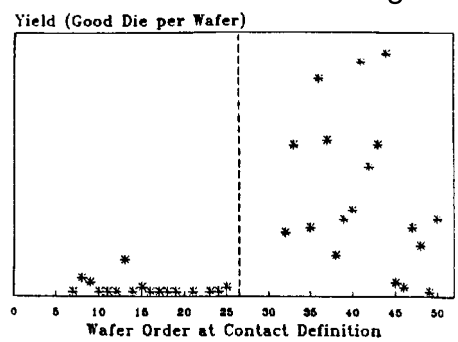
Number wafers and keep track of their history using a bar code reader, a database and a computer.

This allows to change the rational subgrouping on the fly as we look for the problem.

Wafer Tracking Capability - Example

Fraction-non-conforming chart showed increase in number and variability (lot to lot) of defectives. Identified the problem as a contact open, focused on photolithography steps.

Various sub-groupings were tried until an obvious pattern showed in the cassette to cassette loading of the spin dryer:

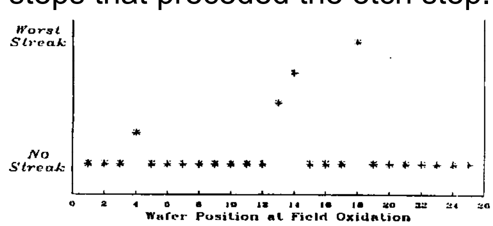


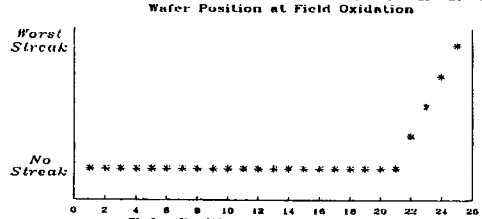
Problem identified as broken heater wire in the spin dryer.

*Presented at ISMS89, G. Scher et al. HP at Fort Collins CO

Wafer Tracking Capability - Example (cont.)

Single wafer etcher began leaving "streaks" on some wafers. Degree of streaking was plotted versus wafer position at various batch steps that preceded the etch step.





Problem located at the poly furnace loading.

*Presented at ISMS89, G. Scher et al. HP at Fort Collins CO

Case Study - Using Real Time Measurements

Processing is so complex, that in-line readings alone cannot always explain yield drops.

Recently, we have acquired the capability to collect real-time sensor readings.

These readings can be collected in the CIM database via RS232 and the SECSII protocol.

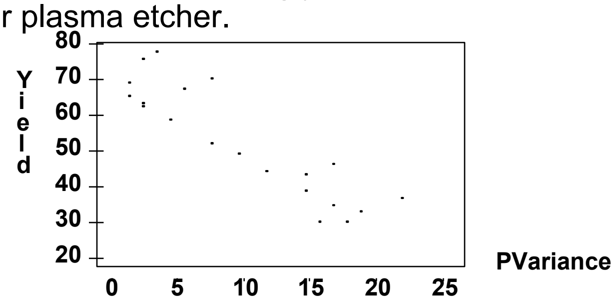
Statistical abstractions of these readings can supplement traditional in-line measurements for yield analysis studies.

Using Real-Time Measurements - Example

Significant yield variations showed on fraction non-conforming chart.

Low yield wafers plotted versus various in-line or batch-position parameters did not show any correlation.

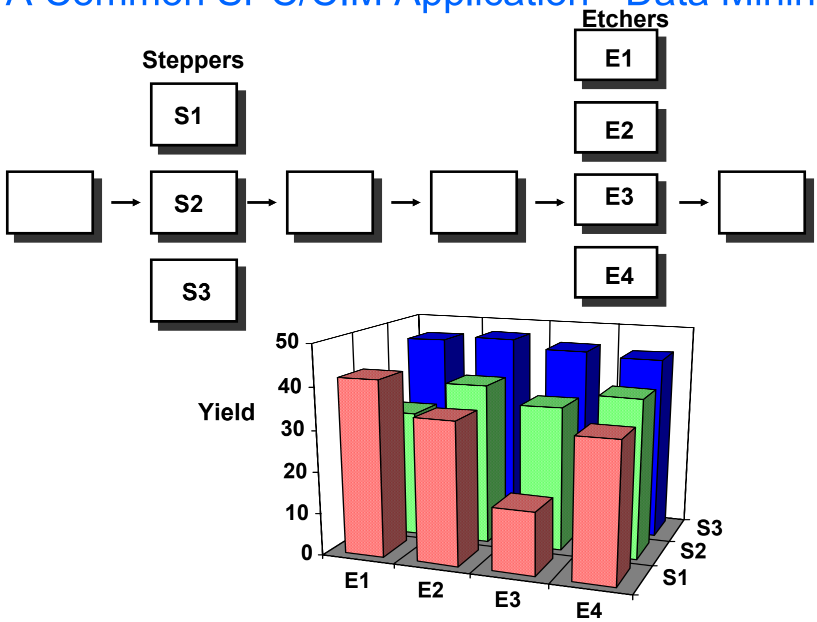
Low yield wafers correlated strongly with pressure variability in single-wafer plasma etcher.



Problem identified as leaky door seal: Erratic throttle control created airborne particulates.

* Presented by P. Byrne et. al.at the 88 ISMS.

A Common SPC/CIM Application - Data Mining



Summary

- Knowing what to measure is important.
- Today's technologies are very complex - it is impossible to plot everything.
- The exploration of production-wide data is necessary in order to create meaningful rational subgroups.
- Computer Integrated Manufacturing (CIM) based on logically integrated data structures is an important platform for SPC.
- Modern “data mining” techniques can find information in a CIMed factory.