X-Ray Inspection Test Conditions for SkyHigh NAND Flash

AN98527 discusses the X-ray inspection test conditions and recommendations for SkyHigh NAND Flash products that should be used to prevent damage to ICs.

1 Introduction

It has been well established that semiconductor ICs can suffer damage caused by X-ray inspection. While this phenomenon does not always result in a system level failure, customers might have no means to recover from the effects of the X-ray exposure if data corruption or other failure mode occurs. SkyHigh studies have shown that programmed cells within a flash array may experience a change in threshold voltage (Vt) as a result of certain X-ray inspection conditions. Any significant negative perturbation in the Vt of a programmed cell will result in incorrect sensing of the programmed bit logic state during a read operation, resulting in such bits incorrectly reading in the unprogrammed logic state.

2 SkyHigh X-ray Qualification Test Conditions

Below are the test conditions and equipment parameters that SkyHigh employs when conducting X-ray inspection as part of the product qualification process. SkyHigh can guarantee that its products will suffer no damage when these conditions are applied:

- X-ray Inspection Test Equipment
  - Shimadzu (Model SMX-160GT) [1]
  - Dosimeter: High Dose LiF TLD
  - 300-µm thick Zn Filter
- X-ray Inspection System Conditions
  - Tube Voltage: 110 kV
  - Tube Current: 40 µA
  - Center Distance to Source: 40 mm
  - Exposure Time: 240 seconds
- X-ray Inspection Test Procedure
  - Products are functionally tested and programmed to a known data pattern containing both programmed ‘0’ and unprogrammed ‘1’ logic states prior to X-ray inspection.
  - Products are arranged in a circular pattern around the center of the X-ray system stage to insure uniform exposure.
  - The Zn filter is placed between the X-ray source and the products being inspected.
  - A dosimeter is included in each batch of units to record the X-ray dose absorbed during inspection.
  - Products are exposed to the X-ray beam for 240 seconds (4 minutes), which corresponds to the worst-case inspection time of most circuit board inspection systems and has been determined to be adequate to assess any board assembly issues.
  - After exposure, products are retested to insure there is no loss of functionality or change in pre-programmed data pattern has occurred.
  - With this test procedure, X-ray dose received by the products will not exceed 10 rads, while still enabling adequate imaging and resolution required for circuit board inspection.

[1] **Note:** Equipment is mentioned as a point of information and not as a product endorsement.

3 X-ray Inspection Recommendations

There are many commercially available circuit board inspection systems and each employs different X-ray set up conditions and exposure doses. It is not possible to provide a single set of recommendations that will apply to all inspection systems. However, in order of effectiveness, the following are the mitigation techniques SkyHigh recommends minimizing the effects of any potential damage resulting from X-ray inspection:

1. If X-ray inspection is performed after the flash has been programmed, consider erasing and reprogramming the flash data.
2. Use a 300-µm thick Zn filter; 1-mm thick Al or Brass filters are also effective.
3. Use the smallest X-ray tube kV-peak possible that still produces adequate images during board inspection.
4. Use the smallest X-ray tube current possible that produces adequate images.
5. Use the largest X-ray tube to sample distance (i.e. lowest magnification) possible.
6. Use the shortest inspection time possible, preferably on a sampling basis rather than 100% board inspection.

Document History

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Revision	ECN	Orig. of Change	Submission Date	Description of Change
**	–	–	07/11/2012	Initial version.
*A	4958468	MSWI	10/12/2015	Updated to Cypress template.
*B	5841679	AESATMP8	08/02/2017	Updated logo and Copyright.
*C	6259520	YUOH	08/02/2018	Updated Document Title to read as “AN98527 - X-Ray Inspection Test Conditions for Cypress NOR/SPI/NAND Flash”. Updated Abstract. Removed “X-ray Inspection References”. Updated to new template. Completing Sunset Review.
*D		MNAD	06/03/2019	Updated to SkyHigh format .
*E		MNAD	08/18/2021	Removed NOR from the title.