

Fault Isolation & Failure Analysis in Semiconductor Manufacturing

Application of high resolution phase contrast X-ray imaging to failure analysis of flip chip packages

Application

X-ray imaging is a well established technique for the non-destructive imaging of internal defects in semiconductor chips and packages, however as the dimensions of semiconductor devices continue to decrease, considerable demands are placed on the resolution performance of typical x-ray systems.

A further disadvantage of traditional x-ray imaging is the reliance upon absorption contrast as the dominant contrast mechanism. While absorption contrast can be used to differentiate between materials of different density, the technique is less suitable for detecting cracks, blisters and delaminations and provides little if any contrast between materials of low atomic number.

An alternative approach to the failure analysis of semiconductor packages is the preparation of cross sections for SEM imaging. In this case the spatial resolution is far superior to x-ray imaging however differences in the mechanical properties of the diverse materials found in a semiconductor package may make it difficult to prepare sections without introducing artificial defects, particularly along interfaces.

Solution

A new form of high resolution x-ray imaging, the X-ray ultraMicroscope (XuM) has been developed which exploits both phase and absorption contrast.

For more information please contact:

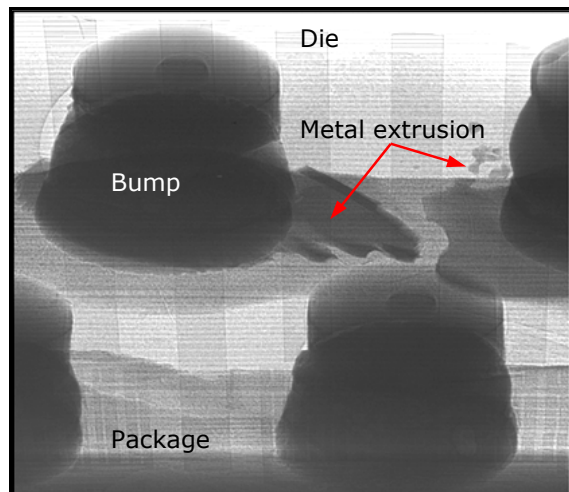
XRT Limited

Suite A3, Port IT Business Park,
63 Turner Street, Port Melbourne
VIC 3207, Australia
Tel: +61 3 9249 2900, Fax: +61 3 9646 3469
www.xrt.com.au



X-ray ultraMicroscope (XuM)

The XuM can reveal features down to less than 0.1 micron, 100 times smaller than conventional x-ray imaging. Such performance was previously only possible using multi-million dollar synchrotron sources, but is now available in a laboratory based system as an attachment to a scanning electron microscope.

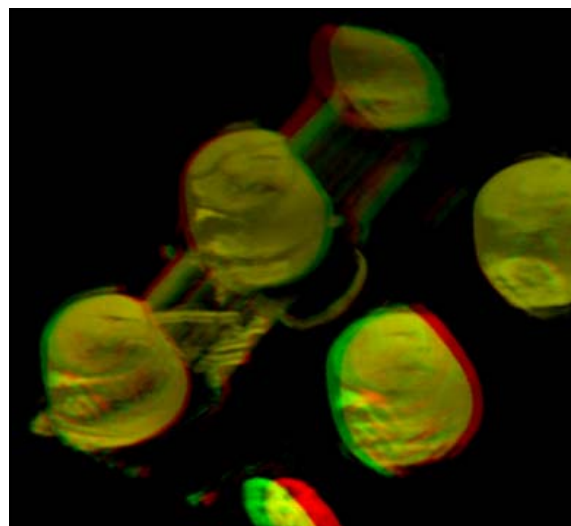


Figures

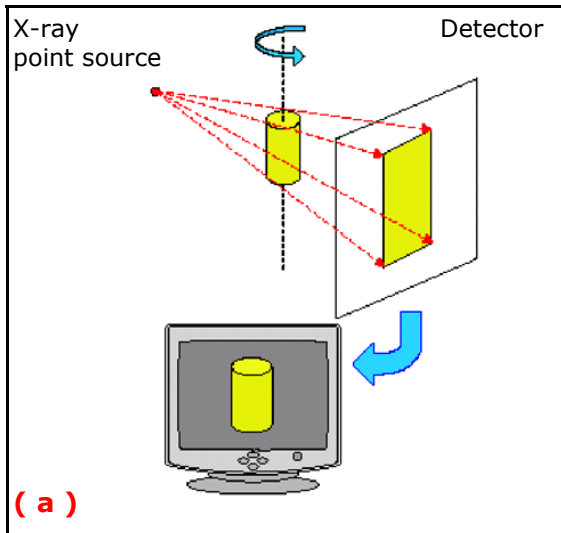
Above: High angle XuM image of a section of a flip-chip.

Below: XuM Stereo anaglyph. Both images show metal extrusion at the solder bump—package interface.

(Sample preparation is described overleaf.)

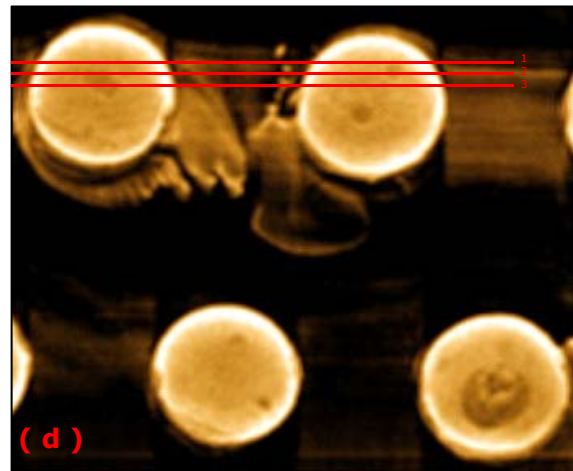
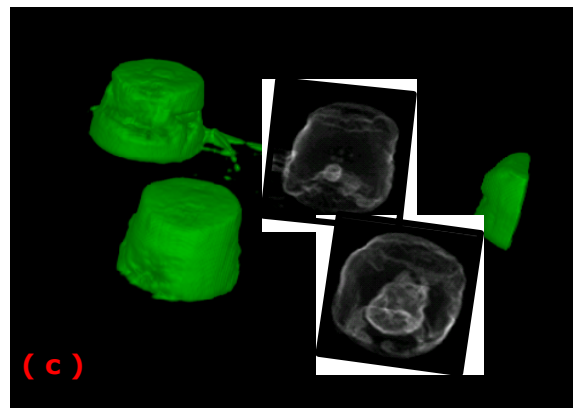
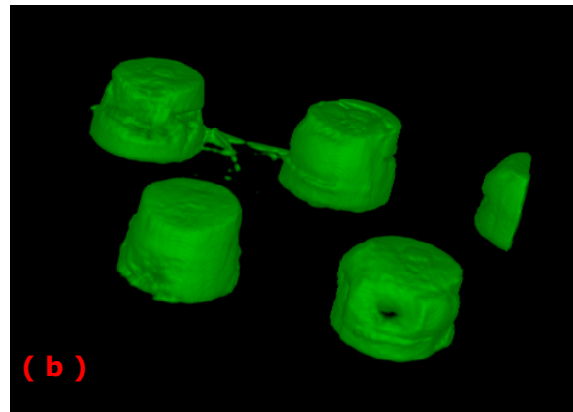
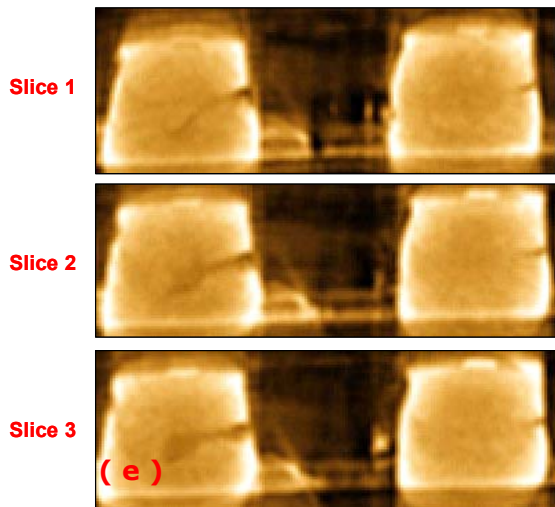


XuM in Action



3D Microtomography

In addition to planar and high angle imaging, XuM images can be acquired at many rotation angles to produce a 3D tomographic data set. Data can be reconstructed using a cone beam algorithm and then surface rendered for "virtual cross sectioning"



List of Figures

- (a) Schematic for 3D imaging
- (b) Surface rendering of 3D dataset, with underfill set to transparent.
- (c) As image (b) with selected gradient rendering to expose internal voiding within bumps.
- (d) Virtual slices from the tomographic reconstruction show cracking and voiding at 3 levels.
- (e) A virtual horizontal section shows the location of slices in figure (d) Clear evidence of voiding can be seen in several bumps.

Sample Preparation

The XuM provides a unique capability not possible with existing electron beam, optical or other conventional techniques, enabling the acquisition of microscopic x-ray images of the internal structure of a sample. It operates with an energy range of approx 4–12 keV and therefore some sample preparation is required to enable transmission of the x-ray signal through the sample. In the examples presented above, the sample was polished down to approximately 150 microns in thickness, leaving the die–bump and bump–package interfaces intact.