X-ray Inspection Considerations for Surface-Mounted Flash ICs

About this document

Scope and purpose

AN98522 is intended to help those customers who perform X-ray inspection of the surface-mounted integrated circuits (ICs) on their circuit boards.

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1 Summary

This document is intended to help those customers who perform X-ray inspection of the surface-mounted integrated circuits (ICs) on their circuit boards. X-rays behave basically the same as visible light rays, since both are wavelike forms of electromagnetic energy carried by particles called photons. The difference between X-rays and visible light rays is only the energy level of the individual photons, which is also expressed through the wavelength of the rays. Just as filtering of visible light wavelengths (that is, energies) can be used effectively to prevent damage to photosensitive materials, Infineon has shown that filtering of specific X-ray energy levels can be used to prevent damage to X-ray sensitive semiconductor ICs.

It has been well established that semiconductor ICs can suffer irreversible damage from charging effects caused by X-ray energy. While this phenomenon does not always result in a hard failure, customers often have no way to recover from the effects of the X-ray exposure. The following table shows the approximate total X-ray dose damage of commercial off-the-shelf (COTS) devices:

Type of Semiconductor Device (COTS)	Total Dose Threshold (K Rads)
Linear	2-50
Mixed Signal	2-30
Flash Memory	5-15
DRAM	15-50
Microprocessors	15-70

Infineon studies have also shown that there is a substantial X-ray dose variation among inspection equipment suppliers as shown in the table below:

Supplier	Approx. Dose (Rads)
A	0.057
B	3
C	10
D	12
E	25
F	35
G	60
H	700

We found that in most cases, these suppliers have recommended X-ray doses that are significantly higher than what is necessary to achieve successful inspection results. The key is to minimize the total cumulative dose to the IC while achieving a useful inspection image.

The original goal of Infineon experimentation was to detect 50 µm copper traces (typical for a PWB) and the underlying 0.5 mm IC solder balls at the lowest possible X-ray dose. We quickly proved that the X-ray tube voltage is not the predominant factor for damaging charge storage cells. After discussing our results with several suppliers, it became apparent that the choice of X-ray tube filtering is the key factor of concern.

It was concluded that silicon dose is sensitive ONLY to X-rays with energy in the range 2-9 KeV; that 50 µm Cu traces are best imaged with X-ray energy of 9-20 KeV; and that tin and lead are well-imaged by X-rays over the energy range of 30-50 KeV and higher. While many thick metal filters effectively reduce Si dose, they also have the effect of making the relatively thin copper traces in a PWB very difficult to image by strongly absorbing X-rays in the energy range 9-20 KeV. A thin 300 µm zinc filter will be a very effective agent to absorb very soft X-

rays to which silicon is vulnerable, yet transmit soft and medium energy X-rays required to obtain good radiographs of thin copper traces and solder balls. Zinc foil can be integrated with the inspection “carrier” or put near the X-ray source.

As a general rule, if customers have no filtering capability, they should limit the cumulative X-ray inspection exposure to the SMT memory devices to 1,000 Rads or less. Infineon has submitted a patent for the use of zinc filtering that will enable X-ray suppliers to produce systems that are better ‘tuned’ for the electronics industry.

Revision history

Document version	Date of release	Description of changes
**	2007-05-21	Initial version
*A	2015-10-09	Updated to template
*B	2017-08-03	Updated logo and Copyright
*C	2021-03-19	Updated to Infineon template

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