

RMD MAGNETIC VISION SYSTEM FOR IC INSPECTION

RMD offers a new, non-invasive method of locating faults and failures in both integrated circuits and printed circuit boards using magnetic imaging. This new technology can be used in IC design to accurately locate short circuits, insulation failure, and metallization flaws from the back side of a silicon wafer or chip. It can also be used to locate defective traces or components on PC boards.

The RMD Magnetic Vision Scanning System is, in effect, a high-resolution magnetic field microscope that records the magnetic field distribution generated by currents in circuits. The magnetic field image can be viewed in real time during the scanning process. Proprietary data analysis techniques make possible spatial resolution in the .5-10 micron range even when the sensors are 10 to 200 microns from the IC. This eliminates the need for “trenching” the silicon for IC inspection.

Two anisotropic magnetoresistance (AMR) sensors are used to simultaneously measure the magnetic field in the x and y directions. Automatic x-y scanning is accomplished by integration of software and hardware. Automated z-axis navigation permits inspection of components that are not planar or have variable height. Integrated visible light or infrared cameras are also available for multi-modal imaging, and machine vision applications. The nominal scanning range is 2 x 2 cm, with larger scanning tables optional up to 12 x 15 inches.

MAGNETIC VISION SCANNING ADVANTAGES

- Does not require thinning wafer as does NIR imaging (Near Infra-Red)
- Can see through intervening non-ferromagnetic layers.
- High resolution.
- High sensitivity.
- Can produce both magnetic fields and the geometry of the magnetic field source.

MAGNETIC VISION SCANNING APPLICATIONS

- Design flaws in integrated circuits.
- Short circuits in integrated circuits.
- Defects in metallization traces in integrated circuits.
- Defects in insulating layers.
- Defects in conductors in pc boards.
- Defective components on pc boards.
- Defects in high density IC packages such as flip-chips and ball grid arrays (BGA)

MAGNETIC VISION SCANNING FEATURES

- Adjustable range and resolution
- Adjustable scan height and scan height control
- Real-time display of magnetic field during scan
- Several alternative display schemes – 2D and 3D
- Zero in on high field areas at high scan rate then shift to high resolution
- Can be programmed to scan an IC, a PC board, or a populated board.
- Micron resolution of current source identifies exact shape and position of fault

Magnetic Imaging to Detect a Serpentine Structure in an Integrated Circuit

RMD is developing technology to generate high resolution images to solve the problem of locating a microscopic conductor in an IC. ICs with an FIB induced defect in the form of a metal serpentine structure (Figure 1) connected to external pins on the IC package provide a test structure to demonstrate the imaging of a microscopic defect with micron features.

As seen in Figure 2, a magnetic imaging system developed by RMD can locate the defect with high spatial resolution but does not provide the micron dimensions of the structure generating the field. This is due mainly to the distance from the sensor to the structure (~ 350 microns), and no post-processing of the magnetic field image.

Typically, IC manufacturers use NIR imaging to locate shorts or high current areas in ICs as part of process development and testing. During IC fabrication the active side of the silicon is mounted against a chip carrier and bond wires are connected to conduct electrical signals. Therefore, the NIR imaging must be done from the back of the IC. Unfortunately, this means that the NIR image of the functional region on top of the silicon must be made through ~250 microns of silicon. The silicon absorbs heat and some of the IR light, blurring the images. A technique known as trenching, where a focused ion beam is used to cut the silicon, is commonly used to remove silicon and improve the image. However, this is an expensive and time consuming step (Figures 3 and 4).

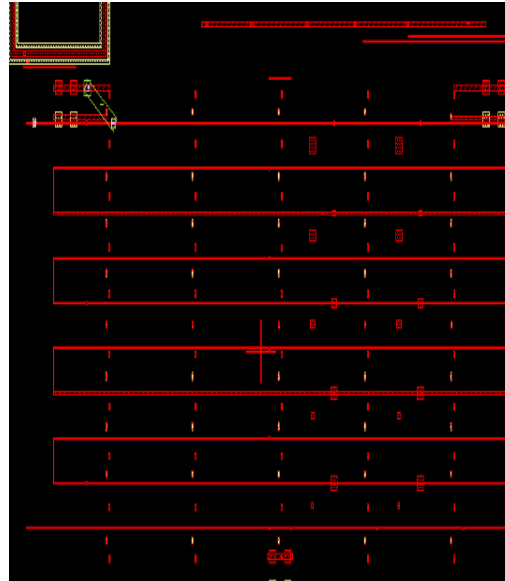
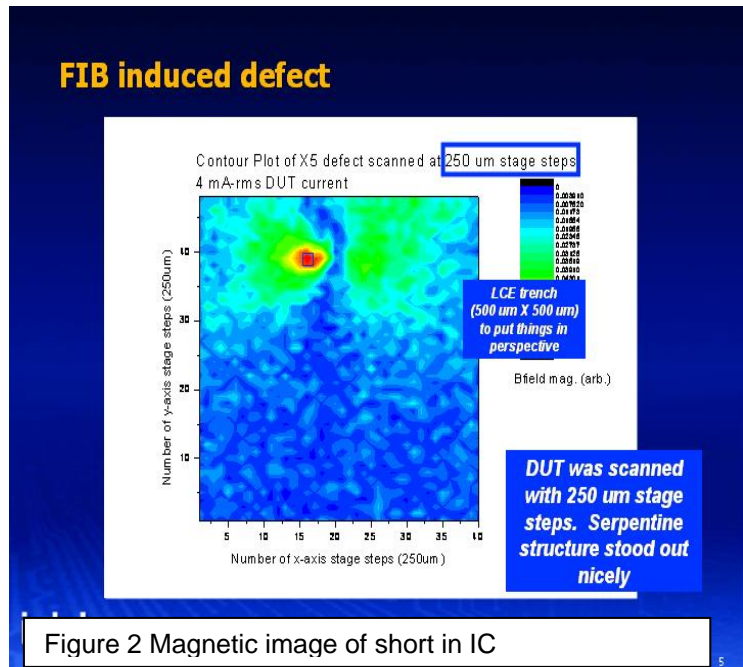


Figure 1 the serpentine structure has overall dimensions of 65 microns long by 27 microns wide. The conductor is 0.5 microns wide.



Another approach to imaging is to scan the IC with a small magnetic sensor and produce a magnetic field image. The problem with this approach is that, in general, one cannot achieve spatial resolution better than the distance between the sensor and the conductor in the active portion of the IC. If there is 250 microns of silicon between the sensor and target then spatial resolution is limited to ~250 microns. Attempts have been made to solve this problem using current density mapping, a complex mathematical transform of the magnetic field data. While this approach has shown some positive effects, it does not appreciably improve the spatial resolution of the image under the circumstances encountered during IC inspection.

Figures 3 and 4 show a square notch cut in the silicon that is 300 x 300 microns. Since MR sensors are made on silicon that is ~250 microns thick, it is difficult or impossible to get the sensor into the notch no matter how small the actual sensor is. Therefore, trenching is of little benefit to conventional magnetic imaging

RMD has recently tested a promising new approach to reconstruct the shape of the source of the electric current that generates the magnetic field (in this case, the serpentine structure). We first modeled the concept using the actual dimensions of the serpentine structure: separation between lines of 3 microns (along the Y-axis), length for each line of 61 microns (along the X-axis) and width of each line 500 nanometers. The goal was to determine, through modeling, how far the sensor can be placed above the serpentine structure and still recover the exact geometry of the current source.

Figure 5 shows a simulated image of the electric current in the serpentine structure used to model the magnetic fields. Figure 6 shows the magnetic field created in the structure with no noise and the sensor to source separation (Z) of 0.1 microns. I

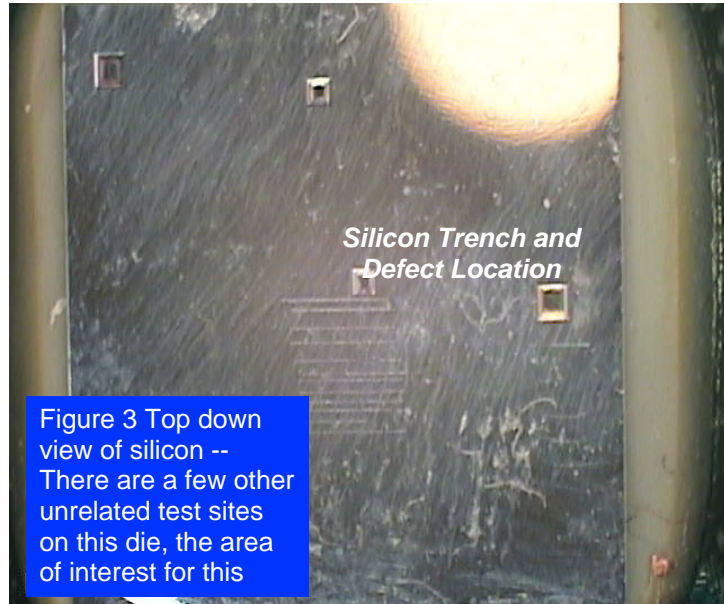


Figure 3 Top down view of silicon -- There are a few other unrelated test sites on this die, the area of interest for this

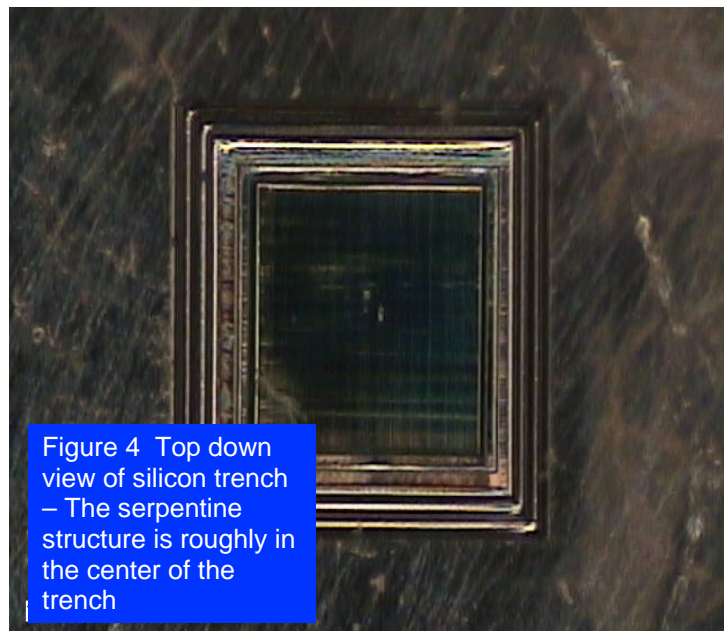


Figure 4 Top down view of silicon trench - The serpentine structure is roughly in the center of the trench

reality this is unachievable, but it provides a baseline for the quality of the image we hoped to produce.

Figure 7 shows an image of the current source (defect) recovered from the magnetic field (as in Figure 6). This data showed that with RMD's algorithm, it is possible to make an image of the geometry of the source with spatial resolution 20 x greater than is possible with conventional current density mapping. This means that the sensor system can achieve 1 micron resolution when the sensor is 20 microns from the surface of the IC. At a separation of 250 microns, spatial resolution is ~20 microns without trenching. This is far superior to NIR imaging and magnetic microscopy utilizing conventional current density mapping.

RMD plans to refine its analytical and imaging model so that it can be used to produce images with 15 nanometer resolution with separation between the sensor and IC near 250 microns. This research will allow the inspection of structures with submicron dimensions from the surface of the silicon. With sufficient refinement, it may also be possible to image such structures from the outside of an IC package. This capability would open large markets in both IC NDE and IC manufacturing and QA/QC.

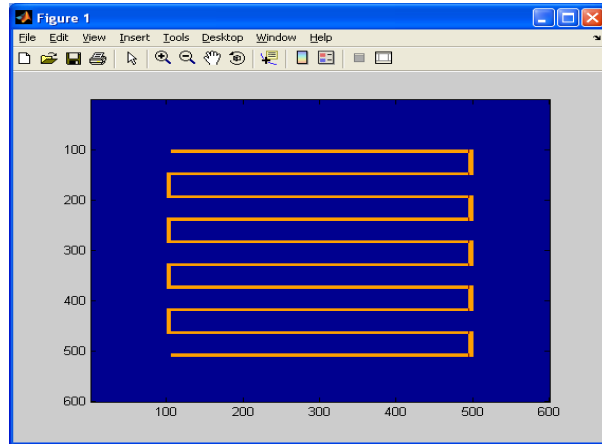


Figure 5 Simulated electric current in the serpentine structure

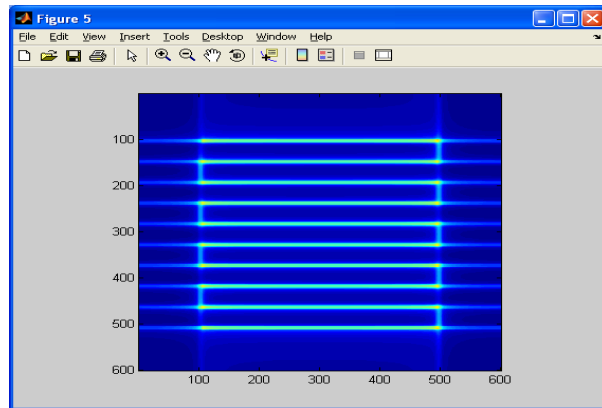


Figure 6 Magnetic field created by the serpentine at $z=0.1$ micron

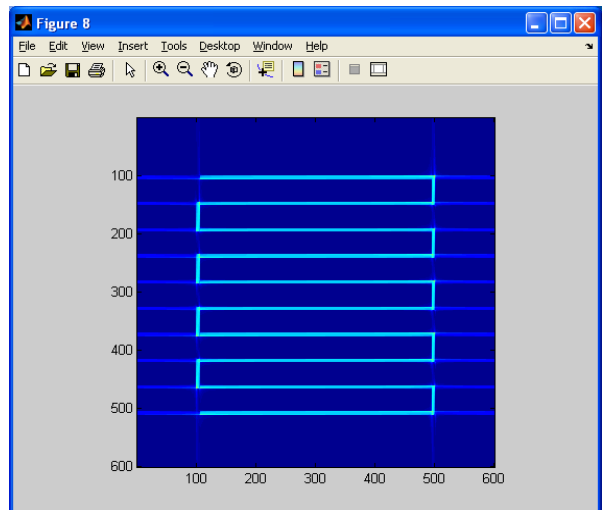


Figure 7 image of the serpentine structure obtained By RMD.