Unit Level Traceability for Automotive Semiconductors

Purpose

The present article provides a generic description of Unit Level Traceability (also referred to as Die Level Traceability, DLT, or Component Level Traceability, CLT) in the semiconductor industry and describes some of UTAC's capability to support it. Additional details can be provided under NDA.

Scope

Unit Level Traceability (for short ULT) is a critical aspect of the semiconductor industry that ensures that each individual chip or die can be traced back to its source and monitored throughout the manufacturing process. Especially for automotive applications, semiconductor manufacturers must ensure that their products meet the highest standards of quality, reliability, and safety. Unit level traceability plays a crucial role in achieving these goals. Examples of automotive safety-critical applications include Advanced Driver Assistance Systems (ADAS), Collision Warning and avoidance, Airbag, and many others.

What is Unit Level Traceability?

Unit level traceability refers to the ability to track individual semiconductor chips or dies throughout the manufacturing process, and through the entire device's life cycle. Each die is assigned a unique identifier, such as a serial number, that allows it to be traced back to its source. This traceability is maintained throughout the entire manufacturing process, from wafer fabrication to final testing and packaging. Furthermore, traceability can be granted as well after delivery to customer and deployment in the application.

Why is Unit Level Traceability important?

Unit level traceability is essential for several reasons. First and foremost, it enables semiconductor manufacturers to ensure the quality and reliability of their products. By tracking each die throughout the manufacturing process, manufacturers can identify any issues that arise and take corrective action.

Secondly, unit level traceability is critical for safety reasons. Many semiconductor products, especially those used in automotive applications, are required to meet strict safety standards. Traceability allows manufacturers to identify any defective or potentially dangerous products and remove them from circulation before they cause harm.

Finally, unit level traceability is essential for regulatory compliance. For example, Automotive Industry has stringent regulations governing the use of electronic components. By maintaining traceability throughout the manufacturing process, semiconductor manufacturers can demonstrate compliance with these regulations.

To name an example, ULT can significantly speed up Failure Analysis (FA) process. By reading out the marking code of a semiconductor device, it is possible to reconstruct its history, and retrieve information like:

- where it was produced
- when it was produced
- what production lot it belongs to
- which equipment, which machines have been used to produce it
- the entire set of its electrical parameters
- how these electrical parameters relate to the expected/typical values
- which other devices and/or production lots show similar behavior

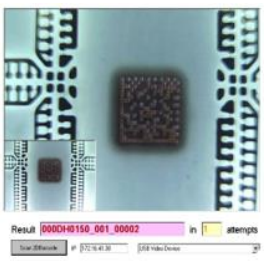
While it is common praxis in the industry to electrically read-out the chip-identifier from a working device, package marking code can be typically read even on an electrically non-working (failed) device.
UTAC can support the traceability of multiple semiconductor devices per package and apply sophisticated AI algorithms to identify potential deviations from expected production output before the devices leave UTAC's premises and are shipped to the customer.

How is Unit Level Traceability achieved?

Unit level traceability is achieved through advanced manufacturing and tracking technologies. For example, each device can be laser-marked with a unique identifier that can be read throughout the manufacturing process. Automated testing and inspection systems can also be used to ensure that each die meets the required specifications.

Inside of UTAC's production facility, the substrate (e.g.

the Lead Frame) is laser-engraved with an identifier, such as a barcode. During the die-attach process (physical transfer of the dies from silicon wafer to the packaging substrate), the link between x,y coordinates in the wafer and x,y coordinates in the substrate is generated and stored in dedicated data servers. Throughout all package-building steps, the single machines can identify the substrate and trace device-specific information related to the process step.



Laser Engraver

Die attach

After devices are shipped from UTAC's facility, devices are tracked via Package 2D marking. This is an effective technology used to support unit level traceability. This technology involves marking a unique identifier, such as a 2D barcode, on the surface of the packaged semiconductor component. This marking can be read by automated equipment and used to track the component throughout its lifecycle in the field.

Package 2D marking is typically applied after the die has been packaged, tested, and characterized; in any case before the devices are singulated and therefore separated from the substrate. The marking is typically applied to the top or side of the package using laser printing technology. The marking must be highly durable and resistant to abrasion, corrosion, and other environmental factors to ensure that the identifier remains legible throughout the component's lifecycle. It can be very tiny and therefore applied to very small packages.

In addition to providing traceability and identification, package 2D marking can also support supply chain management and inventory control. By tracking each component's unique identifier, manufacturers can monitor inventory levels and track components as they move through the supply chain. This can help manufacturers to optimize production schedules, reduce waste, and improve overall efficiency.

Importance of ULT in Automotive

In the Automotive industry, strict criteria are applied for the traceability of the components throughout their life cycle. This applies to all components, not only to electronics.

Let us consider the example of a defective Electronic Control Unit (ECU). Through Failure Analysis process, it is possibly to identify whether one semiconductor device is responsible for ECU malfunctioning. If this is the case, by reading the marking code engraved on the package it is possible to retrieve all its traceability information. The manufacturer of the device will then be able to take several actions, including:

- Determine whether other potentially defective devices are in the field, quantify how many, and track where (to which end customer, to which plant or location) they have been shipped. By doing so, the impact of a recall can be drastically reduced.
- Determine the root cause of the failure. Based on the traceability information, it is possible to isolate the process step which generated the malfunction. The problem could be for example related to a single manufacturing system, or limited to a specific interval of time, or to a specific production lot.
- Improving the process. Once the root cause of the malfunction has been identified, and the corrective measure has been determined, the manufacturer can quickly implement the necessary process improvement steps.

Conclusion

Unit level traceability is a critical aspect of the semiconductor industry that enables manufacturers to ensure the quality, reliability, and safety of their products. By tracking each die throughout the manufacturing process, manufacturers can identify any issues that arise and take corrective action before the product is shipped to customers. Using advanced manufacturing and

tracking technologies, combined with robust data management systems, UTAC enables its customers to achieve unit level traceability and meet the highest standards of quality and safety.