SIMS
Application note 279

SIMS
Secondary Ion Mass Spectrometry

Imaging of Semiconductor Contact Pads

Summary

The surface chemistry of integrated circuit bond pads is crucial to correct connection welding. SIMS imaging provides a rapid method of assessing surface chemistry and identifying pads covered by even a few monolayers of contamination. Understanding of the distribution of contamination, in this case a fluorocarbon deposit, leads to better process optimization and higher product yield.

Introduction

The bond pad is of vital importance to semiconductor technology as it is the portal through which signals pass to and from the integrated circuit. Failure of a simple wire bond will mean early failure in service or low device yield.

The bond pad is simply a small, 20 to 100 micron, usually square, metallic area around the periphery of a chip that is connected to the internal circuit. It is generally composed of an aluminium-silicon sputter deposited alloy. When the chip is packaged, connection is made to the bond pads via fine ultrasonically welded wires. Any

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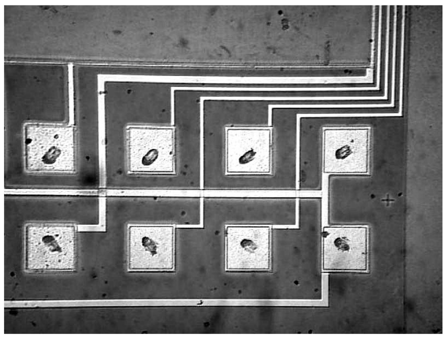
contamination on the surface of the pad leads to a poor weld and consequent failure.

Electrical testing of the chip function, using contact probes, cannot show poor surface chemistry as the probes penetrate the surface, breaking through any barrier layers.



Bond pads showing contact probe penetration

SIMS

Secondary Ion Mass Spectrometry uses a focused, monoenergetic, chemically pure ion beam of typically 1-10 keV to sputter erode the surface under analysis. Ionized secondary particles are then analyzed and detected in the mass spectrometer. At very low ion beam currents analysis is confined to the top few monolayers – excellent for detection of surface contamination. If the ion beam is scanned in a raster pattern over the surface, a spatially resolved image can be recorded. Thus the spatial distribution of an element can be mapped.

As the ion beam dose is increased and sputtering becomes more aggressive, subsequently deeper layers are exposed and concentration as function of depth can be determined. SIMS is the most sensitive surface analysis technique with detection limits in the low ppb for many elements.

A flood of low energy electrons is used during analysis of insulating samples, such as glass, to prevent the buildup of surface charge.

The analysis presented here was made using the Hiden SIMS workstation, a complete and highly flexible quadrupole SIMS/SNMS instrument equipped with the IG20 gas ion gun, cesium ion gun and MAXIM SIMS/SNMS analyzer.

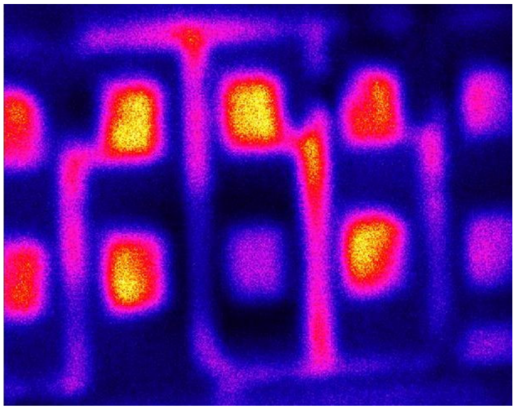
Imaging Analysis

The purpose of the analysis was to identify bond pads with non ideal surface chemistry which may lead to failure during the wire bond process. It had been noted from earlier mass spectral analysis that generally the surface contained significant fluorocarbon contamination and this was the most likely cause of failure.

Using 5keV Cs^+ primary ions focused into a 25µm spot of less than 2nA, mass resolved images of ^{27}Al were collected. The Hiden Elemental Surface Map (ESM) software has provision for fast single frame collection, ensuring that the ion dose is maintained near to the static SIMS limit. Images can be collected with a wide range of pixel density, from 100x100 to 4000x4000, with separate control of the pixel dwell time and data rates of over 3000 pixels per second.

The MAXIM secondary ion analyser can collect ions from an area of up to 6mm diameter, although, in this case, the images were confined to regions approximately 800µm across in the region of the row of bond pads.

The image below shows the bond pad area at a resolution of 500x500 pixels. The bond pads are approximately 80µm across and show up clearly, together with some of the wiring interconnect.



SIMS Mass Resolved Image (^{27}Al) of Bond Pads

Towards the centre of the image a bond pad is clearly visible with significantly lower surface concentration of Al than those around it. Similarly, the two other pads at the extreme right of the picture also show a lower signal.

Using the image for navigation, it was possible to collect mass spectra from these pads to compare with that from the 'normal' pads. The spectra confirmed that there was a significantly higher fluorine contamination on the pads sufficient to obscure the metal, most likely residue from a reactive ion etch step earlier in the IC fabrication process.

CONCLUSION

Imaging SIMS is the ideal tool with which to investigate the distribution of very thin surface layer contamination. Operated with sufficiently low beam current density and a high sensitivity analyzer like the Hiden MAXIM, it is possible to collect images with top monolayer specificity. This is vital when addressing bonding and adhesion issues as it is that uppermost monolayer which will interact with other components.