Memory Test Optimization for Parasitic Bit Line Coupling in SRAMs

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I. INTRODUCTION

Memory test optimization can significantly reduce test complexity, while retaining the quality of the test. In the presence of parasitic BL coupling, faults may only be detected by writing all possible coupling backgrounds (CBs) in the neighboring cells of the victim [2], [3]. However, using *all* possible CBs while testing for every fault consumes enormous test time, which can be significantly reduced, for the same fault coverage, if *only* limited required CBs are identified for each functional fault model (FFM). So far, no systematic approach has been proposed that identifies such limited required CBs, nor corresponding optimized memory tests generated that apply limited CBs [1]. Therefore, this paper presents a systematic approach to identify such limited CBs, and thereafter presents an optimized test, March BLC, which detects all static memory faults in the presence of BL coupling using only required CBs.

II. CBS IDENTIFICATION FOR STATIC FAULTS

This section describes how to identify the limited CBs for single-cell and two-cell FFMs.

A. CBs identification for single-cell faults

Single-cell static faults occur within the faulty cell, while BL coupling effect takes place in the neighborhood (two immediate *left* and *right* neighbors of the victim lying on the same word line) of the faulty cell. Thus, these two effects are independent. As a result, one can maximally stress single-cell faults by applying the worst-case CBs (WCBs). WCB for a logic 0 in the victim is CB 00 , and CB 11 for a logic 1 in the victim [2].

B. CBs identification for two-cell faults

Two-cell static faults occur between two cells - a victim and an aggressor (A_g), and require specific state or transition in A_g as a necessary condition to sensitize a given fault. For these FFMs two scenarios are identified:

1. *When A_g is not one of the neighborhood cells*. Here, the influence of BL coupling is independent of the given FFM. Such faults can be detected by applying WCBs.
2. *When A_g is one of the neighborhood cells*. Here, the influence of BL coupling depends on the FFM. Since the FFM requires a specific logic value (fault definition) in one A_g for sensitization, the other neighborhood cell can be used to stress the faulty behavior. Two types of such FFMs exist.

1. *Homogeneous fault models*: Here, the required logic value in A_g is the same as the expected value in the victim after sensitization. Therefore, one only needs to identify the WCB in the other neighbor, which is not defined by the fault. For example, consider CF_ds, FP = $< 1w0; 0/1/- >$. After sensitization by $1w0$, the expected content of A_g is a logic 0, while the content of the victim is also a logic 0. A $r0$ is required to detect the fault using WCB 00.
2. *Non-homogeneous fault models*: Here, the required value in A_g is not the same as the expected value in the victim after sensitization, for example CF_tr, FP = $< 0; 0w1/0/- >$. In addition, BL coupling has its own WCB requirement during detection. Selecting the WCBs depends on which of the two effects is dominant, which cannot be theoretically derived. For these FFMs, both backgrounds should be applied, to ensure proper fault detection.

III. OPTIMIZED TEST: MARCH BLC

We present March BLC, an optimized test that detects all static faults in the presence of BL coupling using only the required CBs, with a test time complexity of $46n$. Compared to March m-MSS ($108n$) [3], which applies all possible CBs, the test time is significantly reduced by over 50%.

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\begin{array}{lll}
\text{March BLC} = \{ & \Updownarrow(w0); & \text{ME0} \\
 & \Uparrow(r0, r0, w0, r0, w1, w1, r1); & \text{ME1} \\
 & \Uparrow(r1, r1, w1, r1, w0, w1); & \text{ME2} \\
 & \Uparrow(r1, r1, w0, w0, r0); & \text{ME3} \\
 & \Uparrow(r0, r0, w0, r0, w1, w1, w0); & \text{ME4} \\
 & \Downarrow(r0, r0, w0, w1, w1, r1); & \text{ME5} \\
 & \Downarrow(r1, r1, w0, w1); & \text{ME6} \\
 & \Downarrow(r1, r1, w0, w0, r0); & \text{ME7} \\
 & \Downarrow(r0, r0, w1, w1, w0)\} & \text{ME8}
\end{array}
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