The Last Byte

Current testing for nanotechnologies: Myths, facts, and figures

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■ The well-known merits of current testing—I_{DDQ} in particular—include quality improvement, cost reduction, and burn-in elimination. I_{DDQ} offers a screen that allows for quick identification of defective parts, during both wafer and final test. Traditionally, I_{DDQ} is seen as an approach that compares quiescent current measurements against a predefined pass/fail threshold. That threshold is typically the same for all tested devices, thereby assuming a clear distinction between leakage and defect currents. Increasing background leakage and varying device parameters complicate limit setting. From that perspective and with the advent of nanotechnologies, I_{DDQ} might die, but as a phoenix it will revive, as even more attractive I_{DD} test approaches exist.

When activated, nearly all manufacturing defects either change the device's I_{DDQ}, affect the transient supply current (I_{DDT}) behavior, or affect both. Some of these defects escape voltage-based tests by not directly altering the device's functionality, but still affect its lifetime operation. Observing supply-current behavior offers an easy detection screen.

Nanotechnologies impose challenges related to growing device complexity and higher integration densities. As a result, the total normal leakage is often one or more orders of magnitude higher than the defect current, rendering the traditional I_{DDQ} approach invalid. At the design level, existing solutions for this include backward or forward body biasing, built-in current monitoring, and power partitioning. Solutions at the test application level include using delta I_{DDQ}, current signatures or ratios, relative I_{DDQ}, I_{DDT}, or combined I_{DDQ}-I_{DDT} tests. The main requirement for applying current testing to nanotechnologies is the availability of tools that measure rapidly and have a wide range, a high resolution/repeatability, and real-time data processing capabilities to support advanced I_{DDQ} test strategies.

Several myths about nanotechnology are circulating: Leakage currents surpassing defect current levels render I_{DDQ} invalid. Wide leakage current variation across a production lot inhibits proper limit setting. The expected increase in parameter variability for nanotechnologies masks defect current visibility.

Normal leakage—high or low—does not impact I_{DDQ} application. The only requirements for I_{DDQ} are current stability at the selected measurement points and a repeatable test condition. If the test meets these conditions, application is unrestricted. Wide leakage variation imposes a burden on limit setting only if you use a single product-related limit. Data processing techniques such as delta or relative I_{DDQ} help eliminate this variation and set a product-related delta or relative limit. Defect current visibility in large background currents relates to the actual measurement resolution/repeatability. This, along with measurement speed, is one of the areas in which existing ATE is lacking, but luckily, commercially available add-on solutions overcome this issue.

In addition, increasing design complexity results in a better matching of state-dependent leakage. This results in a reduced IC-related vector-to-vector I_{DDQ} variation. This reduction at least partially or fully compensates for the increase in transistor-to-transistor leakage variability in each new IC technology generation.

Nanotechnology is not the showstopper for the application of current testing—the current measurement capabilities embedded in existing ATE are. Available high-speed, high-resolution, measurement add-on capabilities, combined with die-oriented decision making and repeatable test conditions, enable the application of current tests to nanoscale ICs, permitting the industry to reap the true benefits of I_{DDQ}, even in the presence of large background currents.

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