Die Tilt and Bond Line Thickness Measurement
INTRODUCTION

During the die attach process the silicon chip is attached to the die pad or to the die cavity of the leadframe. Typically this is done using adhesive die attach or eutectic die attach. One of the most important aspects in this process is the adhesive thickness or bond line thickness (BLT). For the reliability of the package the magnitude and uniformity of the BLT is vital.

TECHNOLOGY OVERVIEW

For the die bond process accurate placement of the die is the key. The control of the BLT height is an important step to ensure die attach quality and reliability. A common method for measuring the BLT height is to use a microscope and the focus difference between the cavity and the die surface. There are a few drawbacks in this method. To collect the measurement data on the four corners of the die may take several minutes and automation is not possible. The result itself is also depending on how the user is defining the focus. GR&R results mostly exceed 30% and are not acceptable. A scanning system using a high resolution point sensor can overcome the restrictions of this method. New confocal sensor technologies provide reliable data, independent of surface reflectivity and can measure the BLT height within seconds.

MEASUREMENT OBJECTIVE

The cyberTECHNOLOGIES’ CT SERIES is designed to measure the BLT height on a complete leadframe. The CT 300 can handle one or multiple leadframes up to 310 mm x 310 mm (12” x 12”). The heart of the system is a chromatic white light sensor that takes advantage of chromatic aberration.
MEASUREMENT TECHNOLOGY

A very bright white light source focuses a small spot onto the sample surface with the different wavelengths focusing on slightly different focal planes. The reflected light is collected and a spectrometer analyzes the light intensity vs. wavelength. A height reading is generated from the maximum intensity of a certain wavelength on the spectrometer. The sensor achieves a resolution of 0.01 µm (10 nm).

The sensor is mounted on a motorized z-axis. The autofocus routine finds the correct starting level even on different lead frames height automatically.

SCAN SPEED

The chromatic white light sensors are available with different controller models, a LED based controller with 2 kHz or 4 kHz data rate and a 14 kHz controller based on a very bright arc lamp. With fast magnetic linear motors and 50 nm encoder resolution, the CT SERIES can scan bidirectionally and reaches a scanning speed of up to 150 mm/sec depending on the lateral step size. The BLT height on 4 locations is measured with 2 scans in less than 2 seconds.
AUTOMATION FOR DIE TILT AND BLT MEASUREMENT

The procedures for accurate height measurement can be completely automated using the ASCAN Software.

ASCAN is the automatic scanning routine and it is very easy to use. Especially for measuring die tilt and BLT a “plug-In” for ASCAN was created for reducing the inspection time for changes in the production as well as increasing the process efficiency. This specific “plug-In” for the automatic software program ASCAN includes a lead frame designer and with only a few steps the convenient integrated wizard changes or sets up a new program.

3D-Illustration of the two horizontal scans for BLT measurement
DEFINING SETTINGS IN THE WIZARD

After defining the lead frame corners in the wizard, size and position automatically of the lead frame are calculated automatically.

Wizard for leadframe size definition

Wizard for detecting the leadframe position
Moreover, the sizes of the cavity and die are calculated automatically. The thickness of the die is measured automatically by placing a single die on a small vacuum field on the CT300 stage. The die is scanned and the thickness is determined. If the die thickness is known, it can also be entered manually. The die thickness is used to calculate the BLT height.

![Automatic die thickness measurement or manual entry of die thickness](image)

**MEASURING BLT AND DIE POSITION**

In the next step the scan path will be taught to the program. For measuring the BLT (bond line thickness) and die position 3 scans are required. In order to reach a higher accuracy in X and Y the step size should be 5 microns (smallest step size is 1 micron).
Scan setup for measuring BLT and die position

Two horizontal scans are required for defining the distance and size of the BLT and the die as well as the cavity center position in X-direction. The other scan is necessary for the die and cavity center position in Y-direction. An edge detection algorithm is used to determine the height difference from the base, defined by the green reference cursors, to the top of the edges with the red primary cursors.

**Calculation of BLT:**

To calculate the BLT height, the thickness of the die is subtracted from the absolute height of the die relative to the cavity. The absolute height is determined from each edge of the BLT (see images below).

**Illustration for BLT measurement**

2D Profile scan with primary (red) and reference (green) cursors for BLT measurement
Calculation of die center position in X-direction:

Based on the same profile scans as for BLT, additional edge detection determines the center position in X-direction for each scan. The result of each scan is the absolute value of the die center on the stage. These two values from scan 1 and 2 are averaged to calculate the die center position in X-direction.

Illustration for determining die center position in X-direction

2D profile scan for measuring die center position in X-direction
Calculation of cavity center position in X-direction

In order to calculate the cavity center position in X-direction the data from the die center measurement is taken. In the profile scan the is be removed using a cut-off filter. Then the edge detection identifies the base and the cavity. The result of each scan is the absolute value of the cavity center on the stage. These two values from scan 1 and 2 are averaged to calculate the cavity center position in X-direction.

Note: The depth of the cavity is not used, only the edge between frame and cavity.
Calculation of die center position in Y-direction

After the scan in Y-direction the edge detection is applied to find the edges for measuring the absolute value of the die center in Y-direction on the stage.

Illustration for determining die center position in Y-direction

Calculation of cavity center position in Y-direction

Based on the same scan in Y-direction, the cavity center position is determined after the same principle in X-direction.

Illustration for determining die center position in Y-direction
STEP AND REPEAT IN LEADFRAME DESIGNER

Based on the results from lead frame, die and cavity size from the previous settings and calculations, the Lead Frame Designer determines the number of cavities in X- and Y-direction for measuring die tilt and BLT.

The Designer shows the step and repeat function of the measurement with the exact offsets in X- and Y-direction. Furthermore, each position visualizes the measurement and its scan direction as a white line to show the scan path clearly.

Offset visualizes scan path

Leadframe Designer with Step and Repeat window
USER FIELDS AND FIDUCIALS IN ASCAN

ASCAN allows defining fields that appear at different instances. These fields are called user fields which are used to enter search attributes for the measurement program. Instead of selecting a program from a long list the operator just types in the program attributes or uses a bar code reader to select and start a program. Other field types are used to enter additional information.

The entries of the field(s) can be stored in the ASCAN result file or can be used as a SPC filter.

User fields of a measurement program

Finally the fiducials are taught manually to ASCAN. After starting the scan the system verifies the reference points automatically with the sensor or manually with the live video for checking the correct position as well as calculating the rotation of the sample to define the exact starting point for the measurement.
START SCANNING

Once a program is created and saved, just one click is needed to start the measurement.

Using the ASCAN Step & Repeat function multiple parts can be placed on the stage and are measured as well as analyzed fully automatically. The data and results are displayed on the screen, with indication for Go/No Go, including actual measurement results and statistics. The integrated SPC module provides the ability to control trends and access every data set individually, with user defined warning, control and specification limits. All data can also be stored or exported in a large variety of data formats and automatically imported into external production control systems.
CONCLUSION

With their high resolution and high measurement speed, the non-contact scanning systems of cyberTECHNOLOGIES’ CT SERIES are ideal for measuring lead frame products. Even large parts can be scanned and are measured with submicron accuracy. The advanced analysis and algorithms as well as the convenient programming in ASCAN software makes even the most challenging measurements fast and easy for operators, technicians or engineers alike.

For more information on cyberTECHNOLOGIES’ suite of 3D surface metrology systems please contact us at info@cybertechnologies.com.