An Application of IDD Spectrum Testing Method to the Fault Analysis

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Abstract

IDDQ information is very useful to localize faults in a LSI. But it is time consuming to discover test vectors which induce abnormal IDDQ. Since the IDD spectrum testing method can detect abnormal supply current easily, we can acquire the test vector information in a short time by the method. An application of the method is introduced and we show experimental results.

1. Introduction

Fault analysis is very important to improve device quality and productivity. The fault analysis, however, become complicated work recently due to multiple layers and high density transistors of the device.

IDDQ is effective against fault analysis because the location of fault can be identified relatively easy by using the emission microscope(EMS) and/or OBIRCH. But discovering test vectors which induce abnormal IDDQ is time consuming. A set of test pattern usually consists of a large number of test patterns, and the each test pattern is made of a large number of test vectors. It takes a long time to measure IDDQ of whole test vectors.

IDD spectrum testing method can detect faulty supply current of faulty devices in a short time. The method identifies a test pattern which induces faulty supply current from the set of test patterns. Since the test pattern cause a faulty supply current, the pattern certainly has some test vectors which induce abnormal IDDQ. Since we have only to measure IDDQ of the selected test pattern instead of the all test patterns, we can shorten time to acquire IDDQ information.

2. IDD spectrum testing method

A supply current of a device flows by applying a test pattern to it. If the test pattern is applied to the device repeatedly, the supply current also flows repeatedly. This means the supply current has a frequency spectrum. The spectrum consists of fundamental frequency 1/T and its harmonics. T is the length of the test pattern. If the device has faults, and faulty current flows by applying the test pattern, the spectrum has the same fundamental frequency and the harmonics, but the spectrum power is different from the spectrum of the fault free device. In other word, we can recognize the faulty current by the deviation of the spectrum power. The spectrum can be acquired in a short time, so we do not need time to detect faulty supply current.

The method which compares the supply current spectrum is called IDD spectrum testing method. Since the faulty supply current includes abnormal IDDQ, abnormal switching current, and so on, it is expected to detect abnormal IDDQ by measuring each test vector of the test pattern which cause the abnormal supply current. Therefore the IDD spectrum testing method is powerful technique to detect the abnormal IDDQ in a short time.

After the test vectors which induce abnormal IDDQ are identified, we observe the device under abnormal IDDQ conditions and normal IDDQ conditions by using EMS or OBIRCH. If a different image is observed, we can prospect a location of the faults.

3. Experimental results

A customer return (supposed to have faults) was analyzed by the IDD spectrum method. This sample was passed by the production test, but it was expected to have faults. In such a case, abnormal IDDQ is likely to be observed. But the number of test patterns is 117, and the total number of test vectors is over 600000. It is time consuming to measure IDDQ of every test vector. So the IDD spectrum method was applied first. As a result, the method found some test patterns whose spectrums are different from the ones of the reference. This means the test patterns induce faulty supply current. One of them has 1362 test vectors. IDDQ was measured in every test vector of the pattern. Then we found out the customer return has IDDQ abnormality. Consequently, we only measured IDDQ of the identified test pattern instead of whole test patterns. The total time to discover an abnormal IDDQ diminished over 50 times than the conventional method.