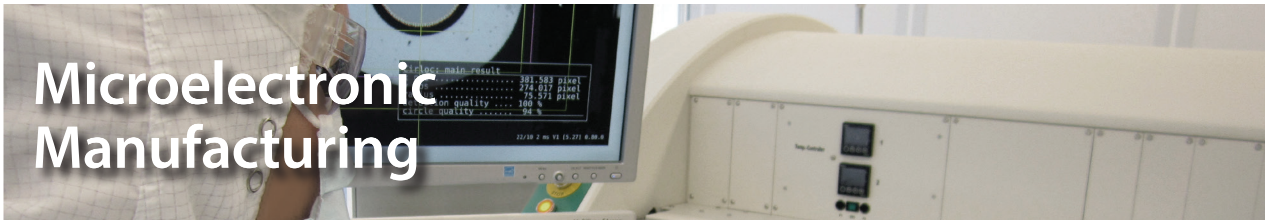

Microelectronic Manufacturing

SILICON Heartland OH SMART MICROSYSTEMS™

Developing a Robust Manufacturing Process in Microelectronics Assembly

William Boyce
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AT SMART MICROSYSTEMS WE FREQUENTLY help our customers resolve product weaknesses or field failures in an assembly. We also help develop microelectronic assembly processes that will reduce or eliminate field issues and quality excursions. As an ISO quality organization, we think about these scenarios as either preventative or corrective actions. Here, the operative word is action. In the former case, we are considering a corrective action to an existing weakness in a process or system. In the latter case, we are managing a preventative action in an effort to prevent the need for a corrective action. When we help customers develop a microelectronic assembly process, we build preventative measures into the process from the start. As a general rule, prevention is always preferable to correction.

In an earlier article the concept of starting with the end in mind was discussed. *(see MEPTEC Report Spring 2016)* This approach remains mindful of the desired outcome throughout each step of the development process. That principal is just as valid here. However, in designing a production process for microelectronics assembly it is also important to look backwards at the process. Those who are trained in classical quality tools, such as six sigma methodology, are acutely aware of the need to check all incoming materials. Looking backwards at the process means remaining ever vigilant of the quality and condition of our incoming materials, both from the source and from previous processes. This principal is vital to the health of the process and the balance sheet.

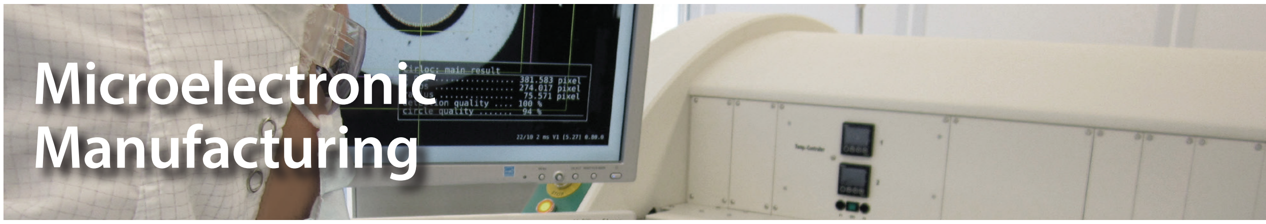
In all process steps it is usually assumed that all incoming material meets the prescribed minimum quality specification and that the material has been specified properly. If this is a valid assumption in most cases, then why is it that the majority of failures are still driven by incoming materials? Just because it is assumed that incoming material is "good" material does not mean that incoming material should not be checked periodically. It is advisable to establish an incoming material sample inspection routine for raw material or components that come from an outside supplier. This inspection routine should include an inspection of the critical characteristics of the material on a sample lot basis. It is always more effective and less costly to conduct sample lot inspection of incoming material than it is to discover failed finished goods at the end of the line. This is prevention, not detection.

Incoming Inspection Data (2016)										
Upper support flange (37DR-75)										
		Inner Dia	Height	Dia	TP	TP	Height			
	Feature	Center hole		Side Hole	Side Hole	Cent Hole	Weld Protrusion (4 places)			
	USL	9.85	10.14	8.72	0.07	0.15	0.4			
	LSL	9.65	9.69	8.62	0	0	0.3			
Month	Week	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
Jan	1	9.770	10.040	8.625	0.010	0.065	0.310	0.350	0.320	0.370
	2	9.760	10.020	8.621	0.011	0.052	0.333	0.370	0.360	0.390
	3	9.760	10.020	8.700	0.020	0.041	0.313	0.322	0.310	0.384
	4	9.760	10.010	8.710	0.065	0.051	0.350	0.370	0.333	0.318
Feb	1	9.780	10.100	8.631	0.052	0.038	0.370	0.390	0.313	0.365
	2	9.760	10.110	8.645	0.041	0.019	0.322	0.339	0.350	0.360
	3	9.813	10.090	8.650	0.051	0.022	0.390	0.370	0.370	0.310
	4	9.780	9.980	8.718	0.038	0.011	0.384	0.390	0.322	0.333
Mar	1	9.760	9.750	8.717	0.019	0.062	0.318	0.384	0.370	0.313
	2	9.753	9.780	8.710	0.022	0.070	0.365	0.318	0.390	0.333
	3	9.752	9.912	8.631	0.011	0.033	0.313	0.365	0.339	0.313
	4	9.801	9.955	8.645	0.062	0.035	0.350	0.313	0.310	0.350
Apr	1	9.813	9.695	8.650	0.070	0.101	0.370	0.350	0.333	0.370
	2	9.780	10.010	8.645	0.033	0.132	0.322	0.370	0.313	0.322
	3	9.760	10.045	8.650	0.035	0.092	0.370	0.322	0.333	0.321
	4	9.753	9.980	8.718	0.055	0.087	0.390	0.370	0.313	0.369

Figure 1. Example of an Incoming Material Inspection Log.

Developing and maintaining a robust inspection plan that insures the integrity of materials from outside sources is vital to the health of any process. Shown above is an incoming inspection log for a machine tool part that is used in a sub-assembly. Selected critical dimensions are measured and recorded on a sample lot basis to insure the quality of incoming material. The incoming material is not being controlled because there is no control of the upstream process. It is simply monitored, and accepted or rejected back to the supplier. Incoming inspection is not process control.

What happens when the possible source of discontinuity is from an upstream step, internal to your own process? What can be done to prevent that? A commonly recommended tool is "Statistical Process Control", abbreviated as SPC. As the name implies, product sampling and statistical methods are used to measure and control a process. The goal is to set process limits (control limits) within the designs or customer limits, recognize the trend when a specific process is moving in an unacceptable direction, and intervene before design limits are reached. In other words, "dial the process back in" before it gets out of control. As an example using wire bonding, a periodic pull test can be performed on one wire of 3 parts per lot. When the wire



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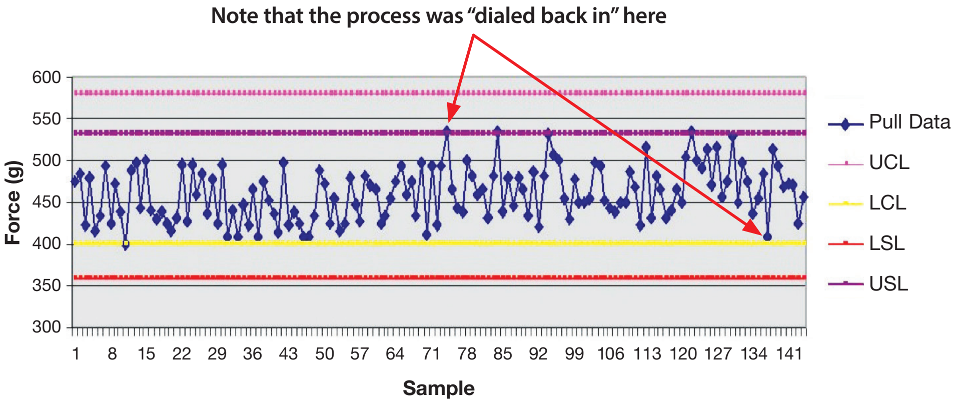


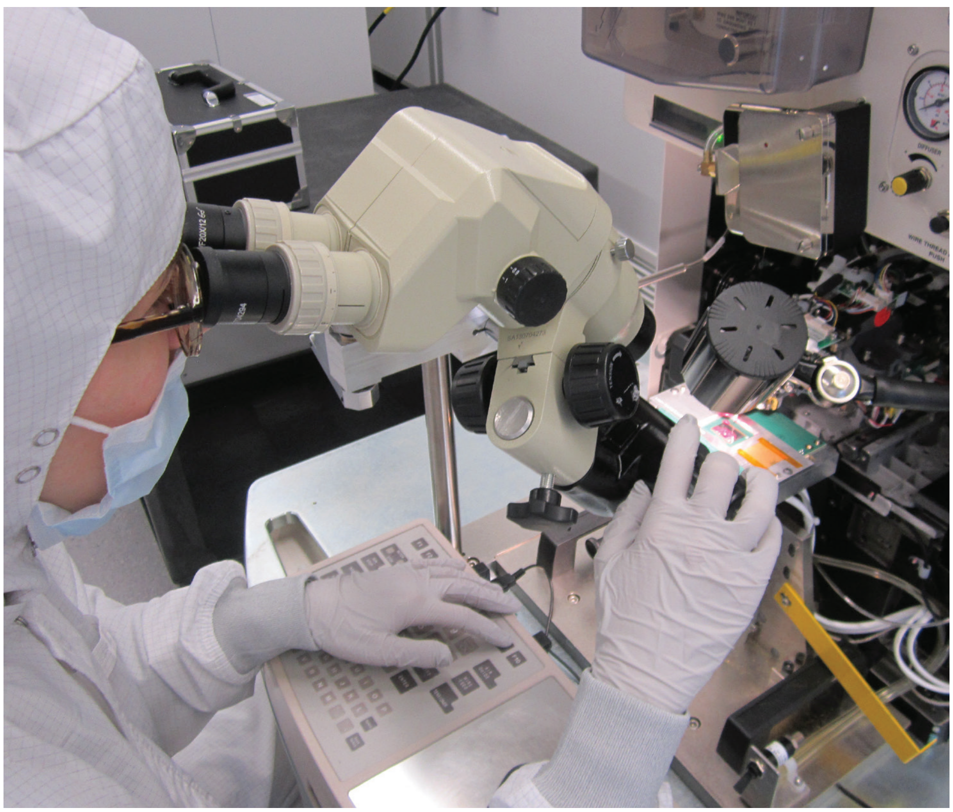
Figure 2. Example of early SPC data collected for a real wire bond process.

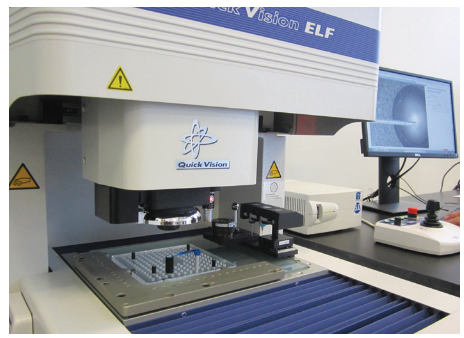
bond pull strength trend line declines it serves as an early warning indicator that action needs to be taken. Perhaps the bond tool needs to be replaced. When the SPC control limit is exceeded, action is taken before the design or customer limits are reached. Shown above is an example of early SPC data, collected for a real wire bond process.

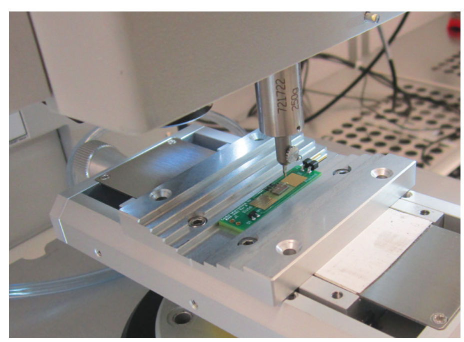
As was mentioned at the beginning of this article, the focus is on prevention more than correction. There are a lot of tools available to achieve this goal. Developing a solid control plan for an assembly process is a great way to get started. During the design and development phase of the product, failure mode analysis tools like DFMEA and PFMEA can uncover most of the areas in which control needs to be established. This information can then be fed into a solid control plan, sometimes referred to as a "plan for success". Once the assembly process is in production mode and the control plan is being followed, data can be collected and fed back into the process for continued improvement. In the six sigma environment, this would be described by the acronym DMAIC, to Define, Measure, Analyze, Improve, and Control. Using these techniques the product or assembly begins under control, remains under control, and improves quality over time with reduced cost and greater profitability

William Boyce is the Engineering Manager at SMART Microsystems. He is detail-oriented and is a hands-on engineering leader with a wide range of diverse skills from his background in automotive sensing.

He has served in senior engineering roles over the last 19 years with accomplishments that include manufactured automotive sensors.







Wire bond process (shown left), coordinate measurement machine for incoming inspection (shown top right), and wire bond pull test (shown bottom right).

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