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SEMICONDUCTOR EQUIPMENT

Process Integrated Quality Control for Wire Bonding

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As costs of field failures keep increasing in many fields of electronic applications (i.e. automotive call-backs), achievement of zero failure rates of the goods delivered to the end user becomes an imperative goal to pursue. Current methods of monitoring wire bond quality for both heavy and fine wire applications, however, fall short of finding 100% of all failure modes as they don't monitor every aspect of every wire bond connection. A major reason for this deficiency is that most QC systems only monitor wire deformation and/or use ultrasonic current as a signal to conclude bond quality. "Normal" wire deformation and current characteristics do not guarantee good bond quality in every case. Because different types of bond failures affect the available signals in different degrees, it becomes important to monitor all of them to get a wide decision base.

A newly introduced multi-dimensional process integrated quality control (PiQC) system now offers the capability to monitor a multitude of significant bonding process values for comprehensive wire inspection in achieving 100% quality control. Through the use of a transducer integrated sensor and ultrasonic generator, the PiQC system is capable of recording all relevant signals for a wire bonding process including (resonance) frequency, wedge tip mechanical oscillation, friction, transducer impedance, scrub behaviour in addition to wire deformation and ultrasonic current. The addition of a sensor provides a signal very sensitive to the process acting on the tip of the bonding tool. (See chart 1) Bond failures, not conspicuous in wire deformation and current characteristic, can show abnormal characteristics in the signals provided by this sensor.

The multitude of signals acquired by the PiQC system forms a more sufficient condition for judging bond quality. If a faulty bond is conspicuous in at least one signal, it is possible to detect it. The PiQC system is the first method that allows for monitoring feedback of the most decisive time frame for the formation of a bond (the first 5 ms) and also enables conclusions about the surface conditions of the substrate.

Real-Time Data Collection And Analysis

By acquiring data in "real-time" during the bond process, the PiQC system does not impact machine throughput for throughput-neutral, 100% quality control. Unlike other process control systems, it does not rely on assumptions. Instead, values or signals are recorded in real-time and statistically analyzed based on a newly developed mathematical decision model in the "PIQC box" – a high-speed computer utilizing FPGAs (field programmable gate arrays) instead of typical I/O boards and normal software code. Control algorithms are implemented in very high-speed integrated circuit hardware description language (VHDL). The PiQC box allows the user to derive extensive quality statements about the process. Signal feedback and processing allows detailed analysis of the welding process and translation into an optimized reference process.

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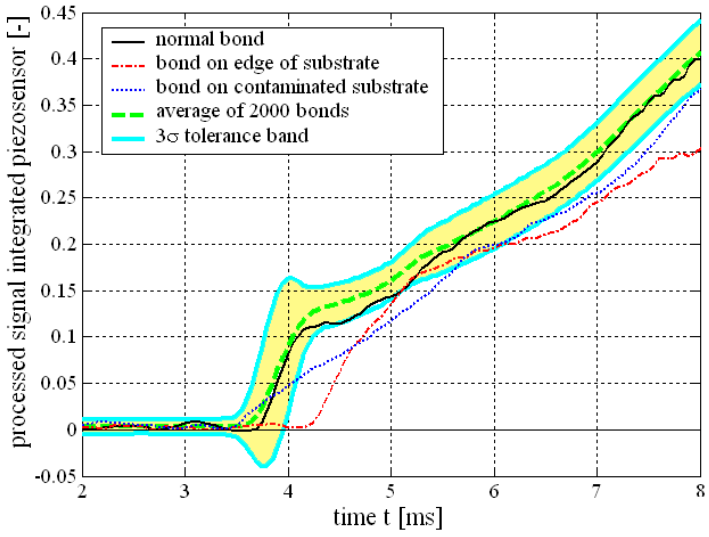
The PiQC system calculates a quality index for each bond based on the actual feedback signals from the process. It does this by first calculating an individual quality index for each signal and, then, combining these individual quality indices to an overall quality index. The individual quality indices are obtained by comparing the actual signal characteristic with a reference characteristic learned by the system in a preliminary automated procedure. (A quality index value from 0 to 100% is calculated based on six different input signals and multiple mathematical transformations, thereof, compared to the respective reference curves). The total quality index and its signal specific components can be displayed graphically at any time.

After a learning phase, PiQC can recognize any deviations in real-time, which can be classified and interpreted by an operator (see information flow of PiQC in chart 2). Signal deviations can be linked to certain failure modes, enabling process specialists to react faster to production issues that affect quality. Without the PiQC system, these process problems typically can only be detected after destructive statistical testing that is not in real-time.

With all of these advanced capabilities, the new PiQC system offers new possibilities in quality control, especially for companies with ever-increasing quality demands. The user is presented with a maximum of relevant information to ensure optimized process control.



Flow Chart 1: Processed signals of integrated piezoelectric sensor

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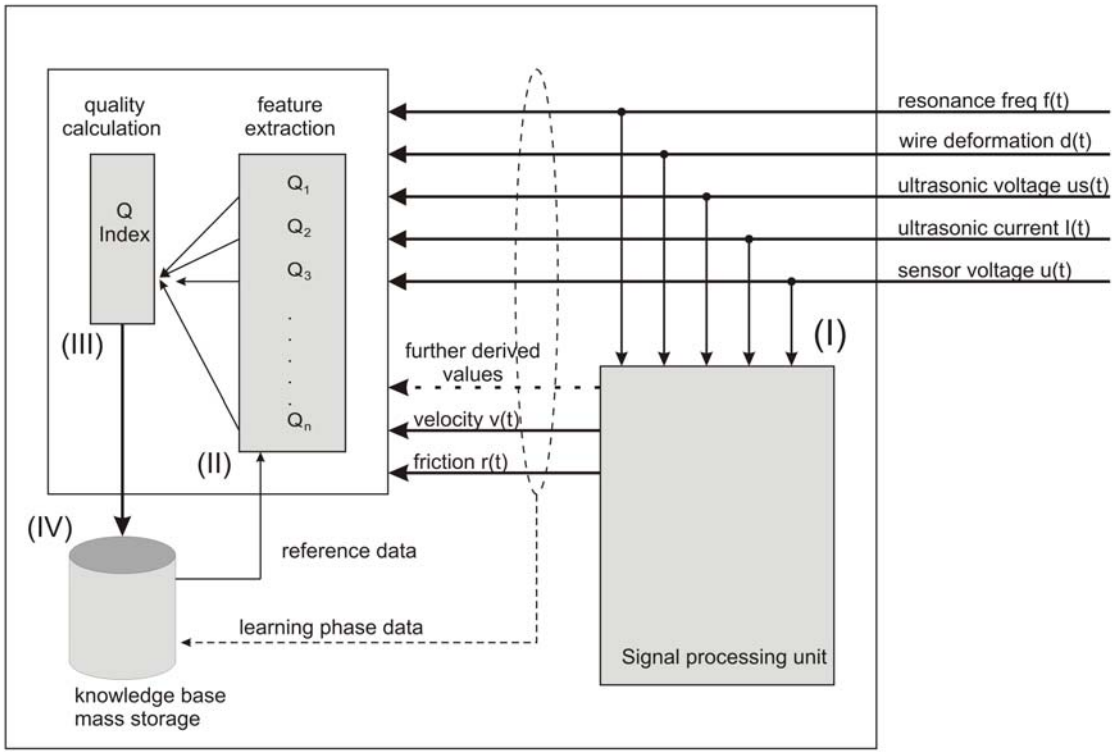

Flow Chart 2: Signal flow of PiQC

About the Author:

Roberto Gilardoni serves as sales engineer with German wire bonder manufacturer Hesse & Knipps Semiconductor Equipment GmbH. He directly supports the company's U.S. operations that are based in San Jose, CA and directed by Joseph S. Bubel, president of Hesse & Knipps, Inc.

Prior to joining Hesse & Knipps in 2003, Mr. Gilardonoi served as a service engineer, representing U.S. semiconductor companies throughout Europe and as European service manager for a U.S. wire bonder manufacturer.

Mr. Gilardoni holds an Engineering degree Dipl.-Ing. (FH), specializing in manufacturing and an Automation Engineering degree Dipl.-Ing. (FH).