Post Decapsulation Internal Visual Inspection

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About Eric

Erik Jordan is responsible for the sales of decapsulation equipment in North America. He specializes in equipping labs with automated decapsulation equipment for Failure Analysis and counterfeit detection. He has partnered with multiple organizations including SMTA, ERAI, CTI, ISTFA as well as Universities to present decapsulation as a counterfeit detection solution. He is a contributing member of SAE 6081 and is the head chair for decap on SAE 6171. Erik has published work with SMTA, ERAI and ISTFA regarding decapsulation as a method of counterfeit detection.

Workshop Title

Post Decapsulation Internal Visual Inspection

Overview

One of the biggest problems in the integrated circuit industry as of lately has been counterfeiting. Counterfeiting of integrated circuits has been going on for a very long time but until recently the process hadn't been refined. Now that the counterfeiting process is becoming more and more sophisticated, the testing of counterfeits also needs to become more sophisticated. Because the counterfeiting process is still quite crude in its nature, visual inspection has become a cornerstone process. Through visual inspection some of the simplest mistakes can be caught before taking steps to the more advanced, and often times, more expensive test methods.

A growing number of Independent Distributors (ID's), Authorized Distributors (AD's), Brokers, and Test Labs are looking for methods to maximize the information available for visual inspection. Because visual inspection is the most detailed inspection process to fight counterfeit integrated circuits (IC's), documenting any and all information available from a single component is critical.

A non-decapsulated sample, or external visual inspection, yields minimal information with regards to authenticity. Furthermore, external characteristics are the most commonly and easily counterfeited aspects of an integrated circuit. Because of this internal visual inspection and documentation has become the flagship of quality control programs around the world. The biggest problem in obtaining this information is that decapsulation is required. To further understand the extent of information available with a non-decapsulated IC compared to a decapsulated IC, the below chart displays information available with both samples.

	Non-decapped samples	Decapped sample
External markings	**YES**	**YES**
External lead inspection/testing	**YES**	**YES**
Surface swab test	**YES**	**YES**
Die level markings	**NO**	**YES (when present)**
Die level logo	**NO**	**YES (when present)**
Die presence	**NO**	**YES**
Die size	**NO**	**YES**
Bond wire integrity	**NO**	**YES**
Bond pad integrity	**NO**	**YES**
Double ball bonds	**NO**	**YES**
Manufacturing defects	**NO**	**YES**
Field Failures	**NO**	**YES**
Handling mistakes	**NO**	**YES**

Die level counterfeiting is an extremely difficult process to do properly. All die level counterfeits can be caught using proper inspection techniques. Some are very simple to inspect for while others can be more tedious to spot. With proper equipment and training, external markings and internal markings are quite easy to inspect for, however, these markings can cause problems for other inspection characteristics. Often time, quality control over emphasizes finding the OCM markings, so much so that they miss other suspect findings. Because of this, quality control is encouraged to create checklists of suspect findings so that they don't miss key characteristics.

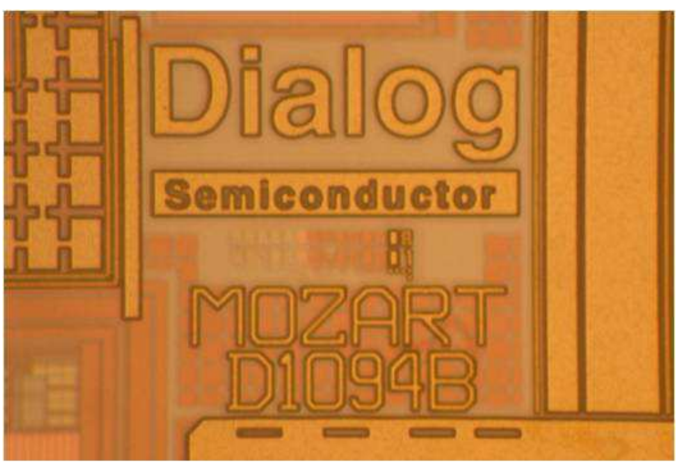

Figure 1: Displays die level markings of Dialog Semiconductor Mozart D109B

Die presence is obviously an easy characteristic to inspect for however, samples with no die are not that uncommon in this industry. These samples are commonly run as "dummy" samples and frequently have OCM markings on the exterior. With no decap of these components they will easily pass external inspection.

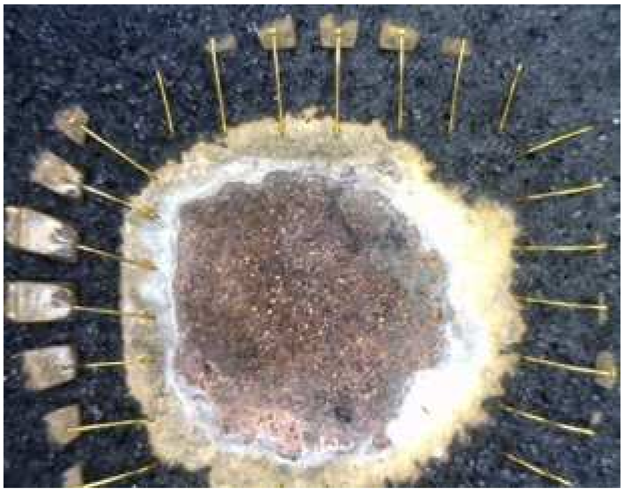

Figure 2: Submitted sample for analysis revealed no die was present

Figure 3: Ball bond of sample shown in Figure 2 displays wires were attached lead frame

Because bond wires and internal components are extremely fragile, counterfeiters will frequently make mistakes in their counterfeiting process that causes damage to the internal structure. Counterfeits don't typically get concerned with this because they cover over their mistakes during the black topping process.

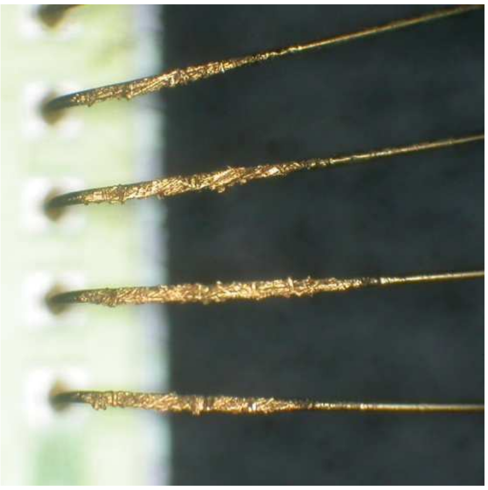

Figure 4: Result of over-sanding to remove original external markings

Die level alterations must be very precise in order to pass inspection processes. However, the counterfeiting process is typically the opposite. Die harvesting, when done improperly and lead to many faults that can be caught visually. Die harvesting is becoming more common because when done properly, can pass virtually all inspection processes.

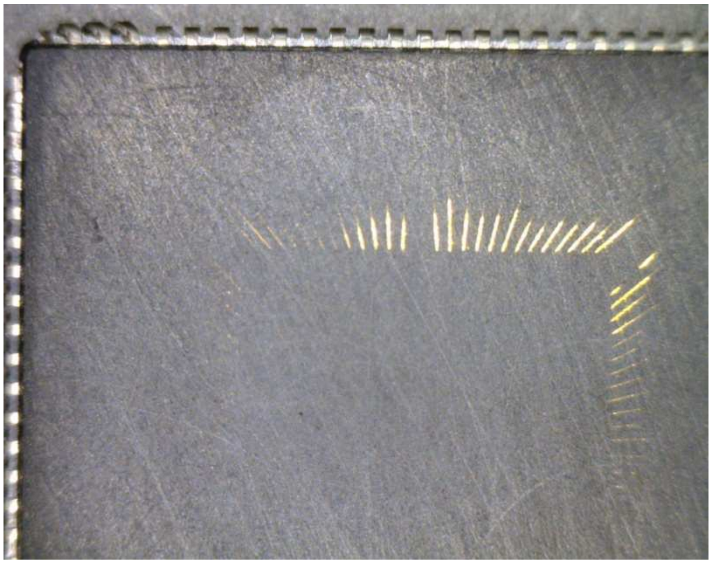

Figure 5: External view of sample after over-sanding

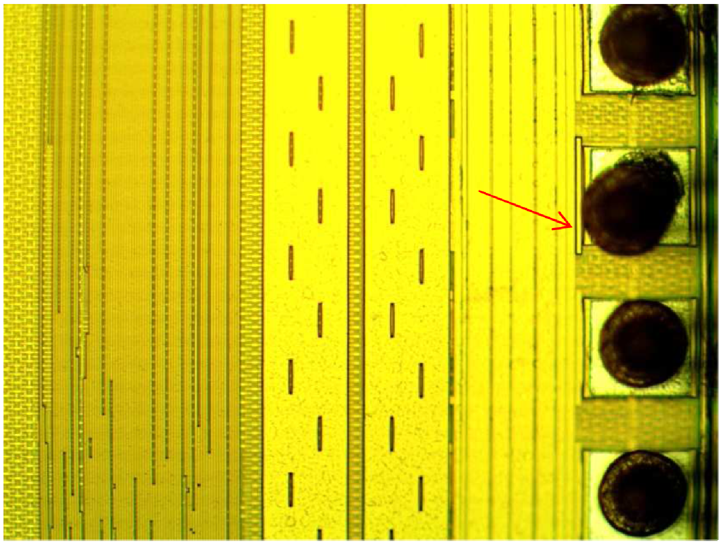

Figure 6: Example of ball bond shifting

Die harvesting is most common when counterfeiters are manufacturing counterfeits. These style of components are specifically made to pass all counterfeit inspection. Manufactured counterfeits are essentially refurbished components however they are made to meet the specs of a specific component in order to 1) fulfill the remaining portion of an order or 2) create a component that is of high value. Manufactured counterfeits/refurbished components are completely legal until the intention of those completed components is represented as new. These components are highly sophisticated when compared to common black topping or remarking however, these components have an Achilles heel that can be easily inspected and documented.

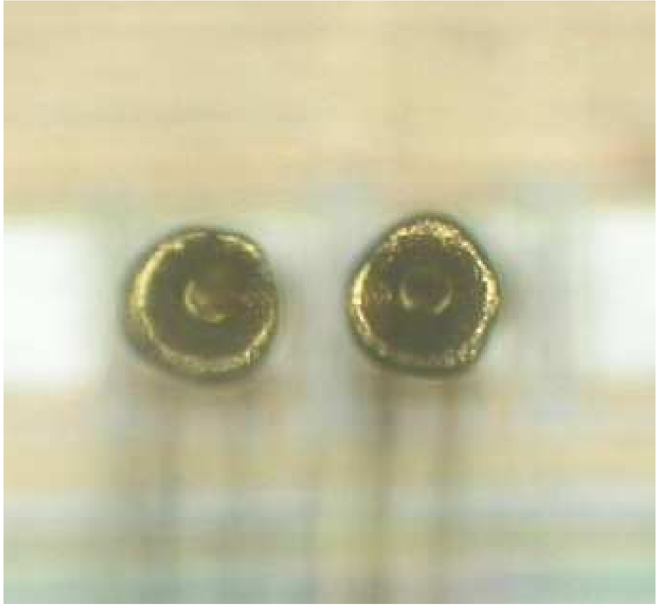

Figure 7: Top-down view of double ball bond

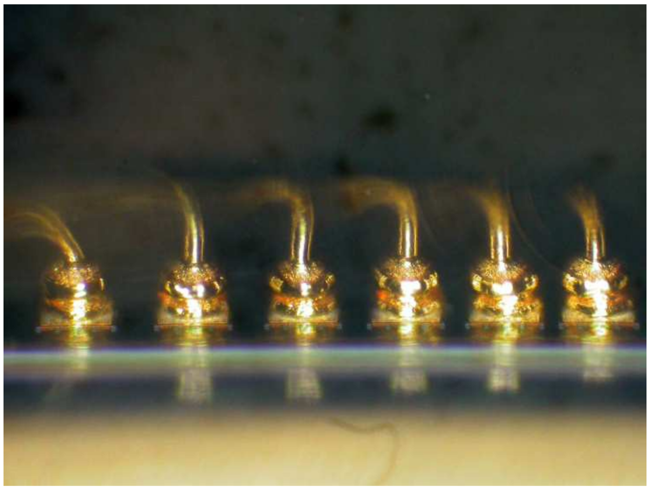

Figure 8: Tilted angle view of double ball bond sample

In order to properly refurbish a component so that its electrical functionality is intact, the new ball bond must be attached to the original existing bond. This process creates the pancake effect displayed in the above picture. The top down inspection of a component with this characteristic is difficult if not impossible requiring the tilting of the component for a side view.

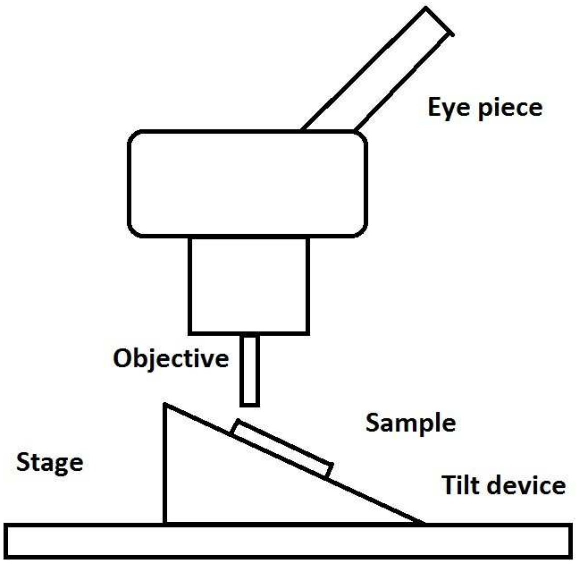

Figure 9: Diagram of microscope setup to achieve side-angle view

Remaining characteristics like field failures or handling defects are typically easy to inspect, assuming quality control is inspecting properly. Components that have failed in the field are particularly dangerous because those components should not be in the supply chain however they frequently end up back in circulation.

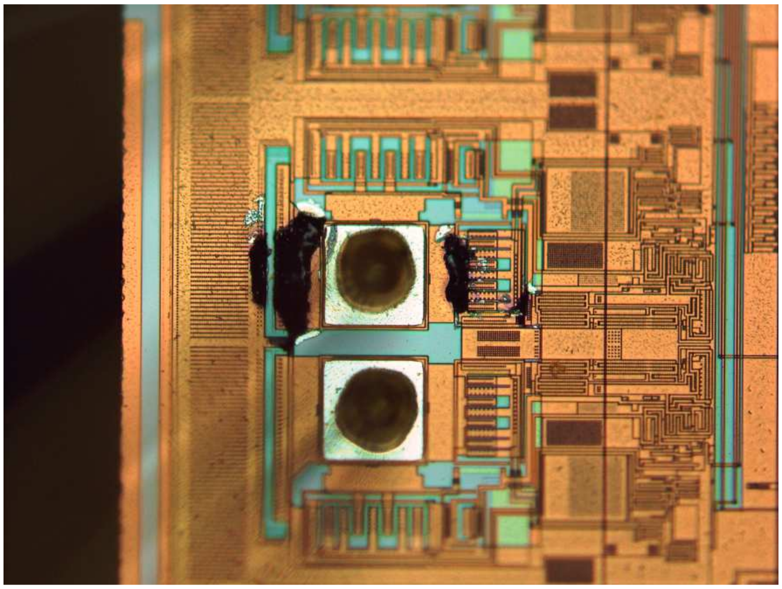

Figure 10: ESD damage of sample found in supply chain

Manufacturing rejects should also be destroyed but more commonly end up being used to fulfill order quantities of matching components. Manufacturing rejects are very dangerous because they reason they are rejected can frequently be design flaws and aren't easily inspected.

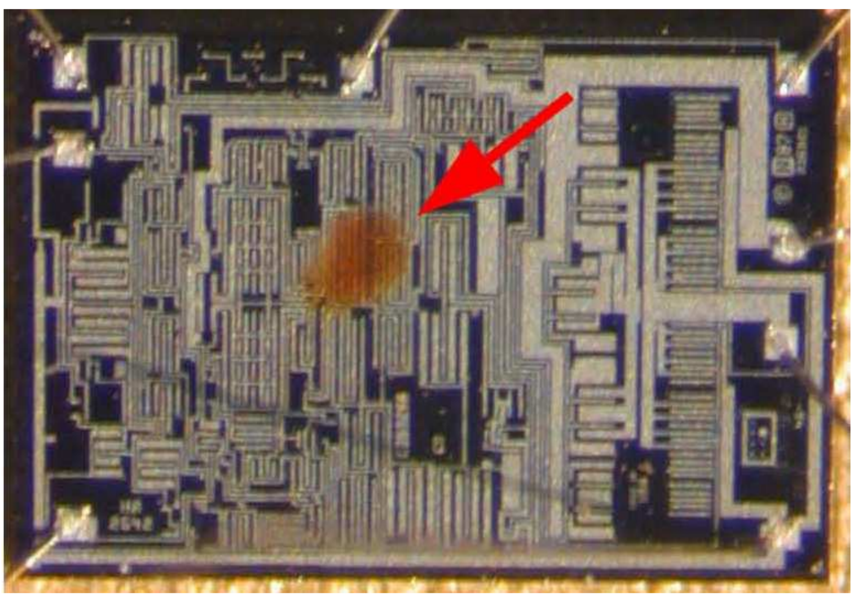

Figure 11: Watermark from OCM of failed component found in supply chain

The key to proper visual inspection is not only the accessibility of information but the correct inspection and documentation methods of suspect characteristics. Improper inspection of components leads to passed components that can cause a lot of damage when placed into their final product. Proper counterfeit detection involves detailed inspection of multiple aspects of a component in order gather as much information possible in so that each component can be successfully labeled counterfeit or authentic.

In order to properly inspect for counterfeit components it is critical to understand that one inspection method alone will not provide enough information to detect all counterfeits. Instead, a collaboration of multiple inspection processes, comparison of data amongst sample testing batch, comparison to “known good/golden sample” when possible, and documentation of findings results in the highest confidence level of authenticity of counterfeit labeling of components. Until as much information from a given sample is obtained, the risk of passing counterfeit components will remain.