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Precision epoxy dispensing combined with traceability

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Demand of satellite communication systems has been growing rapidly during the last few years. Delivery time, manufacturing quality level, first-pass yield, and finally, price, are getting more and more important today. To meet these demands, RF components require ever-increasing levels of integration, culminating in the RF system-in-package (RF-SiP) platform. It is important, however, that regardless of the integration scheme, RF performance characteristics are not degraded. Additionally, with each level of integration comes a more complex thermal management scheme that involves the whole satellite sub-system and the microwave modules.

Driven by the requirements discussed above, and based on existing operator-less ghost-shift capability over night [4], TESAT's microwave assembly technology experts have the concept of "hi-rel production documentation." This capability is especially important in order to provide end users a detailed view inside applied manufacturing processes, especially if the product is already hermetically sealed and has been anonymously pre-produced (i.e., pre-produced independent from a customer purchase order, or a dedicated customer to stock). In this manner, the complete assembly line including epoxy dispense, pick and place, cure, plasma cleaning, wire-bonding, automatic optical inspection and electrical test, is setup and operated. For the epoxy dispense process, we had to consider how to introduce an adequate inline adhesive volume measurement and determined which data should be archived. The initial goal is to replace two of four quality inspector eyes. The medium- to long-term goal is to eliminate manual visual inspection completely.

Inline volumetric scan

The MRSI-175Ag epoxy dispensers already contain height sensing in order to control the clearance of the pump nozzle above the substrate (30µm); typically, the sensor is a triangulation sensor. The implementation of the right confocal height sensor has two major advantages vs. the triangulation type: 1) Height sensing can be performed very close to obstacles e.g., hybrid components, substrate stacks, or housing walls, where a triangulation sensor system fails; 2) The same confocal light sensor can be applied in dual use for high-speed inline volumetric scan of the adhesive pattern.

An inline volumetric scan can be performed either pattern by pattern, or at the end of the dispense process. We prefer the pattern by pattern approach where the applied adhesive pattern is scanned immediately after dispense at up to a 10 inches per second robot gantry speed. The dispense system uses measurement algorithm processes that gather sensor data and calculate applied adhesive volume in nanoliters. This volume is stored within a traceability data file.

A comparison of volume results has been performed among the MRSI software algorithm, volume extraction by a capability of the 3D visualization software, and an off-line topography laser measurement system providing a sub-micron height sensing resolution. Volume results are within a <3% variation (Table 1).

MRSI-175Ag software	20.8nl
3D visualization software	20.7nl
NanoScan laser system	21.2nl

Table 1: Adhesive volume result comparison.

Overall reduced process speed, including volumetric measurement, might occur as a drawback for the moment (depending on application), but future sensors with increased sampling rates will improve this.

Pattern picture storage

The MRSI-175Ag Dispenser is equipped with two cameras (high and low magnification) in order to capture photographs of applied epoxy dispense pattern. The low magnification camera has a field of view (FOV) for pattern up to approximately a length of 4.5mm.

Traceability file data addresses the photograph of die/pattern N20 (which is GaAs-MMIC 2100700-116; as an example, see Figure 1).

A file name numbering scheme takes multi-picture patterns (patterns larger than a low magnification camera field of view), as well as product tray-schemes or multi-ups (several substrates or hybrids on one boat) into account. Stored pattern pictures can either be evaluated manually for low production volume, or be processed automatically using the vision tools of the applied automatic optical inspection system. Multi-colored LED light helps to achieve the right contrast for automated picture evaluation.

Traceability data file

Up to now, a traceability data file for an epoxy dispense process has often been neglected or was not even used in manufacturing. The new system provides a class of traceability file including the following production data: 1) Production order number; 2) Adhesive lot number; 3) Datamatrix product serial number; 4) Adhesive pattern volumes; 5) XYZ-cloud file names; and 6) Pattern picture file names.

Jet valve technology

Hi-reliability production documentation features as discussed above are very helpful for initial dispense process

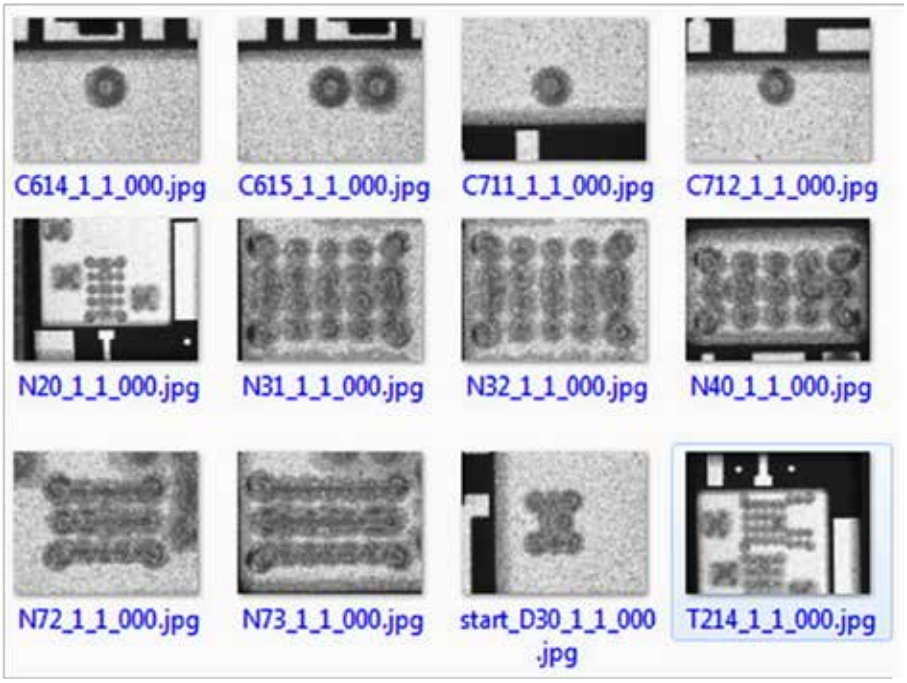

Figure 1: Picture documentation of adhesive pattern.

development in order to characterize various choices of valves that may be integrated, as well as their dispense results (Figure 2). Selectable choices are: 1) auger pump technology; 2) jet valve technology; and 3) precision time/pressure system. The choice of pump is dependent upon the application, including epoxy characteristics (viscosity, grain size, etc.), substrate flatness, dispense height (packaged walls verses flat substrates), desired speed, and volumetric control.

Adhesive volume tolerance

A drift of inline measured adhesive volume against set-point can be controlled by programmable tolerance limits (e.g., +/-10%).

Outlook for pick and place

Confocal height sensor and related software can also be installed on MRSI-705 pick and place machines as a feature. Detailed software capability will be developed in close cooperation with the TESAT hybrid group. Inline high speed height profiling of placed die can be performed in a similar fashion to epoxy dispense technology with respect to the following results: 1) Die parallelism with respect to ground (heat-sink surface); 2) Die placement accuracy (position and angle) can be verified; 3) Bond-line thickness (BLT) of an adhesive joint can be extracted; 4) Adhesive fillet characterization is possible; 5) The analysis software could be programmed to look for the presence of foreign

Figure 2: Jet valve on MRSI-175Ag dispense machine at the left, auger pump at the right.

particles on top of the die, such as chip debris transferred from the die package by the pick tool. Chip-outs at die edges could also be identified. Figure 3 depicts a 3D visualization of performed height profiling (same software as on MRSI-175Ag).

Summary

We have pushed ultra low-volume microwave epoxy dispense into a new performance class over the years [1-3]. Features such as high-speed inline

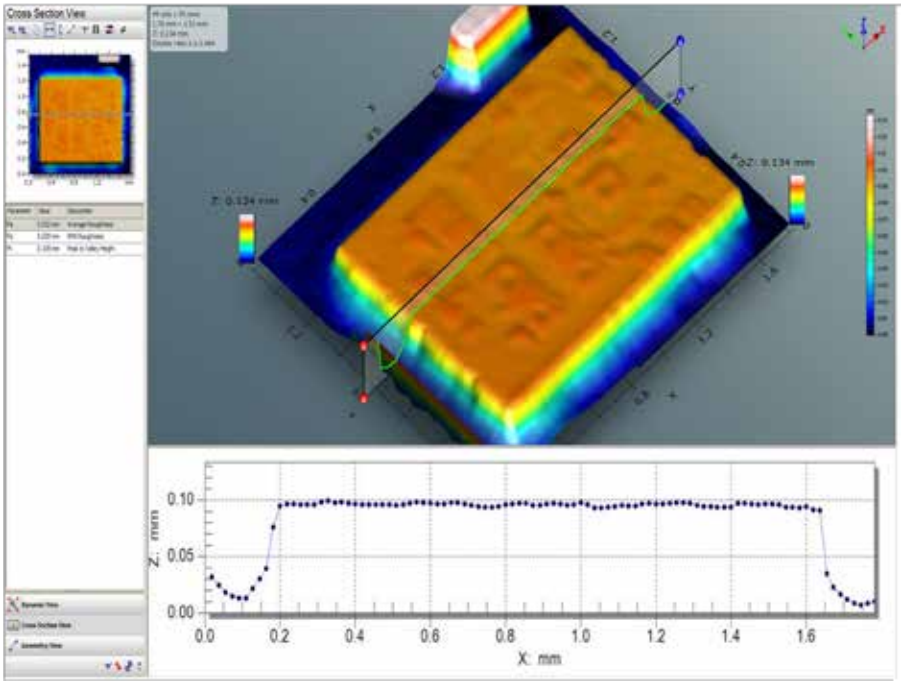

Figure 3: Height profile of placed die on MRSI-705.

volumetric scan provide a new level of process control and production documentation that supports high-reliability (hi-rel) operator-less manufacturing as required for medical, defense and space applications.

Acknowledgment

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