Precision Measurement for Microelectronic Assembly

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AS NEW PRODUCTS AND COMPONENTS continue to miniaturize in the growing and expanding microelectronics field, the test and measurement requirements have become more demanding. Finding solutions to these stringent measurement requirements is crucial to maintain quality products, and to accelerate the design and development processes. Full service suppliers must not only provide microelectronic assembly services, but also perform life and environmental testing, as well as precision measurement, functional testing, and final inspection. Exposure to this full service type of product development creates a unique perspective on the demands and benefits of including precision measurement which can bring added value to a customer.

All new products begin as an idea or concept that grows into a part or product over time. The models, drawings, and test requirements should be defined with the product as it is developed. As new information is learned from life testing for example, the models, drawings, and test requirements should change in tandem to reflect the new data gained from testing. It is imperative that precision measurement is included as a requirement during initial and subsequent development. This iterative approach to product development—also known as concurrent engineering coupled with a "test early, test often" strategy—should result in a well-defined and properly documented part.

In any new product development, drawing and part requirements flow from the top down. This means that data and design intent are passed down from the top-most assembly, which derives its requirements from the customer or end use application, to the bottom-most component. This idea is represented in Figure 1, in a generic representation, where the sensor requirements are derived from an automotive engine assembly. This top down approach to part testing and precision measurement requirements can lead to disconnects between the design intent of the part and the test measurement plan. Geometric Dimensioning and Tolerancing (GD&T) has eliminated—or at least alleviated—much of this disconnect, but issues persist. A linear dimension, width for example, implies that the feature must be in tolerance along the length of the entire part, but the actual location of the width measurement during inspection may vary, causing a disconnect. Therefore, it is vital that the customer is consulted by their supplier through the entire development and measurement plan processes. Experienced suppliers do not simply collect data; they work with the customer to be sure the development and measurement plan processes are in concert with the established end-use design intent of the product.

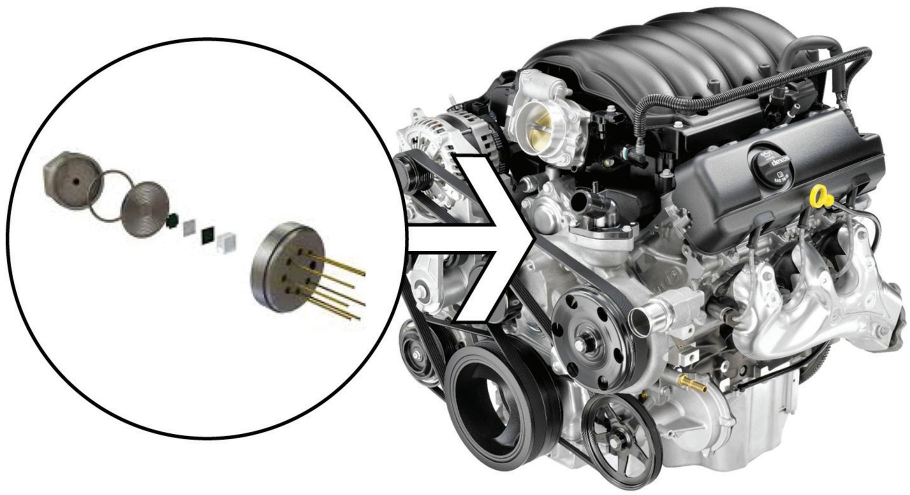

Figure 1. Exploded view of microelectronic sensor for automotive engine applications.

Even with a well-developed and properly documented part there can still be gaps in the precision measurement test plan. Gaps sometimes exist because the design intent is not clearly and definitely expressed. Requirements defined on a specification or on an engineered drawing which cannot be measured are a common occurrence. Regrettably, any defined specification or dimension that cannot be measured is of no value. For example, if alignment fiducials for die placement are covered after the die is placed, there is no way to obtain a measurement for die placement accuracy after assembly (see Figure 2). It is not uncommon that the designers responsible for defining the mechanical characteristics of a part have never been responsible for measuring those features. It is the responsibility of experienced suppliers to work with the designers to ensure that the intent of a dimension is fully understood so that it can be properly addressed and realized. In most cases, this concurrent engineering strategy results in a drawing change early in the iterative design process .

Once the design intent is understood, the characteristics have been categorically passed down to the part, and the part drawings are properly conveyed to the measurement and inspection plan, the next step is to select the best tool for the job. When considering a suite of potential measurement systems provided by a full service supplier—such as optical inspection, CSAM, 3D X-ray, interferometry, and SEM—it is important to be able to measure the smallest detail features with precision and accuracy. For mechanical assemblies

Die placement fiducial onsubstrate – without die.

Die placement fiducial covered by die – can be assembled, cannot be measured after.

Die placement fiducial aligned with die – can be assembled, cannot be measured after.

Die placement fiducial outside of die – can be assembled, can be measured after.

Figure 2. Die Placement Fiducial Scenarios for Precision Measurement.

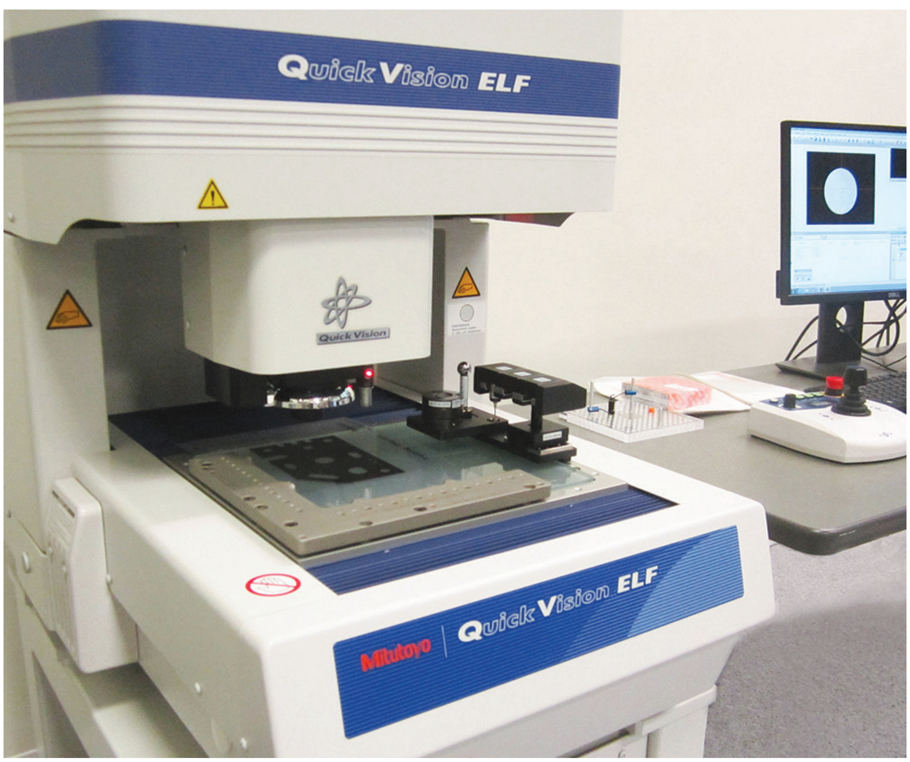

Figure 3. Mitutoyo Elf Coordinate Measurement Machine.

used for microelectronic packaging, a coordinate measurement machine (CMM) has significant advantages (see Figure 3). It is a fully programmable optical and touch probe system with a measurement accuracy of (2+3L / 1000)µm. The combination of touch probe and optical system in one platform allows the measurement of features not accessible by other systems. A measurement plan can be programmed into the system for measuring all of the features on numerous parts in a multi-up fixture. The system can also measure data without operator intervention, virtually eliminating operator contribution to overall measurement variation. This rapid and efficient method gains extraordinary precision, accuracy, and repeatability in a fraction of the time, passing the savings on to the customer.

All too often in an organization the process of outgoing or "final inspection" is not given the attention it requires. Similar to a complex mathematics problem, the last step is typically simple addition or subtraction, and it is there that most of the errors occur. The final inspection stage can bring added value to a customer when gaps in the precision measurement test plan are avoided. Full service product development facilitates concurrent engineering and eliminates errors throughout the stages of process development, including the precision measurement test plan. Whether your applications include demanding tests, measurement accuracy, optimizing specific designs and processes, or simply accelerating time to market, the team at SMART Microsystems can help with our state-of-the-art tools and quality-centric approach to precision measurement.

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 including: manufactured automotive sensors, leading new product development teams that created over $25M new revenue/year, certified in EIT and Six Sigma Green Belt, industry recognized expert in Al wire bonding, and designed and led metrology lab and machine shop at Sensata.

William has a Bachelor of Science in Engineering degree from the University of Rhode Island, and has has been a member of the IMAPS New England Chapter for over 10 years.

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