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Motor Control Power Transistor Authenticity Analysis

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Abstract
The range of genuine electronic components both in active production and out of active production (obsolete) corresponds almost exactly with the range of fake components we can encounter on the market in common. Most risky deals are price “attractive” purchases via internet or from unknown sources via many resellers having no traceability to present to the customer. One such situation relates to our recent analysis of power MOSFET transistors assembled in a motor control application. Our goal was to reveal if transistor samples presented to us are bearing features of counterfeiting activities. The procedure applied for genuine origin assessment encompassed the optical analysis of component package marking, X-ray analysis, and IV characteristic comparison with reference component as well. The paper brings description of evaluation steps and a conclusion as well. The article accompanies illustrating pictures and diagrams.

INTRODUCTION

Terms of our authenticity analysis

The reported problem relates to transistors with a sudden failure during operation. Those transistors were from a new supplier implemented immediately in the assembly. Samples for testing were in two transistor model groups presented as IRFB7437 by International Rectifier and 4PP04L03 presented as Infineon. Both transistors have the TO 220-3 non-hermetic package. There were no reference samples for comparison supplied together with samples for analysis. We decided to purchase three reference samples of each model from creditable trustful components suppliers in Czech Republic. We inspected the purposeful reference components as well, and we compared them with introduced samples to find out incidental differences. The reference samples and samples for assessment passed optical inspection for the visual appearance of package marking layout, logo graphics and the symbol coding of model specification and the batch code. The package marking technology was in focus as well. X-ray study of internal structure was a little bit more complicated because in front view, the metal plate at TO 220 package screens the X-rays off the chip and bonds. The side view provides a satisfactory idea about contacts, chip dimensions like thickness, length and angle deviation. The chip angle abnormal offset from the standard position is recognizable by the sample holder tilting. The curve tracing represents a very helpful method for detection of I-V characteristics differences caused by counterfeiting. The curve trace cycling in about 20 cycles could bring useful information about I-V characteristic variation or stability in time. That curve trace cycling has turn out in many other situations where the single scan looked acceptable. However, the loop cycling revealed clearly the unacceptable instability of behaviour.

SAMPLE ANALYSIS

Optical study of samples

The component package marking can show a lot of useful information for component samples classification. In general, component marking includes the manufacturer logo, component designation, batch number, manufacturer locality, year and week of manufacture, and at times, also the production line symbol. The marking layout is also an important object to study. The accessible component datasheets do not frequently include the detailed marking specification and symbols decoding comment.

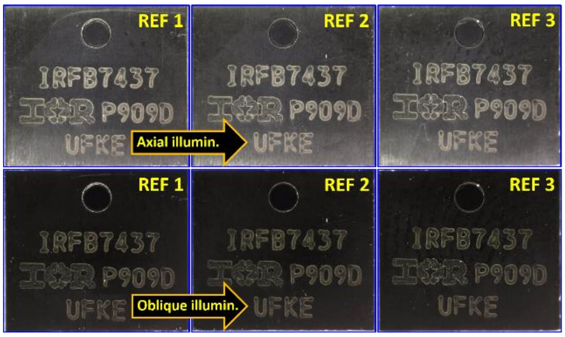


Fig. 1: Reference samples of IRFB7437 visual comparison in axial and oblique illumination.

That is why the reference component is very important for every analysis. As mentioned above, we have procured our own reference components for both transistor types from the local trustful component suppliers. Three reference samples per transistor type seemed enough for us to be able to see possible differences. Fig. 1 and Fig. 2 display the optical comparison of all three samples in each reference group. All three references samples evidently come from the same production batch according to the marking code. The technology of marking and the marking layout including logo design are same as well so that no suspisious optical clues are noticeable.

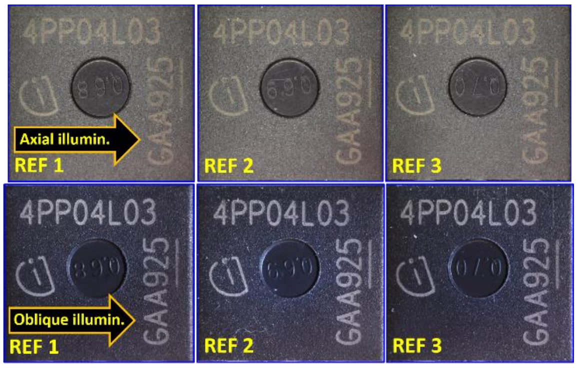


Fig. 2: Reference samples of 4PP04L03 visual comparison in axial and oblique illumination.

The reference sample REF 1 visual comparison with power transistors samples result is in Fig. 3, Fig. 4 and in Fig. 5.

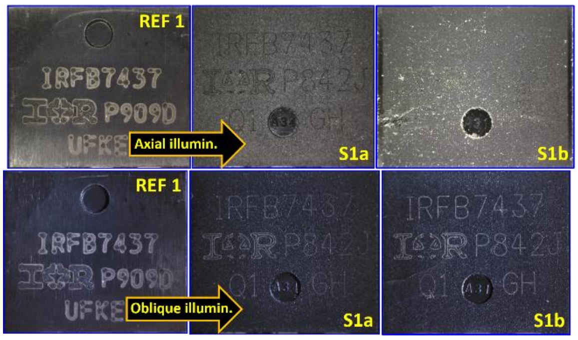


Fig. 3: The batch Q1GH samples visual comparison.

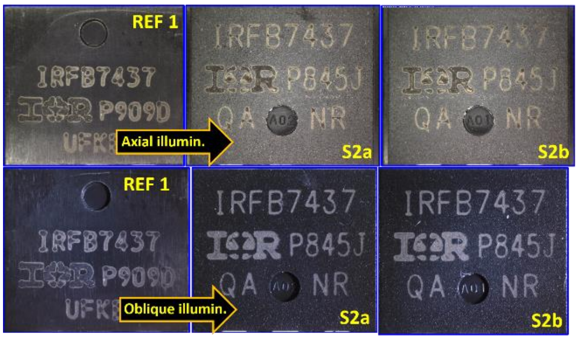


Fig. 4: The batch QANR samples visual comparison

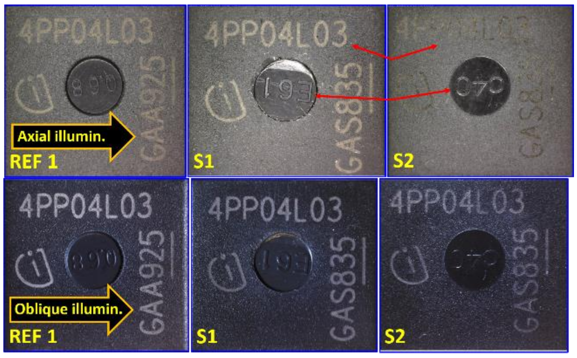


Fig. 5: The 4PP04L03 samples visual comparison.

The red arrows in Fig. 5 show the suspicious difference in the indent mark symbols shape. Unlike the sample ***S1*** where the symbol has a flat contour, the sample ***S2*** has a round contour. Fig. 6 shows a detail of that difference.

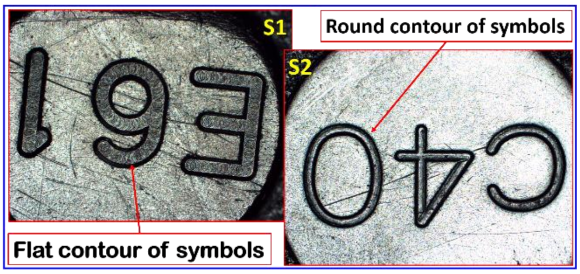


Fig. 6: Remarkable difference in symbols countour.

X-ray study of samples

The X-ray analysis for TO220 component package is more complicated because of integral metal base plate. It shadows the chip and bond wires in frontal view. Nevertheles, the side view can help to check both the chip *y* coordinate offset and the angle offset from the standard position. That was our case because all samples ***S1a***, ***S1b***, ***S2a*** and ***S2b*** have the angle offset about 30 degree from the parallelism to the package edges.

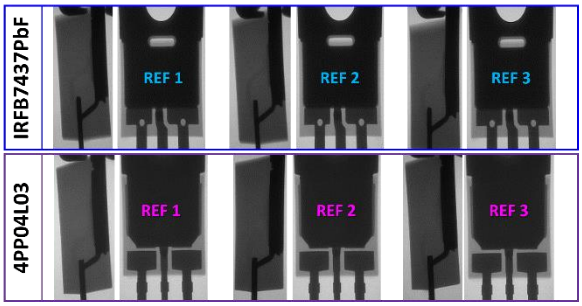


Fig. 7: The X-ray view from the frontal and from the side view for both groups of reference components.

The internal structure comparison of all reference samples both front and side views illustrates Fig. 7 and Fig. 8. There are no deviations noticeable for all reference components in X-ray images.

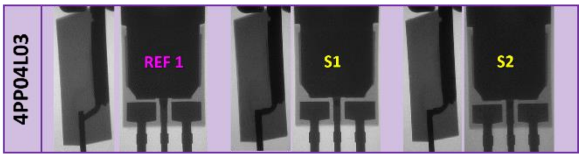
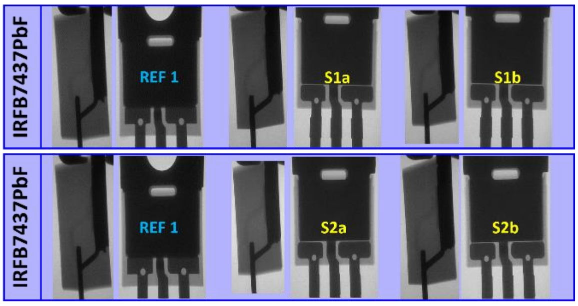


Fig. 8: The X-ray view of 4PP04L03 comparison.

The comparison illustrated with Fig. 9 does not show any remarkable diffrences in lead frame design. Only detailed side view revealed the blurred chip thickess edges what is a typical sign for chip position angle offset. That offset angle is measurable indirectly with sample holder tilt rotation counter offset angle until the chip adges are sharp displayed. That angle difference between related X-ray images is circled in Fig. 10. The “thumb up” symbols mark the chip sharp edge X-ray image.



Fif. 9: The X-ray view of IRFB7437 comparison.

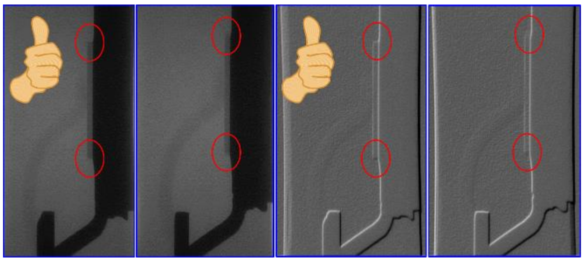


Fig. 10: The X-ray view comparison of horizontal and angled position of the IRFB7437 analysed samples.

ASA – Analog Signature Analysis

The method of curve tracing known also as Analog Signature analysis represents a very helpful tool in component authenticity analysis. The component pin I-V characteristic comparison of various pin pair combinations between an authentic component and a component for verification is mostly very sensitive to counterfeiting process. It is especially true when we repetat the cycles watching the results stability and repeatability. In any component pin pair, there is one a reference pin and the second one is tested relatively to the reference what asignemnt could be also swapt. The I-V plot of a pin is called its “pin-print”. In following figures, we illustrate both our ASA test results for reference components and the comparison results for tested components. The reference IRFB7437 component pin-prints without a set tolerance range are in Fig. 11. The importance of cycled scan illustrates Fig. 12 where the sample ***S1a*** single scan result is not indicating anything uncommon. However, the results of ***S1a*** sample loop scan in Fig. 13 are signalling the irregular failing behaviour what is evidently unacceptable for any application. The sample ***S2a*** is failing even in both scan modes as you can see in Fig. 14 and in Fig. 15. The test results overview table for a single scan provides just an immediate situation snap. Incidental changes exhibit, either by launching single scans successively or by setting the number of loops.

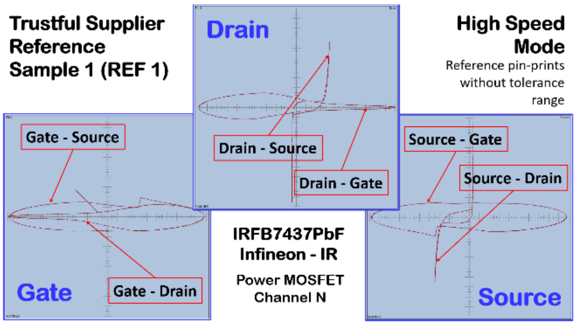


Fig. 11: The pin-prints of the IRF7437 reference sample REF 1 still without tolerance range.

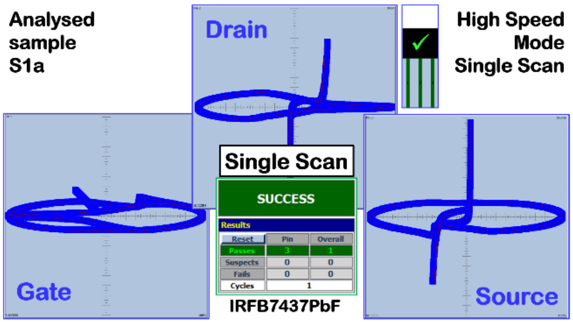


Fig. 12: Sample ***S1a*** pin-prints with single scan result table.

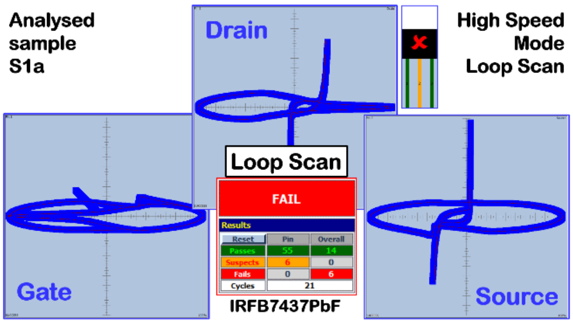


Fig. 13: Sample ***S1a*** pin-prints with loop scan result table.

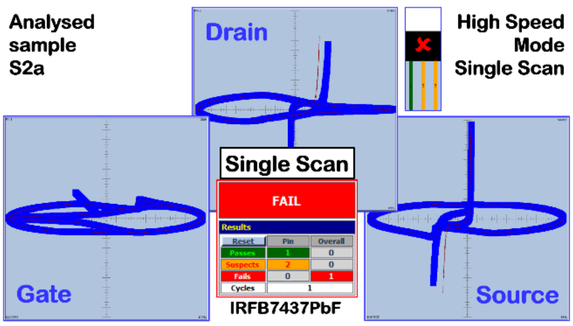


Fig. 14: Sample ***S2a*** pin-prints with single scan result table.

The tolerance range stting is possible set from ±0.1% up to ±5% in steps of 0,1%. For most cases, the highest tolerance range of ±5% is a sufficient choice.

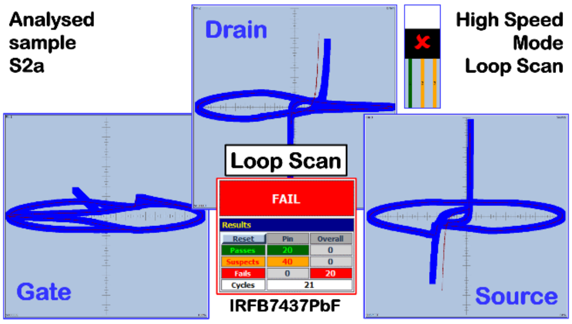


Fig. 15: Sample ***S2a*** pin-prints with loop scan result table.

Fig. 16 represents the instability for three samples in loop mode of 20 cycles where sample 1a is from a different batch than samples 2a and 2b. Sample ***S1a*** seems to be OK for the single cycle mode, but it is apparently failing in the more demanding loop mode.

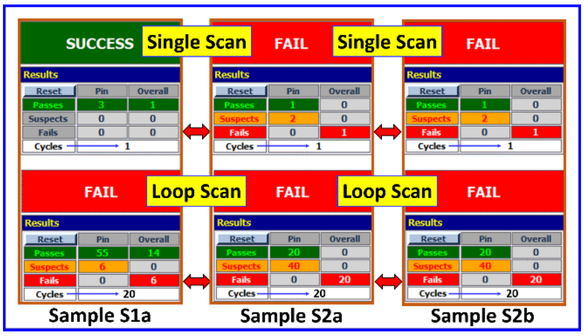


Fig. 16: Single scan mode and loop mode comparison for functional samples of the IRFB7437 power MOSFET N-channel transistor.

The second MOSFET transistor type was the P channel 4PP04L03 by Infineon as mentioned already previously. The tolerance range for ASA analysis was set uniformly ±5%. The other pin print evaluation criterion can be the number of acceptable suspect pins and/or failed pins. That criterion is not so important for authenticity analysis. The 4PP04L03 power MOSFET P channel transistor pin prints without tolerance range are in Fig. 17.

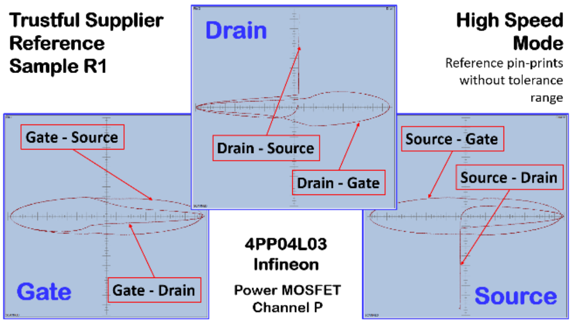


Fig. 17: Reference 4PP04L03 transistor pin prints before setting the tolerance range.

Fig. 18: Single scan mode and loop mode comparison for reference samples of the 4PP04L03 transistor

Fig. 19: Single scan mode and loop mode comparison for evaluated samples of the 4PP04L03 transistor.

Samples of 4PP04L03 transistor passed ASA test like the Fig. 18 and Fig. 19 are documenting.
In spite of differences in package marking, the analog signature analysis both in single scan and in loop scan mode does not reveal any discrepancy between reference and evaluated samples.

CONCLUSION

The power MOSFET transistor evaluation led to an adoption of new organizational measures in sake of counterfeit components risk mitigation in the company concerned. Unlike the delivery where the 4PP04L03 were from, that delivery of IRFB7437 transitors should avoid production assemblies. This reported case can serve as a warning not to risk to procure sensitive application components via other than proven internet brokers. The best electronic components suppliers are those certified for adoptet counterfeit avoidance mesures. The certified suppliers are testing all deliveries for counterfeits occurrence.

ACKNOWLEDGEMENT

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