The electronic component authenticity verification

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Abstract. The article presents a brief insight into the university research of efficient methods aimed at revealing counterfeit electronic components. Methods like multichannel curve tracing, component internal structure X-raying, system on chip optical inspection with higher magnification microscopy and Scanning Electron Microscopy combined with Element Energy Dispersive Spectroscopy (EDS) are powerful means for authenticity verification. Comparative analysis results serve as an illustration of cases where various features differences can warn not to let a particular component delivery penetrate the assembly process.

1. Introduction

The problem of counterfeit electronic components appearance in assemblies where lifetime and reliability represent besides functionality the crucial parameters is not new. A massive incidence became conscious at the millennium beginning, and the problem is still topical. Because of that, both the refinement of existing counterfeit detection methods and the search for new applicable methods is needed. The legal aspect of counterfeit component appearance in any delivery is very difficult to solve if there does not exist a traceability record to find original supplier/manufacturer to claim compensation from in such cases. Nevertheless, the legal aspect and cost recompense claim are less important than to prevent counterfeit electronic component entering the assembly process [1][3]. That is why the analytical methods assisting component authenticity assessment are of higher importance. The goal of all analytical methods development is to determine any component feature susceptible to counterfeiting technology which always differs from the original one. As counterfeiting anonymous subjects are continuously refining their technology, it is necessary to keep up with it in analytical methods, too. Special multichannel curve tracers, optical microscopy, X-ray devices, decapsulating equipment and delidding tools are time-proven requisites for component authenticity assessment nowadays. However, the analytical methods group for authenticity testing is an open system eager to adopt any new efficient and affordable method. There are many testing laboratories offering tests for component authenticity. Even many reputable suppliers of electronic components have established their own component testing laboratories. They assume responsibility for electronic component authenticity in every delivery marked with something like a “Counterfeit free delivery” label.

Having chosen the topic of electronic components authenticity verification methods as one of our experimental research projects, we also established the laboratory for testing electronic components authenticity about 5 years ago. We strive to refine the current methods portfolio and supplement it with other prospective procedures and affordably available equipment. We focus especially on discrete

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semiconductor components and on integrated circuits. We cooperate with local companies and we collect experience with our respective methods abilities. As a by-product, we are extending our collection of suspicious and provably fake components, and we use them also as teaching aids. Our testing facilities comprise a 256 channels curve tracer, an X-ray device, a fiber laser for decapsulation, a final wet etching workplace, a scanning electron microscope (SEM) with Element Energy Dispersive Spectroscopy (EDS) module, an optical microscopy workplace comprising of a polarization microscope, of a stereo microscope and of a confocal microscope.

2. Component evaluation experience example
In course of our recent components samples authenticity evaluation, we have gained some other interesting experience. We would like to present the test of ATmega329 single chip microcontroller with in-system programmable flash. The ATmega329 is an in active production component widely used for various applications. The samples produced for inspection were referred as failing in application quite often. We obtained samples removed from the application module, some of them were functional the other failed to function in the application module. The ordering party provided also some unused samples belonging to the same delivery set. However, there was no trustful reference sample set produced together with other samples. We used as reference the trustful components from our laboratory stock. The immediately visible difference was the component marking position asymmetry as you can see in figure 1.

![Fig 1. Reference and Test component marking position comparison.](image)

The second difference was detected during X-ray inspection [4]. The sample micro-bond wires were displayed thinner than at the reference components. The expected reason had two variants. As the reference components had gold micro-bond wires, the first possibility was that the samples had the same wire material but smaller diameter.

| Material    | Symbol | Density         |
|-------------|--------|-----------------|
| Aluminum    | Al     | 2712 kg/m³      |
| Copper      | Cu     | 8940 kg/m³      |
| Gold        | Au     | 19320 kg/m³     |
| Palladium   | Pd     | 12160 kg/m³     |
| Silver      | Ag     | 10490 kg/m³     |
The second possibility was the other material than gold, namely less dense because material density influences the X-ray contrast. The component internal structure of both reference and test component seen in X-ray device shows apparent difference in micro-bond wires thickness (see figure 2). As we can see in table 1, gold is the densest material among current materials used for micro-bond wires.

**Fig 2.** Reference and Test component X-ray comparison.

After revealing micro-bond wires with fiber laser decapsulation equipment, the analysis with SEM extended with Element EDS module confirmed the assumption based on X-ray analyses. Unlike the reference components, the evaluated samples do not have the gold micro-bonding wires. Their micro-bonding wires base on copper covered with a thin layer of palladium. Both figure 3 and figure 4 show SEM picture and EDS spectrum corresponding consequently with gold micro-bonds for the reference component and the copper covered with palladium micro-bonds for the test component.

**Fig 3.** SEM and EDS of ATmega329 with gold micro-bonds.
**Fig 4.** SEM and Element EDS of ATmega329 with Cu-Pd micro-bonds.

**Conclusion**
The difference in micro-bond wires material as such may, but there again it may not mean that test components are counterfeits. The micro-bond Cu-Pd wire alternative is quite common for the series production both of new and of many currently active components. Nevertheless, components package marking shift and curve tracer analysis results (not published here) are indicating at least suspicious features and behaviour [2][5]. Curve tracing, AKA Analog signature analysis (ASA), even revealed the test component parameters instability in the loop mode. That is very useful especially for obsolete component authenticity verification. The component package base and additive material composition is another feature for comparison with reference component as well as chip, bonding wires and pins.

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