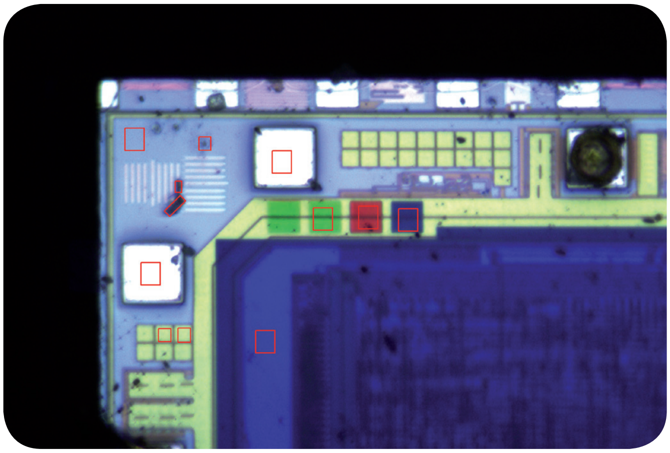

Application Note AN M106

Analysis of a CMOS Chip Circuit Board Using the stand-alone FTIR Microscope LUMOS II

Introduction

The analysis of electronic devices is a complex task since modern systems are highly miniaturized and composed of all kinds of different materials. Especially the identification of contaminations which are often microscopically small is of particular interest as they can lead to malfunction of the electronic device. Knowledge about the chemical composition will in most cases reveal the origin of the contamination and therefore allow effective troubleshooting. Fourier-Transform-Infrared (FT-IR) microscopy is an attractive tool for the analysis of very small structures down to the micrometer range and is capable of identifying not only organic but also inorganic components.

FT-IR microscopy is a well-established method for the analysis of samples that are too small or complex to be measured in a standard IR-spectrometer. With FT-IR microscopy it is possible to obtain an IR-spectrum of very small structures with a very high lateral resolution and thereby revealing the chemical composition of an very defined part of the sample. Therefore this technique is a useful tool for contaminant analysis, quality control or forensic and bio-medical applications to name only a few.

Figure 1: Stand-alone FT-IR microscope LUMOS II.

So far most of the commercially available FT-IR microscopes need an additional FT-IR spectrometer which increases both cost and required lab space. Furthermore they are quite complex to use and require a high level of skill. With the FT-IR microscope LUMOS II (see fig. 1) Bruker offers a space saving, fully automated stand-alone solution that is very easy to use.

Instrumentation

The LUMOS II is an all in one solution with an integrated spectrometer, a high degree of motorization and a dedicated user-interface. Its 8x objective provides the measurement modes ATR, transmission and reflection and high quality visual inspection capabilities. The innovative motorized Attenuated Total Reflectance (ATR) crystal allows performing the complete measurement procedure fully automated including background and sample measurements. A high working distance and the unobstructed access for the sample stage facilitate an easy positioning of the sample. The large field of view of 1.5 x 1.2 mm and the high depth of focus make sample inspection very comfortable. In combination with a motorized stage, fully automated mappings can be performed.

The dedicated OPUS Video-wizard is guiding the user through the whole measurement procedure and always provides the appropriate functions for the current measurement step.

Application example: Identification of contaminations on a CMOS chip of a digital camera

Contaminations have a negative impact on the product quality; especially in the field of microelectronics impurities are an extremely important topic. Since electronic devices are getting smaller and smaller they are also becoming increasingly vulnerable to all kinds of contaminations.

In our first example we analyze a CMOS image-sensor that shows contaminations on both the border and the active sensor matrix. Especially the contaminations on the sensor matrix can have quite dramatic effects on the image quality and it is therefore vital to track down the source of the contamination.

Both areas were visually inspected using the video camera that is integrated into the LUMOS II. For direct chemical analysis the motorized ATR-crystal was used. Figure 2 shows a contamination that is directly located on the Bayer-matrix of the image-sensor. The Bayer-matrix is a color filter array that can be found on most imaging sensors in order to generate color images. It consists of red, green and blue color filters with twice as many green elements as red or blue to mimic the physiology of the human eye. In our example the single filter dots have a diameter of ca. 3 µm and it can be seen that there are two different rows, one type consisting of alternating red and green dots the other one consisting of alternating blue and green filter-dots.

A clean area of the chip was analyzed and the spectrum was identified by a library search as "Poly(methyl methacrylate):Butadiene". Figure 3 shows the measured spectrum colored red together with the blue spectrum from the library search. Obviously, the filter matrix is covered by a polymeric layer. The green colored spectrum of the contamination can be seen on top of figure 3 together with the corresponding library spectrum (dark blue). The contamination was identified as a polyamide, most probably from a biological source or from a synthetic aliphatic polyamide like for instance nylon.

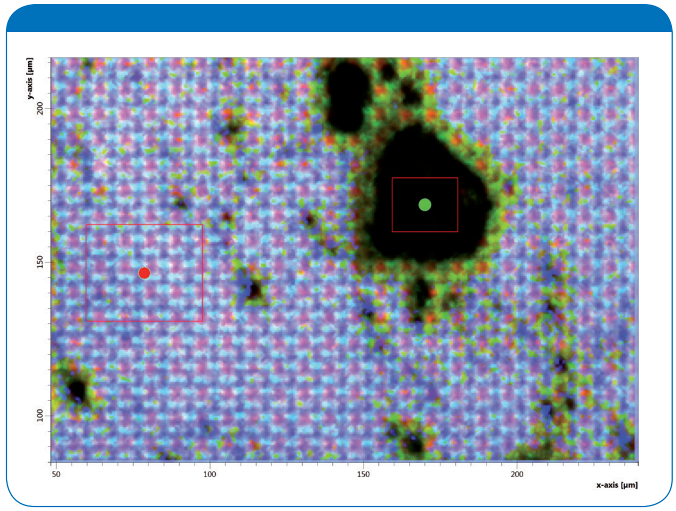

Figure 2: Visual image of the image sensor made with the zoom function of the LUMOS II-camera. The typical Bayer-matrix is visible; the matrix dots are about 3 µm in diameter. Apertures are indicated by red boxes. Settings: 38x32 µm and 21x17 µm.

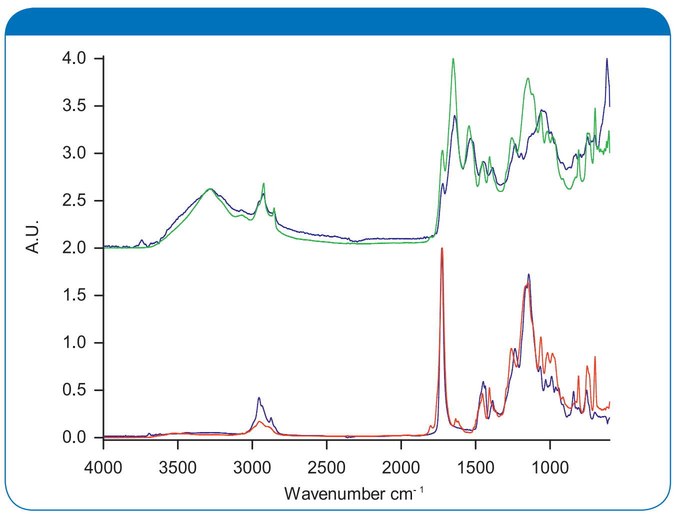

Figure 3: Spectra of the contamination (green spectrum on the top) and the Bayer-matrix (red spectrum at the bottom) both with corresponding library spectra.

Figure 4 shows the corner of the chip with rather complex structures including wire contacts from which two are unused. An analysis of altogether twelve measurement points shows that most of the spectra are similar to the green spectrum shown in figure 5. This spectrum is almost equal to the one already measured on the clean Bayer-matrix. Therefore we can conclude that a transparent protective polymer cover was applied on the whole chip since all the optically different positions have a similar spectrum. There are only two exceptions, the first ones are the two rectangular contact areas (a) both showing no absorptions over the whole mid-infrared range which indicates clean metal surfaces (see red spectrum in figure 5). The other exception is the contamination in the upper right from which two spectra were collected (b). The resulting spectra had still some contributions of the polymer-background which were subtracted before the library search was performed. The resulting spectrum (blue in figure 5) is again a typical polyamide/protein spectrum similar to the one already observed on the sensor area.

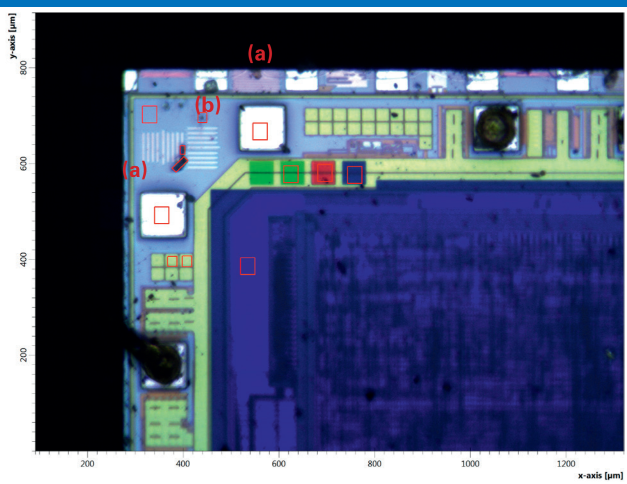

Figure 4: Corner of the CMOS imaging-chip with the measurement positions indicated as red frames.

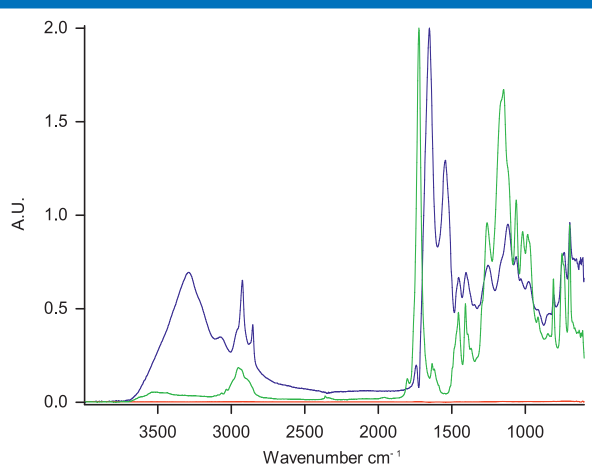

Figure 5: Spectra measured on the frame of the imaging chip. Green: Spectrum of the polymer coating present on most of the measurement points. Blue: Spectrum of the contamination. Red: Spectrum of the blank metal contacts

Material and contamination analysis of the circuit board

Additionally to the CMOS-chip a gold contact on the circuit board with the surrounding structures was analyzed (see fig. 6). Figure 7 shows the color coded spectra of the measurement points. The topmost spectrum was measured on a small dark contamination located on the gold contact which shows again a typical polyamide spectrum. Interestingly, the apparently clean gold surface is showing distinct absorption lines that are resulting most probably from a lipid film covering the contact. This finding shows that even contaminations that are undetectable in the visible image can be discovered by using FT-IR spectroscopic methods.

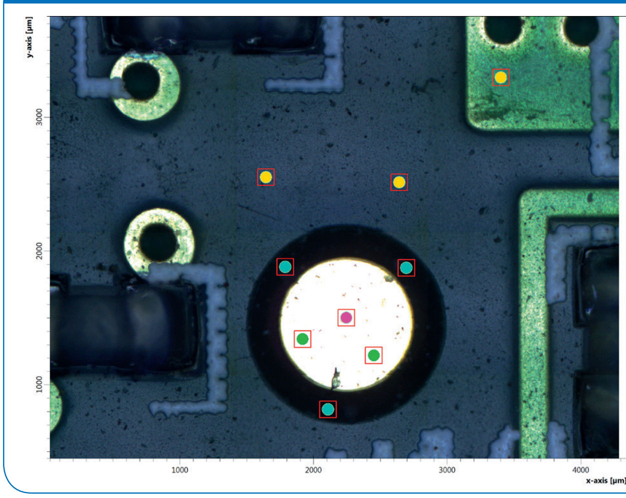

Figure 6: Section of the circuit board with gold contact and different measurement points.

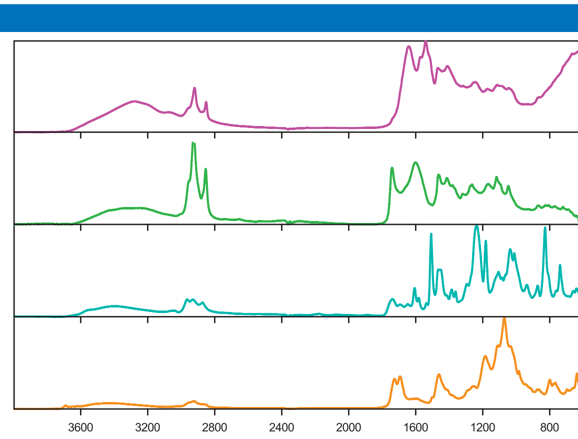

Figure 7: Spectra measured on the circuit board with colors according to figure 6. From top: Polyamide contamination, lipid, epoxy-resin and silicone based solder resist.

The black ring around the gold contact exhibits a spectrum that is typical for an epoxide resin which is likely the uncoated base material.

The spectra measured on the orange measurement positions are all very similar and originate from the silicone based solder resist coating that covers most of the circuit board.

Summary

The new LUMOS II FT-IR microscope is a compact and fully motorized stand-alone FT-IR microscope with a low cost of ownership. Its dedicated software guides the user through the microscopic analysis step-by-step allowing even inexperienced users to operate the system. The fully automated procedure of both sample and background measurements for all measurement modes including ATR saves precious working time.

In combination with the built in library search function it is feasible to quickly identify even unknown samples. Its comfortable use and high performance make the LUMOS II an ideal instrument for the analysis defects and contaminations in various electronic devices. Besides the visible and chemical characterization of contaminations a wealth of material related information can easily be gathered even on very small and complex samples. Also similar analytical questions like inclusions in polymers and rubbers, defects in mechanical parts and contaminations in pharmaceutical products can be solved quickly without method specific skills.

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