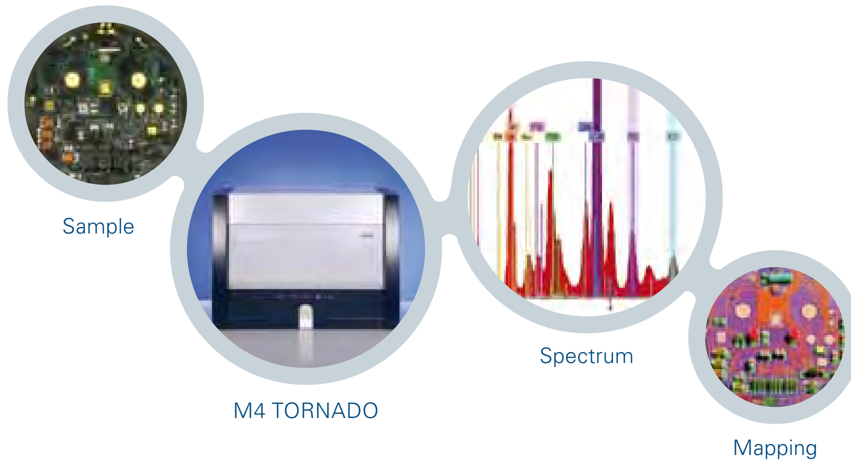

Lab Report XRF 447

Distribution analysis of electronic components

Nowadays the use of electronic components is widespread and includes various consumer goods. In most cases they are assembled on printed circuit boards (PCB). Both components and PCB can be manufactured with toxic elements like Cr, Br, Cd, Hg or Pb. When these products are recycled, the contained toxic elements can be released and pose a potential environmental hazard. Therefore several regulations like RoHS or WEEE limit the amount of toxic elements in consumer products. The examination of RoHS compliance is a very important analytical task. But also the correct composition and coating of contacts and solder points require continuous monitoring to assure product quality, using a fast, non-destructive and sensitive analytical method even for large samples. Micro-X-Ray fluorescence (µ-XRF) analysis is a very powerful tool for this task.

The sample

The examined PCB is from a digital watch and is shown in figure 1. The size of the PCB is approx. 32 x 35 mm.

Instrumentation

The measurements were performed with a Bruker M4 TORNADO. This µ-XRF spectrometer is characterised by the following features:

- Large and evacuable sample chamber of 600 x 350 x 260 mm (W x D x H)
- Fast X-Y-Z-stage with TurboSpeed for fast mappings and distribution analysis on-the-fly

- Effective excitation of fluorescence by high brilliance X-Ray tube together with X-Ray optics for concentration of tube radiation to spot sizes down to 25 µm
- Detection of fluorescence radiation with Silicon-Drift-Detectors (SDD) with high count rate capability
- Quantification by standardless models by use of full pattern fitting

Measurement conditions

The sample was measured with the following excitation conditions: 50 kV, 600 µA. Measurements were performed with a pixel distances of 80 µm. Measurement time per pixel was 5 ms. 100 µm pixel distance produced a grid size of 320 x 350 pixels, which resulted in a total measurement time of approx. 20 min.

Measurement results

Analytic data was accumulated with HyperMap, i.e. the complete spectrum was saved for every pixel. Therefore data evaluation can be performed after acquisition with a wide variety of options.

Sum Spectrum

It is possible to sum up the spectra of all pixels. This gives an overview of all elements in the sample and can be used for first estimations. This sum spectrum of the examined PCB is shown in figure 2. It can be seen that this PCB contains several uncritical elements but also some toxic elements like Cr, Br and Pb.

Sample

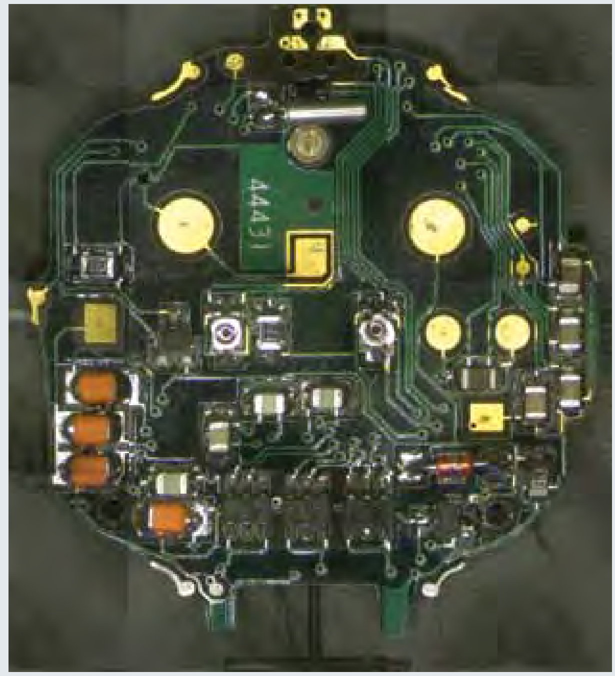

Fig. 1 Image of the analysed PCB

Element distribution

The PCB contains a large number of electronic components of different elemental composition, which is also reflected in the sum spectrum. The distribution of the main elements is shown in figure 3. The distribution of toxic elements shown in figure 4 gives an overview of the distribution of Cr, Br and Pb.

Sum spectrum

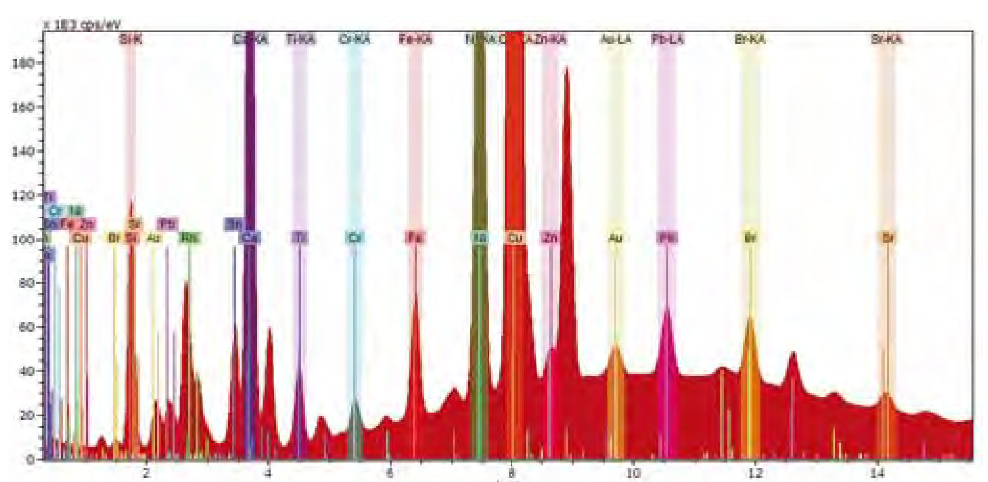

Fig. 2 Sum spectrum of the complete HyperMap

Distribution analysis

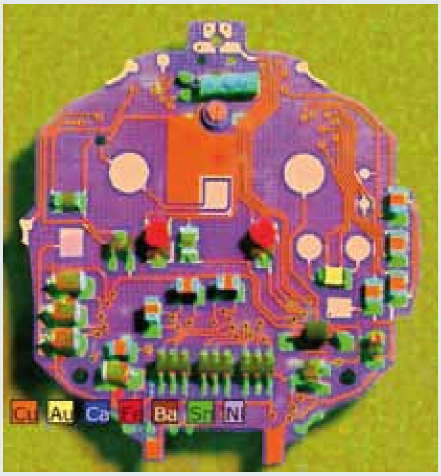

Fig. 3 Elemental distribution of main elements

Distribution analysis

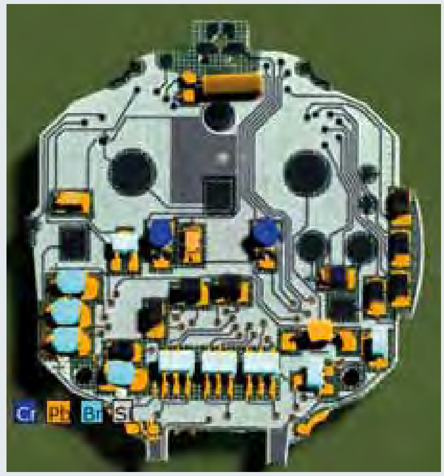

Fig. 4 Elemental distribution of toxic elements

Distribution analysis of scattered radiation

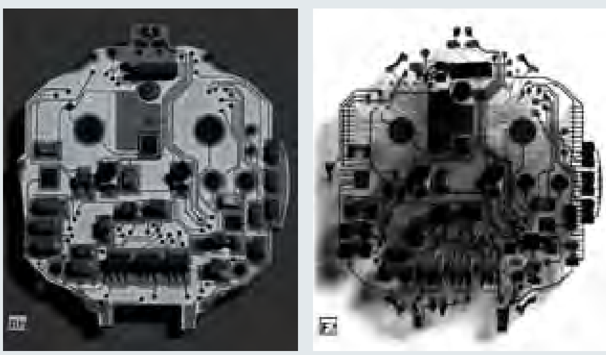

Fig. 5 Distribution of scattered radiation for the Rh-L radiation (surface scattering, left) and the Rh-K radiation (Compton scattering, right)

The availability of a complete spectrum for every pixel allows further examinations of electronic components. For instance, tube radiation will be scattered within the sample. This offers the possibility to use this radiation also for the characterization of the sample. If low energy radiation is used only the surface of the sample can contribute to the distribution image. On the other hand in case of higher energies the radiation penetrates the sample and will be scattered in deeper layers. This can be seen in figure 5. The Rh-L tube radiation with low energy (2.7 keV) gives information about the composition on the surface and Rh-K with higher energy (20.2 keV) also shows structures on the backside of the sample.

This offers an interesting view inside the sample: the Rh-L-radiation gives a contrast both for topology effects and for different elements, the scattering of X-rays depends on the atomic number of the scattering material. The Rh-K-radiation penetrates the sample and will be scattered on deeper layers of the sample and the acrylic stage.

Distribution of single elements

The distribution of single elements can be displayed in different colours and overlaid as shown in figures 3 and 4. This offers the possibility to examine which elements are at the same location – like Cu with Ni and Au on contacts or Cu with Sn and Pb on soldering points. It also offers the possibility to examine the different elements in the components on the PCB. Due to the measurement of several pixels on areas of identical composition it is also possible to sum up the spectra as a basis for quantification. This is shown in figure 6 for a soldering point of the three components in the lower part of the PCB. The spectrum of that point shows Cu, Sn and Pb. The spectrum has good statistics and allows the calculation of both composition and thickness of the SnPb-layer with 6.3 µm and a Sn-content of 68 %. That means this PCB is not RoHS compliant.

But also some other elements that are permissible in concentrations below 1000 ppm (Cr and Br) are present in the sample with concentrations higher than this limit, as it can be seen from the distribution in figure 4.

Analysis of single components

Another interesting question is the non-destructive analysis of single components, for example the correct bonding between lead frame and chip. This is shown for an integrated circuit. The measurements were performed on an area of

Sum spectrum

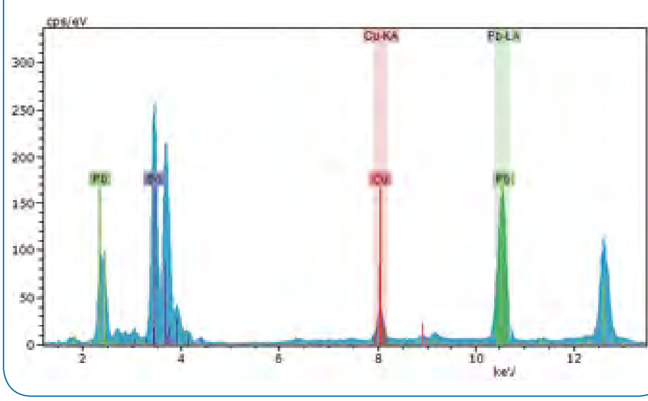

Fig. 6 Spectrum of a soldering point on the PCB

IC sample and Distribution analysis

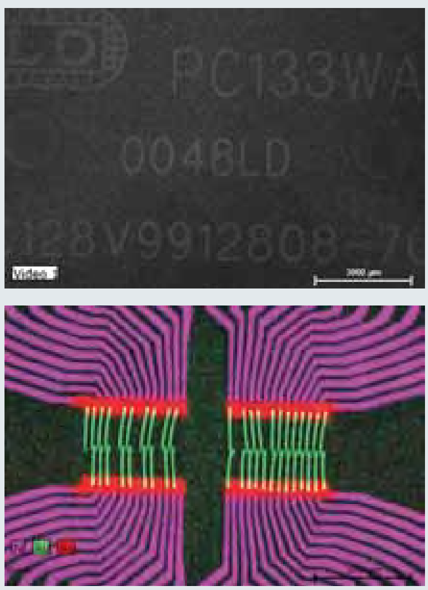

Fig. 7 Image of an IC and the elemental distribution of Ni, Ag and Au that shows the lead frame together with Au-bonding

13.2 x 8.8 mm with a step size of 30 µm for 5 ms per pixel. That results in a total measurement time of approx. 15 min. Figure 7 shows both, the image of the coated IC and the distribution of Ni, Ag and Au.

From that distribution it can be seen that the lead frame is made of Fe coated with Ni. An Ag coating can be found at the end of the lead frame. These points are connected with an Au-bond wire to the wafer. The wafer apparently seems to be made of Si. This cannot be detected because low energy radiation will be absorbed in the IC's plastic cover.

Conclusions

The examination of electronic components with µ-XRF can provide a lot of important information about the composition of a complete printed circuit board but also of single components. This can be used for

- the determination of the elemental distribution of several elements,
- the control of RoHS elements and the compliance for every component,
- the quantification of specific areas of the sample for coating thickness determination or for the compositional analysis of special components,
- the non-destructive examination of IC by measuring the high energetic fluorescence radiation.

HyperMap offers the possibility for accumulation of spectra from larger areas. They have better statistics and can be used for quantification. This offers the possibility to perform analyses for coating thickness testing or for RoHS compliance. µ-XRF has limits of detection that are sufficient for that application (only for Cd the LOD is close to the concentrations allowed by RoHS).

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