Application Note #000382

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XPS, SO-DIMM, Measurements,
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Quality Control

Real World Device Inspection Application with EnviroESCA

This application note introduces EnviroESCA as a tool for real world device inspection for microelectronics. A printed circuit board was taken directly from the sales packaging and was investigated with XPS. The measurements concentrate on the crucial parts like contact surfaces and soldering joints. EnviroESCA and near ambient pressure XPS (NAP-XPS) in quality control applications aims to optimize manufacturing processes and device quality in general.

Motivation

The inspection of fully assembled printed circuit boards with X-ray photoelectron spectroscopy for quality control of automated assembly lines is not an easy task. First of all the sample needs to fit the sample plate, second the sample needs to be vacuum compatible, when using conventional XPS systems, third the sample needs to be properly grounded to prevent charging of the components or the coating. EnviroESCA overcomes these restrictions as will be explained in the following.

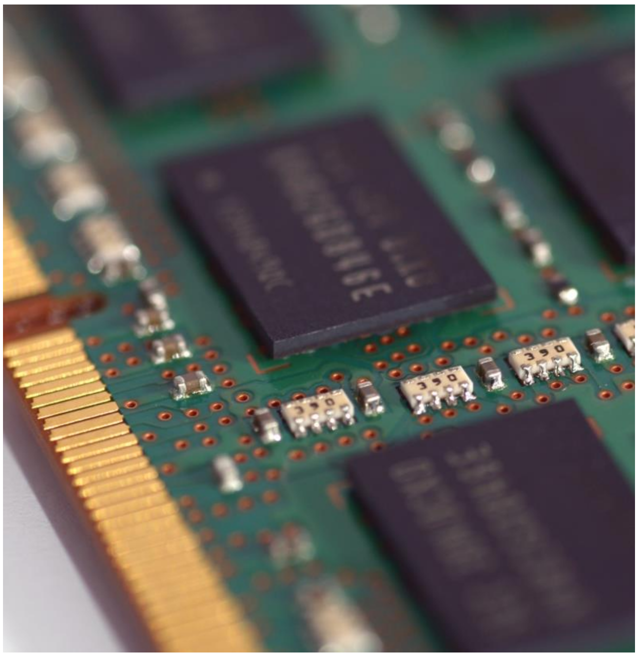

Fig. 1 SO-DIMM PCB used in this analysis

Method

EnviroESCA utilizes X-Ray Photoelectron Spectroscopy (XPS) as its main analytical technique.

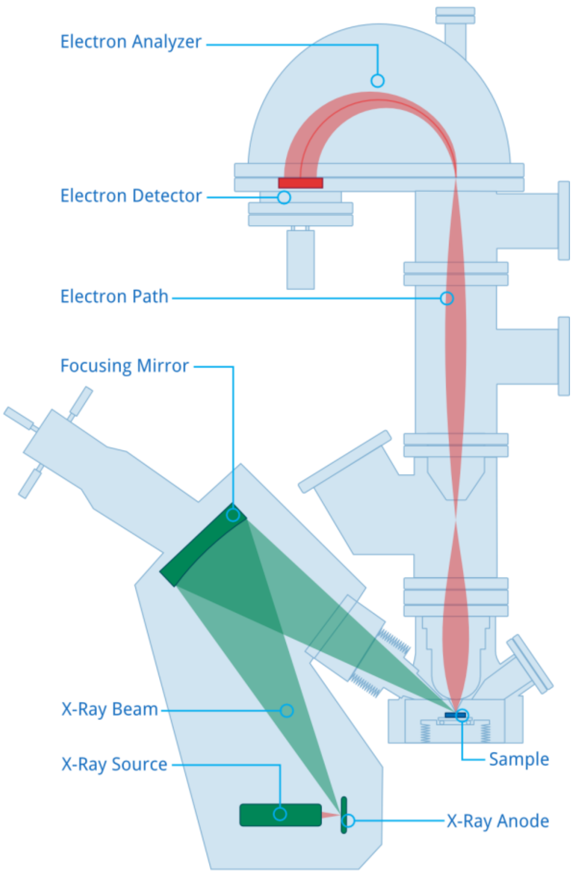

Fig. 2 XPS with EnviroESCA

Hereby an electron beam is generated inside the X-Ray Source and focused onto a X-Ray Anode made of Aluminum. The deceleration of the electrons on the anode leads to the production of X-Rays. This X-Ray beam is monochromated and focused onto the Sample. Due to the interaction between the photons and the atoms and molecules on the surface electrons with specific kinetic energy are released. Thereby only electrons from atoms within a depth of approx. 10nm are able to leave the surface. These electrons travel through the lens system of the Electron Analyzer into the hemisphere which acts as a spherical capacitor forcing the electrons onto circular paths with radii depending on their kinetic energy. The electron paths end at an electron sensitive detector where the electrons are amplified and measured as an intensity in counts / second. Sweeping the voltage of the spherical capacitor while measuring the number of electrons per second on the detector results in a photoelectron spectrum. From these spectra the amount of atomic material on the surface can be calculated.

Experimental Section

With EnviroESCA one can overcome the restrictions of conventional XPS systems easily as it accepts samples up to 120mm in diameter (60mm diameter is addressable). EnviroESCA can easily work in atmospheres up to several dozen of mbar vacuum compatibility is not a problem. Environmental Charge Compensation allows to analyze parts and contacts on the PCB without any means of additional charge compensation with flood electron sources or low energy ion sources. Also masking, contacting or painting with carbon or electrical conductive coating is not needed.

Because XPS is a non-destructive technique these inspections can be performed without influencing the performance of the investigated device.

Results

In the following raw measurement data is presented that was taken on different position on a SO-DIMM PCB board. The board was taken with bare hands from its sales packaging and was placed on the EnviroESCA sample plate. The data has been taken on non-sputtered surfaces the same way as it would be the case in a quality control application on a production line.

1. Inspection of the gold contact bar

The contacts of a printed circuit board modules are the connectors to the surrounding electrical system and therefore play a major role in the functionality of electronic devices. The quality and purity of these gold coatings ensure the operability and durability of the module. The spectroscopic performance of EnviroESCA in XPS allows for a non-destructive quality control of these platings as the detection limit for surface impurities is extremely low. Even the lowest amount of metallic impurities can be detected.

Figure 3 shows the view through the main sample positioning camera of the EnviroESCA. This camera is being used to navigate on the sample surface to select regions of interest where the XPS measurements will be performed. A pilot laser passing through the lens system of the electron energy analyzer indicates the measurement position and helps the user to address the desired region on the sample.

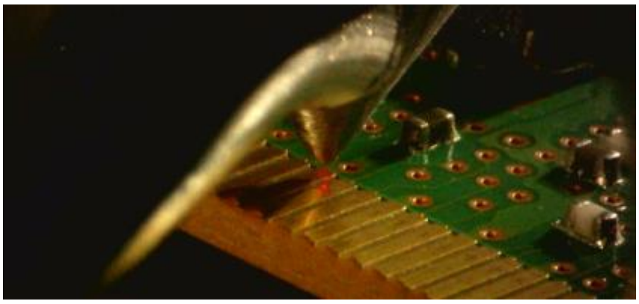

Fig. 3 View onto the analysis area on a gold contact

Figure 4 presents a detail spectrum of the gold 4f region. The FWHM of the Au 4f7/2 peak of only 0.55eV is not only a performance value for the energy resolution of EnviroESCA but also an indicator for the build quality of the SO-DIMM PCB itself.

With the high precision sample stage and the automated software user interface line scans across the PCB can easily be programmed. The following figure shows the result of a line scan over three gold contacts. Note that this is not a chemical contrast between two different metals on a surface but a real world sample with a pattern of metallic surfaces and insulators.

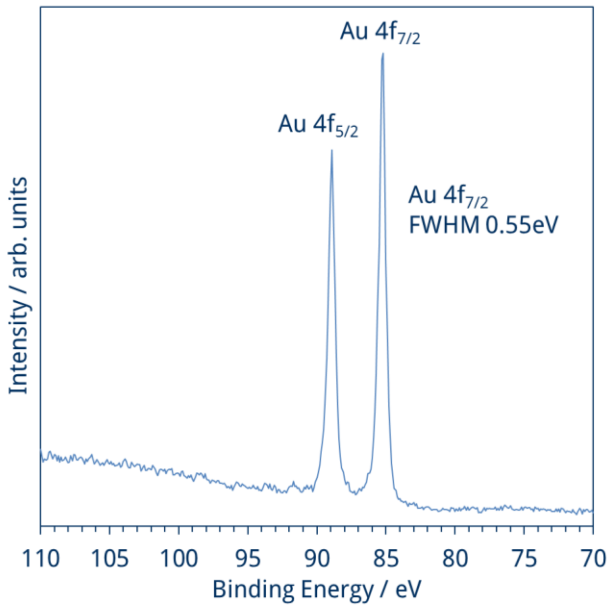

Fig. 4 Detail XPS spectrum of the Au 4f region

In EnviroESCA the spot size of the X-ray source is matched to the acceptance area of the analyzer which is given by the diameter of the nozzle used for differential pumping. In the standard configuration this results in a spot size of below 200 micron. From the manufacturers specification sheet one knows that the width of the gold plated areas are 450+-0.03 micron and the spacing is 150 micron which can clearly be observed as shown in the line scan in figure 5.

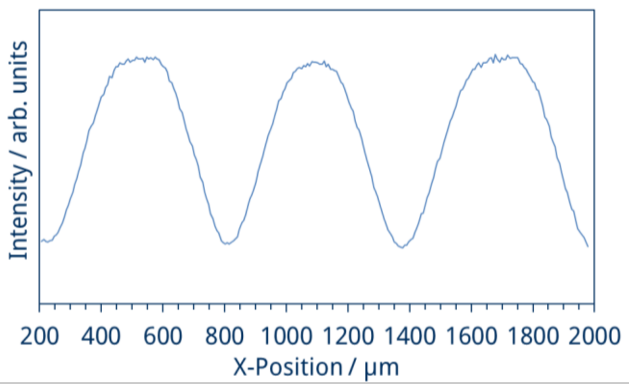

Fig. 5 Line scan across three gold contacts

2. Inspection of a soldering joint on a SMD component

Another crucial part on the PCB are the soldering joints between the PCB and the electrical components. XPS can be used to investigate the quality of soldering joints for process optimization.

For the inspection of a soldering joint a capacitor on the PCB was chosen.

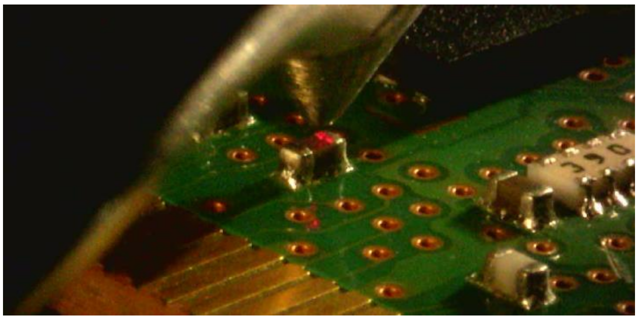

Fig. 6 Analysis position on the soldering joint

The following figures show the XPS signals taken in the Tin and Oxygen region of the photoelectron spectrum.

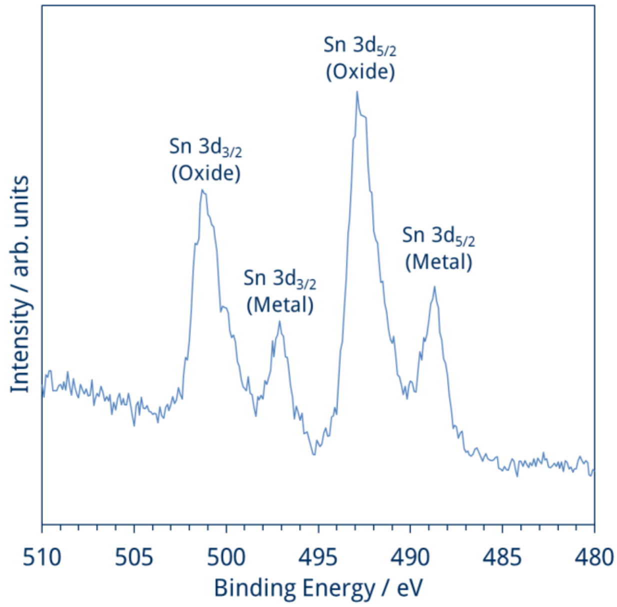

Fig. 7 Detail XPS spectrum of the Sn 3d region

In the high resolution scan displayed in figure 7 two different component in the Tin peaks are noticeable. The low energy peaks belong to electrons released by metallic Tin whereby the higher energy peaks belong to Tin in an oxidized state.

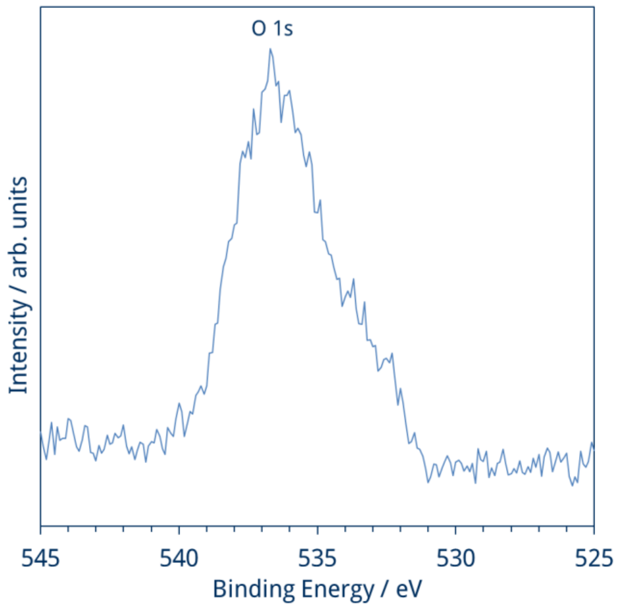

Fig. 8 Detail spectrum of the O 1s region

The oxidation of the Tin is also visible in the Oxygen peak displayed in Figure 8. The peak results from two different peak structures in the Oxygen peak

3. Inspection of the PCB coating

The solder resist covering the PCB ensures that solder is only taken by areas that needs to take solder and that no insulating areas are exposed to the surrounding atmosphere to prevent corrosion of the contacts or vias and to prevent short-circuits with other metallic parts, wires or cables.

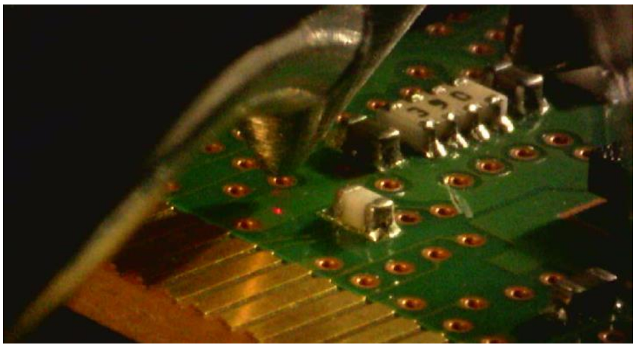

Fig. 9 Analysis area on the coated PCB

Because of the Environmental Charge Compensation of EnviroESCA when working in higher pressures even large insulating surfaces can be analyzed without any further masking, metallic coating or contacting.

Figure 10 shows a XPS survey scan taken on a coated area of the PCB.

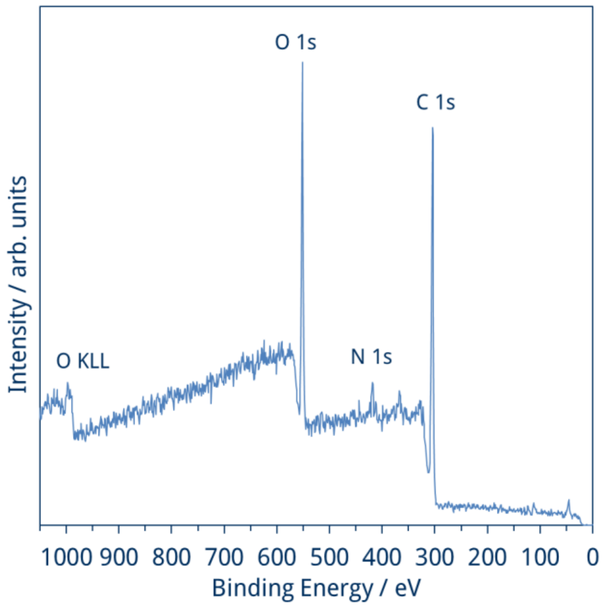

Fig. 10 Survey XPS spectrum of the coated PCB

Conclusion

With EnviroESCA it is possible to investigate the manufacturing quality even of fully assembled PCBs on an everyday basis. The resolution and sensitivity of the machine makes it a powerful tool in quality control processes.