Development of miniature X-ray nondestructive system for next generation 3-dimensional stacked semi-conductor packaging defect inspection

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1. Introduction

In recent years, most electronic devices have become thinner and thinner, and related parts have become smaller. In particular, a three-dimensional stacked semiconductor packaging process has been proposed in which a plurality of wafer chips, which have been completed, are vertically stacked to increase the degree of integration. The most important issue in this regard is Through Silicon Via (TSV). TSV is a package method that forms a vias hole that vertically penetrates various chips when stacking semiconductor chips and then transmits electrical signals between chips by filling conductive materials. It is a package type in which the connection length between chips is reduced, It is possible to realize miniaturization. Meanwhile, it is ideal that the vias are formed so as to have the same depth and diameter on one wafer. However, when vias are formed at different diameters or depths, voids are formed inside the vias, hole may be filled with a less conductive material. When a defective chip is stacked with another wafer chip, some circuits may not be electrically connected, resulting in defective products. Due to the nature of the semiconductor industry, high yields are not only linked to high profits, but mobile subcontractors are also strongly demanding quality enhancement, requesting subcontracted data. Mobile-related mounting technology is rapidly evolving, and bad products in the smartphone market have entered the mature stage, adversely affecting brand recognition (Samsung Electronics, Galaxy Note 7 controversy, production discontinuation and loss of 3 trillion won in opportunity cost - August 2016), And raw materials companies want to prevent as much leakage as possible before final product shipment. As this psychology has been communicated to the suppliers, the demand for the inspection tool, which is a countermeasure solution, has been increasing. Naturally, inspection of the defect of the via hole formed on the wafer has become an essential process in the manufacturing process of the 3D semiconductor package using TSV. The problem is that the more defects are inspected to increase the yield, the slower the shipment of the product. In order to maximize profits through shipment faster than competitors, suppliers are forced to choose products that are delivered quickly. In response to these demands, it is also essential for suppliers to accelerate the process of shipment. There are several methods to detect defects such as focused ion beam (FIB), scanning electron microscope (SEM), atomic force microscope (AFM), ultrasonic inspection and infrared inspection. However, due to reasons such as sample destruction or frequency incompatibility, It is not easy to detect defects through. On the other hand, the nondestructive inspection using X-ray is most suitable for inspecting internal defects because it not only does not destroy the sample, but also easily transmits the metal and silicon.

The problem is that conventional devices capable of inspecting TSVs have the disadvantage that it is difficult to inspect large areas of the technology and structure or the entire area of the wafer, resulting in delayed shipment due to the late inspection speed. As a matter of course, the inspection speed can be improved by providing a large number of inspection devices and carrying out inspection at a time. However, the size of the part to be inspected by the TSV is several to several tens, and a very high resolution device is required to measure it. Since the price of such a device is very expensive, it is necessary to use an astronomical The amount comes in. There is no big advantage in terms of mass production versus investment in terms of partners who need to have a device. We have developed a device capable of inspecting wafers with a large area using a large number of small X-ray tubes. The final customers are domestic and foreign companies that inspect semiconductor parts, especially TSV-embedded semiconductor parts for internal defects. The scale of non-destructive testing market is as follows. The world market for non-destructive testing devices and devices, which was $ 2.78 billion in 2008, grew by 6% annually and reached $ 4.69 billion by 2017.

2. Methods and Results

2.1 Conventional Methods

There are two main ways to inspect semiconductor packaging through TSV processes. First, there is a method of inspecting using a focused ion beam and an electron microscope. This method is a method of inspecting a cut surface of a portion to be inspected by irradiating the sample with an ion beam, which is unsuitable for putting into a production line because the sample is destroyed. A solution is to use an X-ray to look inside without destroying the sample. The second method is to use X-rays. The X-ray is obtained by using the fact that the degree of attenuation according to the density of the material is different from that of the FIB-SEM mentioned above, without damaging the portion to be seen. It can be said that it is very suitable for

inspection of internal defects because it does not destroy the sample. However, since defects of parts containing TSV process are very small (1 ~ 30), it is difficult to obtain images with general X-ray tube, and it is necessary to use a high-resolution micro-focus X-ray tube. However, conventional devices equipped with a micro-focus X-ray tube are not fast to inspect because of the small area to be inspected at a time. To solve these drawbacks, it is possible to consider a method of inspecting several samples at one time by having a plurality of devices, but this method is also not easy because the price of one device costs hundreds of millions to billions of times. The solution is to develop a device capable of viewing a large area using several miniature X-ray tubes.

2.2 Proposed Methods

The apparatus to be proposed is a system composed of a plurality of coupled miniature X-ray tubes, a high-voltage power supply for driving the same, an X-ray-visible light switching unit, an image enlarging optical system and a detector. Since the X-rays generated from several X-ray tubes cover a wide range, the area that can be seen at one time is relatively wide. The attenuated X-ray passing through the sample (wafer or the like) reacts with the X-ray-visible ray switching part attached to the sample to generate a visible ray, and the image of the position of the X-ray-visible ray switching part is magnified by using an optical system . The magnified image is incident on a detector having a high resolution and converted into an image. The difference from the conventional products is that several small X-ray tubes are used. It is possible to perform inspection of a wide image, thereby inviting improvement in inspection speed.

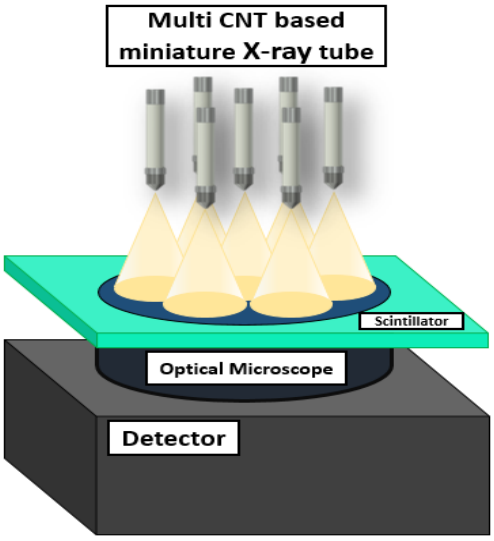

Fig. 1. Concept of multi CNT based miniature X-ray tube

3. Conclusions

Research with the above concept is ongoing, and the finished device is expected to quickly and effectively inspect very small semiconductor components.

REFERENCES

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