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Semiconductor Wafer Test Workshop

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Achieving Low-Risk, Volume Manufacturing on Leading Edge Technology Probecards; Definition and Methodology for Implementing a Process Control System

Douglas A. Sottoway
Anil Kaza
Intel STTD Wafer Test

The Title

- **Made the title so it sounds very important. Why? Because it is. But what is it?**
- **Here is the title to put in your mind...**
  - What is a process control system, why do I need it?

Motivation for PCS

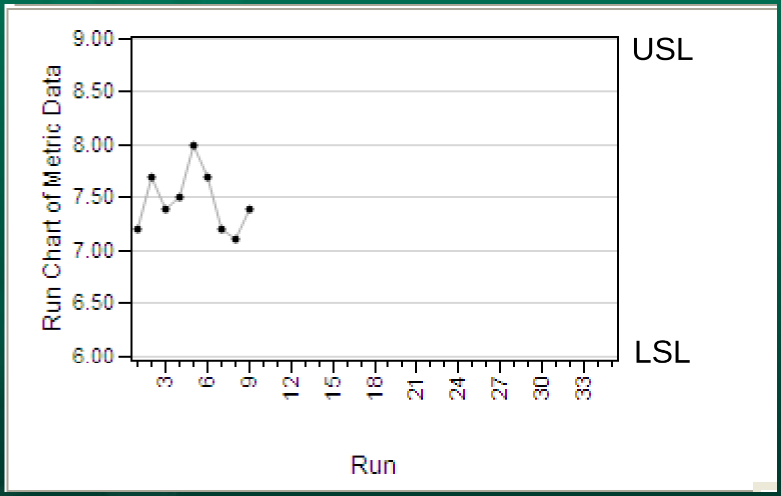
- **Wafer test technology challenges continuing**
  - Shrinking pitch, increasing array size/probe count, current carrying requirements
- **Shrinking process window at test**
  - Performing test efficiently and producing correct results is very difficult
  - No longer have huge margins to allow test process to vary!
- **A robust process control system is now a matter of SURVIVAL!**
  - In my opinion, if you're not doing this already, you need to start now
  - Within spec monitoring not enough
  - 7 years go we needed PCS in sort
    - Every couple months the yield department would find something wrong with tool at sort
    - Control charts were put in place to detect issues, this was better but still too many issues
    - Simple PCS charts not enough, need fab solution, entire system for good process control

The Stoplight

- **In the days of horses and buggies, the stoplight had only red/green**
  - In 1920 William Potts realized the advent of automobiles required a better method, i.e., a yellow caution signal
- **Specifications (red/green only) not enough to ensure a robust output and expected results**
- **Now need yellow, proceed with caution (control charts)**
  - Something bad could happen unless good decision-making utilized
- **Control charts are the core of PCS**

How to Create a Control Chart

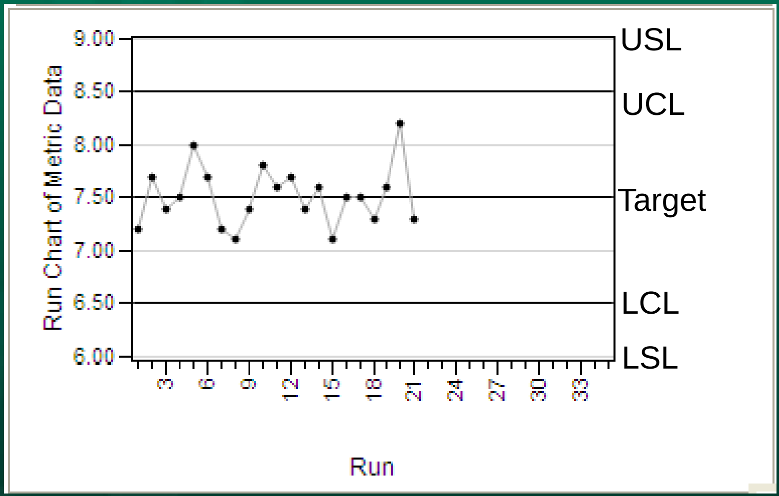
1. **Define Performance Parameters**
   - Contact resistance
   - Find Critical Process Parameters (CPPs)
     - probe length mean



2. **Study variation and set control limits**
   - Control limits should be practical

How to Create a Control Chart

3. **Run baseline process**
   - Engineer identify special cause and fix
   - Find out if process stable and capable
4. **Response procedures documented and trained**
   - Empower workforce with correct tools



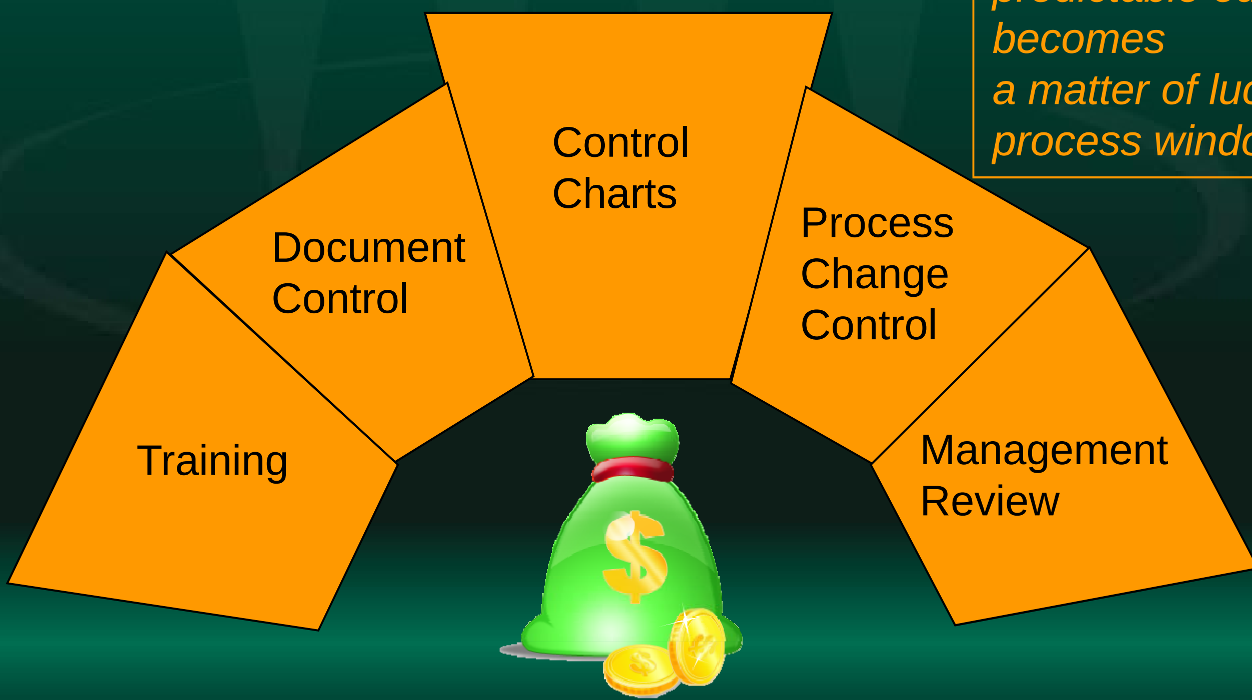
Of Note:

- Expect many signals during initial volume
  - Engineering spends time responding to and learning about the signals
  - Root cause fixes are put in place and response procedures are documented and trained
- The process gets healthier, control charts are improved
- The amount of learning and process improvement made simply from responding to good control charts is amazing, and I've been doing this for 21 years

What is a Process Control System?

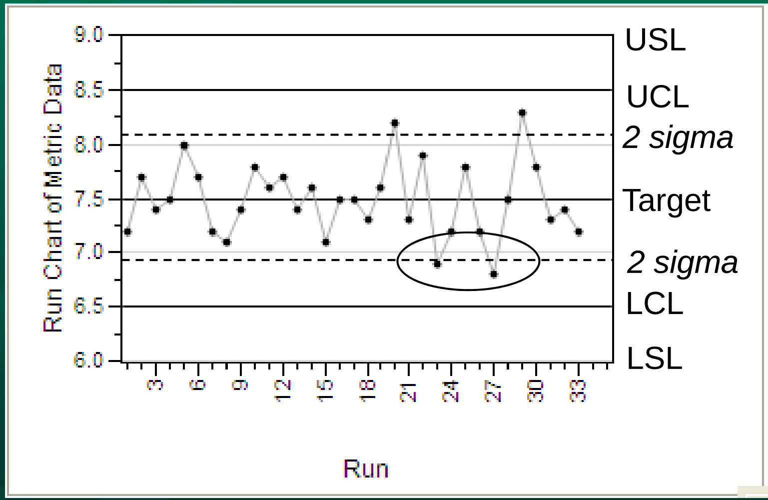
- **Control charts provide the caution light but...**
  - There are other critical components that the organization must have to make control charts fully effective
  - Any weakness in the other PCS components will eventually lead to process health issues

If any piece is missing, predictable output becomes a matter of luck when process windows are tight



Example: During Development Worn Part Signal Found

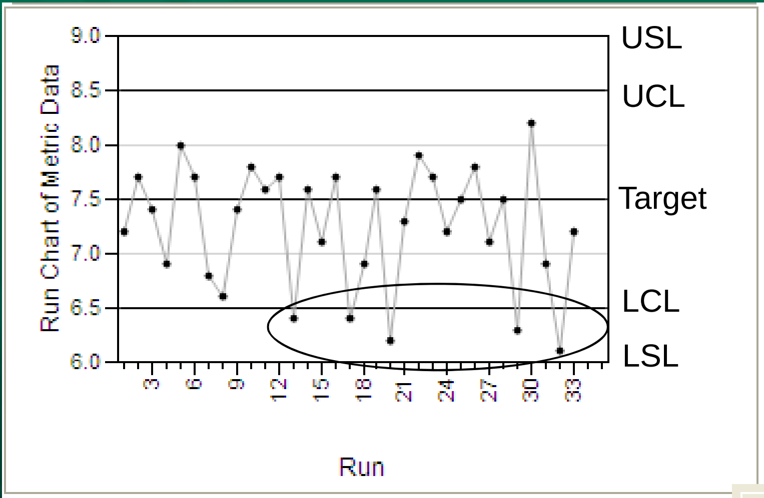
- **Control chart:**
  - Mean of probe length
  - Limits set ~ 3 sigma
    - Cpk to spec limits is 1.3



- **Learning:**
  - Concern with worn part
  - Implement quarterly PM
  - Process step is stable and capable

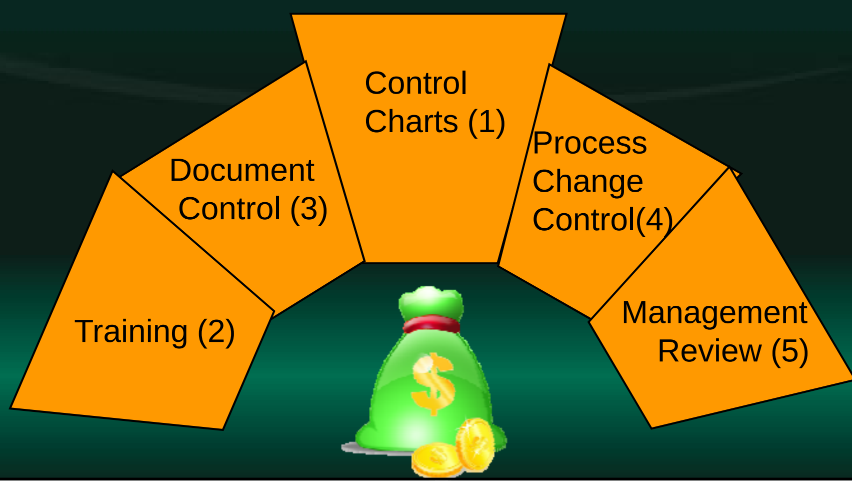
Example: 1 Year Later

- **Production team sees out of controls (OOCs)**
  - Huge increase in volume
    - 2 tools to 5 tools
  - Conclude 3 added tools run a little different
  - Still within spec
  - Increase lower control limit



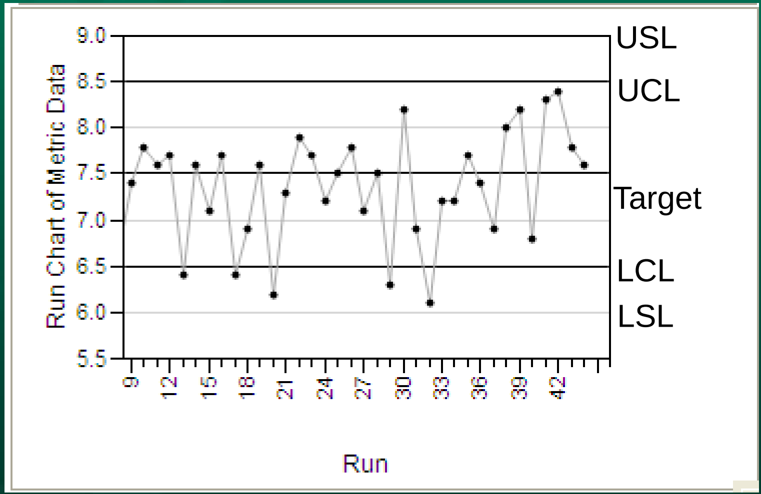
Example: Breakdown in Process Control

- **1 month later quality assurance sees uptick in the array planarity and contact resistance. Two probecards have to be scrapped. Task force started.**
  - 3 months later the planarity and contact resistance problem is correlated to the worn part on the tool that cuts the probe
  - Where breakdown in process control?
    - Process step spec did not contain information identifying worn part issue
    - With increase in volume the quarterly PM was not frequent enough
- **Solution**
    - Development engineer adds troubleshooting section to spec -- how to ID the signal (3)
    - Manufacturing is trained how to inspect the worn piece (2)
    - A volume-based PM is implemented after approval by process change control board (4)
    - Control limits are set using appropriate baseline process data (1)
    - Management sets up a monthly control chart review, requires review of all control limit changes (5)



Example: Engineer Makes Improvement

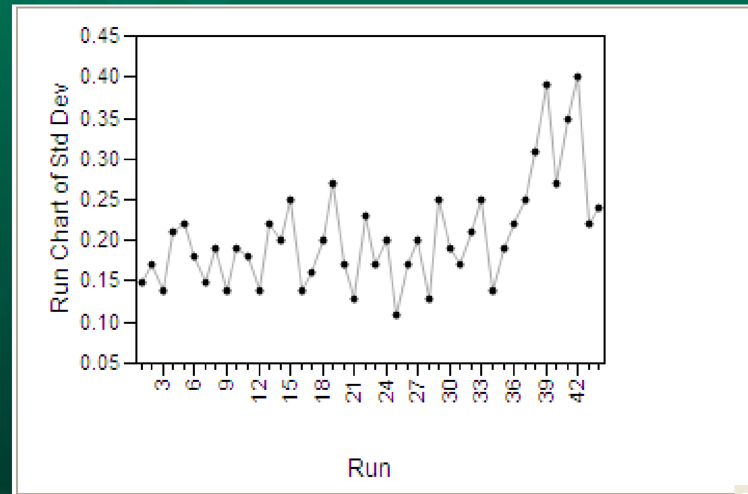
- **Good engineer wants to increase output**
  - Solution found for worn part
  - Extra piece drastically reduces wear
  - Data looks good
  - Manager approves implementation



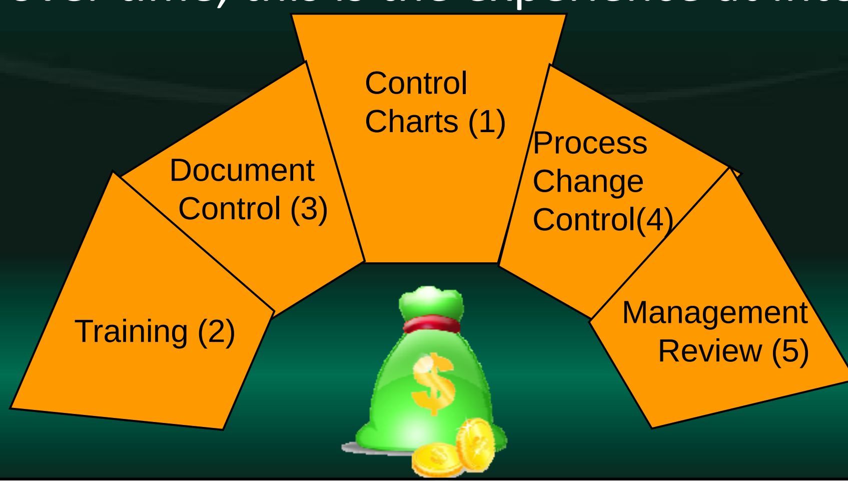
- **Weeks later**
  - Quality engineer starts sending messages to all engineering...seeing some occasional open resistance readings from probes
  - A few weeks later a customer calls and...you guessed it, starts yelling. The good engineer above has already checked control chart finding mean of the process is on target and in control
  - Turns out the extra piece produced a small outlier distribution in the probe length and since the control chart is for mean, the outlier probes did not significantly impact the trend

Example: Breakdown in Process Control

- **Two problems:**
  - Lack of a standard deviation control chart (1)
  - System for process change control was weak (4, 3)
    - Need a process change review board and documentation system for all process changes
      - Fixed set of people with the most expertise
      - Review and approve qualification plans before data collection
      - Standard change control template to ensure consistent expectations



PCS will improve over time, this is the experience at Intel



Call to Action

- **Another quick story from experience**
- **PCS is a matter of survival**
  - All components critical to process health and predictable output