3D measurement for improved quality control of surface mount technology

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Imaging technology for parts inspection can deliver results quickly and accurately at ranges from microns to meters.

Accuracy in quality control is essential to microelectronics and microsystems technology. The manufacture of structures for thin- and thick-film circuits demands precise layer thickness and surface evenness. Simple optical inspection using cameras will reveal obvious geometric errors and defects but not the thin spots that adversely affect electrical characteristics, performance, and reliability. In surface mount technology (SMT) manufacture, automatic optical inspection is currently the most popular method for assessment of component lead solder and finished board solder joint quality. However, even at high resolution, a camera-based inspection system merely creates a flat 2D image that neither delivers an accurate view of the true surface structure nor predetermines component longevity.

By way of solution, inspection products such as MikroCAD, a micro-optical 3D measuring device that uses stripe projection-based imaging technology, can discriminate at submicron levels of resolution and scan areas up to several inches in less than one second. A product of GFMesstechnik (GFM), MikroCAD employs Digital Light Processing (DLP), a display technology proprietary to Texas Instruments, which provides high brightness and resolution. The vertical (z) range of the measuring volume is up to one-fourth the length of the area at full z resolution. Hence, objects with a broad range of levels, such as populated SMT or hybrid circuits, can be scanned and analyzed with precision, enabling fast and accurate control of component positioning in three dimensions.

In detail, the measurement process works as follows. From a specific viewing angle, a camera captures distortions in patterns projected onto surfaces. A sequence of patterns in Gray code—a binary numeral system in which two successive values differ by only one digit—is projected (see Figure 1, top), assigning a unique binary word to every image pixel and delivering secure depth cues for fragmented surfaces. Next projected are several fine patterns of lines, phase-shifted from picture to picture (see Figure 1, bottom). Pattern analysis follows, based mainly on a fast Fourier transform, an efficient algorithm to compute the discrete Fourier transform and its inverse. Exploiting the minor phase-shift differences, vertical resolution to 1/10 of the stripe width can be achieved, as can indications of area flatness down to 1/50 of the stripe width. As many as 60 individual pattern acquisitions per second are currently possible, with resolution at the wavelength of light or below, in acquisition times of less than one second.

In addition to static quality control, dynamic parameters can be controlled with high accuracy. Thermal effects, for example,

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represent a significant issue for today’s high-performance chips. Color-coded visualization, with vertical resolution of $<1\,\mu m$, can display thermal deformation of a processor chip over time (see Figure 2). In addition, the fast acquisition time of the measurement device enables motion sequences to be recorded, making it possible to detect material strain and fatigue long before they become apparent on either visual or camera inspection.

Scalability represents another advantage of the stripe projection method, rendering it useful for other 3D applications, with acquisition areas ranging from millimeters to meters. GFM 3D measurement instruments are available for a wide range of measuring applications. The extensive capacity for level discrimination can also be used, for example, to measure the flatness of sealing surfaces in combustion engines.

We have just launched our measurement software ODSCAD 6.0, which further improves the precision and robustness of the measurement algorithms and has a number of new evaluation functions built in. Moreover, we have released our LabVIEW interface software module, which makes it possible to program our sensor’s complex automatic measurement procedures with LabVIEW’s simple-to-use graphical user interface. Currently, we are working on a sensor with a blue semiconductor light source that will almost double the sensor’s optical resolution. These developments are contributing to more precise measurements of even smaller features, in keeping with the continuing miniaturization in electronics.

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References