FAILURE ANALYSES

Analytical Services

Failure analysis is defined as a process of diagnosis allowing to identify the cause of a problem. The failure analyses are particularly important and useful in microelectronics. The nature of these failures can be very diversified, but usually, these failures represent efficiency or reliability problems or features that must be established and rectified. For logistic reasons, the failure analyses are usually divided in two categories: the failures of assembly, and the failures associated with the integrated circuit, being the chip. These categories are necessary since the differences are significantly related to the techniques of investigation. In some cases, the same techniques can be used for both categories.
Failure analyses are essentially a succession of analytical stages, which allows to identify and to characterize a mechanism of failure, allowing to identify the cause and the corrective actions. The most important element about failure analysis is the process of diagnostic rather than the used techniques. Without an appropriate diagnostic process, even the best techniques would be of no utility, if the defective is destroyed during the investigation.

In the course of investigation, the analyst has to make sure that any observations of anomalies are being closely or remotely linked with the failures noted. These anomalies observed in the course of investigation could turn out to be important indication explaining the mechanism of failure, and allow appropriate corrective actions. Every module being unique, this point must be taken into account during the investigation. Therefore, before destroying a portion of the module to be analyzed, the analyst has to make sure that all the relevant verifications were made before moving on to the next step. There is no typical process for the investigation to perform failure analysis. Every failure has its particularities and the analyst has to take account of every elements.

INVESTIGATION STEPS

Since there is no common process of investigation, it is possible to divide a failure analysis into some generic steps:

1. Collection of information
2. Characterization of the electric failure
3. Non-destructive investigation
4. Identification and characterization of the mechanism (destructive investigation)
5. Identification of "Root Cause"

FAILURE ANALYSES

1. Collection of information

The collection of information is essentially a pre-step before the investigation itself. Without certain information concerning the defective module, no investigation can be foreseen.

The technology of the module influences largely the strategy of investigation. An organic or ceramic Flip Chip product requires different destructive investigations determined by its substrate composition, while a product using the Wire Bond technology does not present the same failure mechanisms.

The identification of electric defective parameters is essential, since without this information, it is impossible to begin the investigation. This information is usually supplied by means of a datalog, which identifies defective pines, the electric values of failure and the parameters of test used to identify the failure. During the failure analysis, the same parameters of test must be used to validate the failure and follow the electric signature during the investigation.

The defective module history represents an important information. A failure arisen after the assembly is very different from a failure after tests of reliability or arisen in service. After assembly, we usually find unrefined defects; as problems of positioning of the chip, the soldering, the mechanical damage, the present defects during the reception of the various components (die, substrate). While failures arisen after tests of reliability or in service are generally of different nature from failures after assembly, even if in certain cases, problems of assembly can be detected after tests of reliability or after several months of service.

With relevant information on modules to analyze, the analyst can develop an action plan for the investigation of the failure. This action plan will contain the steps of investigations and the main possible analytical techniques for the localization of the defect.

2. Characterization of the electric failure

This stage consists in confirming the electric failure and to identifying the characteristics of this failure. The signature of the failure represents, very often, an indication on the possible failure modes or the defective component. Furthermore, it is the "fingerprint" of the failure which can be followed during the investigation.

FAILURE ANALYSES

3. Non-destructive investigation

This step is used before the destructive portion of the investigation, it is mainly used to prelocalize the defect or find additional indications on the failure mode. According to the observations made during this step, certain failure modes can be excluded or always considered, and so reduce the time of investigation by limiting the suspected zone. The main techniques for the non-destructive investigations are;

- X-Ray, allows visualizing the inside of a component or an assembly.
- Acoustic Inspection allows verification of the integrity of the interfaces of assembly.
- Technical TDR, allows to prelocalize the electric failure by characterizing the variation of impedance of an electric signal propagating within the defective circuit.
- Technical MCI, allows to prelocalize the electric failure by characterizing the magnetic field of the defective circuit under bias.
- Thermal Imaging, allows to prelocalize the electric failure by characterizing a temperature variation associated with the defect.

4. Destructive investigation

Deprocessing of the defective component, by steps, allows following the defective circuit, until the defect is identified. Technical miscellaneous can be used for the destructive portion according to the product, according to its history, and according to its signature of failure. Afterward, a characterization of the defect is made to determine the failure mechanism, and so deduct the point of origin and the likely causes of this failure.

5. « Root cause » Identification

Most of the investigations end when the failure mechanism is identified, since the cause and corrective actions are known. In case of a new failure mode, the investigation will continue to better understand the failure mechanism and to identify the fundamental cause of this mechanism.
Diverse methods can be used to identify the cause, as the modelling, the DOE, the process 8D, or «Fishbone diagram", to mention only a few.

Lexicon
TDR → Time Domain Reflectometry
MCI → Magnetic Current Imaging
DOE → Design of Experiment