Failure analysis with magnetic field microscopy

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We, recently, see many consumer electrical products, which include smartphones, electric vehicles and drones, around the globe. Consumers have been demanding electric products with various functions and applications and long-lasting batteries, and manufacturers have been developing electrical products attracting more and more consumers. Such electric products have various semiconductor devices including power field effect transistors and lithium ion batteries.

Not just those products but also failure analysis technique has been making progress. We are likely to confront failure while developing or mass-producing things and we have to scrutinize it. When physical part of them has a problem, we, first, have to locate a defect. Generally speaking, the methods to locate such defects fall into two categories: a destructive method and a non-destructive method. For example, seeing the outside of a sample is the latter and seeing the inside of a sample after cutting it is the former. The non-destructive method is supposed to be performed before the destructive method. Non-destructive methods include X-ray computed tomography (X-ray CT) and magnetic field microscopy (MFM). X-ray CT is very useful in seeing the inside of a sample in three dimensions, which will provide insight into how things such defects within the sample look. MFM visualizes magnetic field intensities across a sample with a magnetic sensor. A superconducting quantum interference device (SQUID), a giant magneto resistance (GMR) sensor, a tunnel magneto resistance (TMR) sensor, and magneto-optical frequency mapping (MOFM) have been used for magnetic field imaging [1, 2, 3, 4]. Data analysis is also important, and some magnetic field analysis techniques have been introduced [1, 3]. When it comes to locating short circuits, it is really important to have a clear magnetic field intensity image. To do that, an electromagnetic field reconstruction method can be used, which calculate subsurface magnetic fields [3]. Using this method, we can obtain the intensity distribution of magnetic fields that are closer to the electric current that creates magnetic fields in distance than the positions where some of the magnetic fields are measured with a magnetic sensor.

In this study, we used a magnetic field microscope that we bought from Integral Geometry Science Inc. The microscope had a TMR sensor and an MI (magneto impedance) sensor. We also used a three-dimensional X-ray microscope, Xradia 520 Versa (Carl ZEISS X-ray microscopy Inc.).

We visualized the path of an electric current flowing through a power metal-oxide-semiconductor field effect transistor device. We, then, made a short circuit between the gate and the source in a power MOS-FET and succeeded in locating it from a magnetic field image. Another example is a ball grid array package with a short circuit between two solder bumps. After locating the short, we put the sample through the X-ray computed tomography scanner and clearly visualized the short circuit in three dimensions. We will talk about more details and other examples such as locating short circuits in lithium ion battery cells in the presentation.

References

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