SCREENING FOR COUNTERFEIT ELECTRONIC COMPONENTS

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ABSTRACT

Counterfeit products have been a growing problem worldwide, and the electronics industry has been no exception. Authentication of electronic components by electrical and physical testing can provide a cost-effective means of risk management, aimed at keeping counterfeits out of the supply chain.

In this presentation, we will review sources of counterfeit components, and discuss the capabilities and limitations of test processes used for authentication. We will then present examples of component authentication using these tools.

Keywords:
Counterfeit, Decapping, Delidding, Screening

INTRODUCTION

Counterfeit products of all types have been a growing problem for almost every industry sector in recent years, and the electronics industry has been no exception.

The counterfeit components market is driven by factors such as pricing, availability, and obsolescence. Components of questionable origin enter the supply chain from many sources, including:

Copies that are reverse engineered by a third party manufacturer

- Faulty components diverted from the scrapping process and from other sources
- Remarking of components
- Recycling of used components (generally not considered as counterfeit if the recycled status is disclosed by the seller)

Major Original Component Manufacturers (OCMs) have implemented improved anti-counterfeit labeling measures, and some countries have added stricter customs procedures.

Counterfeits continue to be a serious problem, however, for many components sourced from brokers in the secondary grey market. Authentication of these components by electrical and physical testing can provide a cost-effective means of risk management, aimed at keeping counterfeits out of the supply chain.

Many electrical and physical tests are available for detection of counterfeits, including:

Electrical Testing

Electrical tests for counterfeits can range from simple verification of resistance and capacitance, through complex full-functional testing of active components. Most CMs and third-party test labs are equipped for resistance and capacitance measurement. Many also have curve tracers, which can be useful for testing of discretes, especially when a known-good component is available for comparison.

Electrical screening of more complex components requires test equipment and programming expertise that is generally available only at the OCM, and some third-party test labs. This testing can add substantial expense to the screening process.

Visual Evaluation

Visual inspection is the front line of counterfeits screening. The printed part number is verified against the shipping documentation, and the date code validity may be checked using historical data and past experience with the supplier s products.

Counterfeiters often use a process known as black topping to place a different part number and/or date code on a component. A thin black epoxy coating is applied to the top of a component, and the surface is roughened to attempt to reproduce the original texture. The new part number and date code are generally printed in a font as similar as possible to the original.

The sides of the component and the topside color and surface texture are examined for evidence of black-topping. The surface of the round mold mark should be smooth, as compared with the rest of the component.

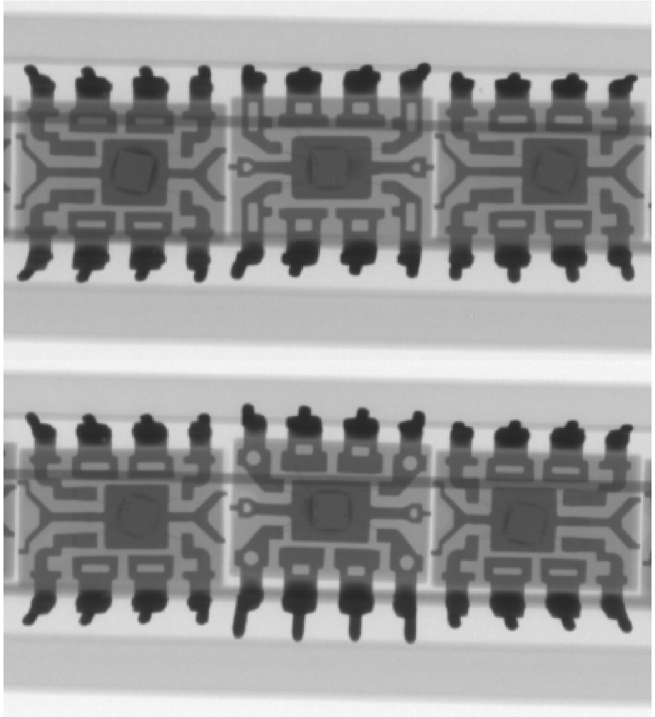
The analyst will then compare the font of the lettering and the manufacturer s symbology against a known-good part, if available. Marking permanency can be tested using a suitable solvent. The solvent test will often also begin to dissolve any blacktop coating that may be present, and remove the texture.

The component leads are inspected for evidence of damage, re-straightening and possible re-tinning. Various types of solderability testing may also be done at this point.

X-ray Inspection

X-ray inspection provides a non-destructive means for examination of internal characteristics of a component. The dimensions of the chip can be determined, and the bond wires and lead frame can be inspected. This information is especially useful if a known-good component is available for comparison.

If necessary, X-ray inspection can often be conducted without removal of the components from their packaging. All of the components in a shipment may be non-destructively inspected for any internal variations among the individual components. In some cases, the process can be automated using the step-and-repeat function provided in some operating software.



X-ray Inspection of Components in Packaging
Note That Components in Center Do Not Match Others

X-ray Fluorescence (XRF)

XRF provides a quick, non-destructive method to determine the alloy composition on the surface of the leads. This can be compared against original component specifications, and is also useful for verification of RoHS compliance.

Decapping / Delidding

The Decapping process uses an acid solution to etch an opening in the top of a plastic component to reveal the internal semiconductor chip and bond wires. Delidding is the cutting open of a metal package (typically a TO-type can), while leaving the chip and bond wires intact. This allows for full inspection and photographic documentation of the chip surface, including fab line ID numbers and symbology.

Component Screening Examples

In order to illustrate the use of these tests, we will consider examples of component screening analysis done at Process Sciences.

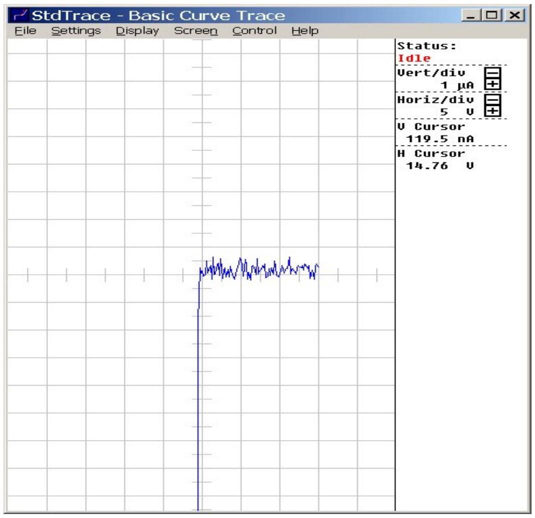
Example 1

Three 2-lead TO-46 metal can packages were received, consisting of one gold (known-good) part, and 2 sample parts to be tested.

Component As Received

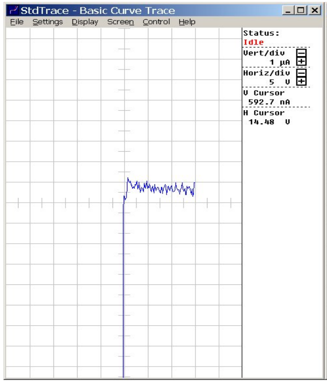
The appearance of the printing and symbology of the parts to be tested matched exactly with that of the *"gold"* part.

All three parts were then characterized by curve tracer, with results as show below.



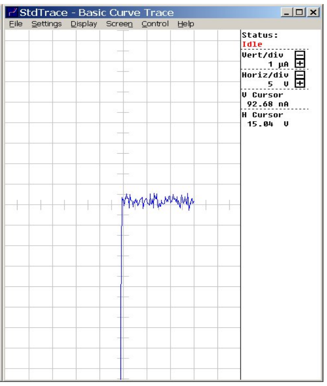
```
Status:
Idle
Vert/div
      1 µA
Horiz/div
      5  V
V Cursor
 119.5 nA
H Cursor
 14.76  V
```

"Gold" Base to collector



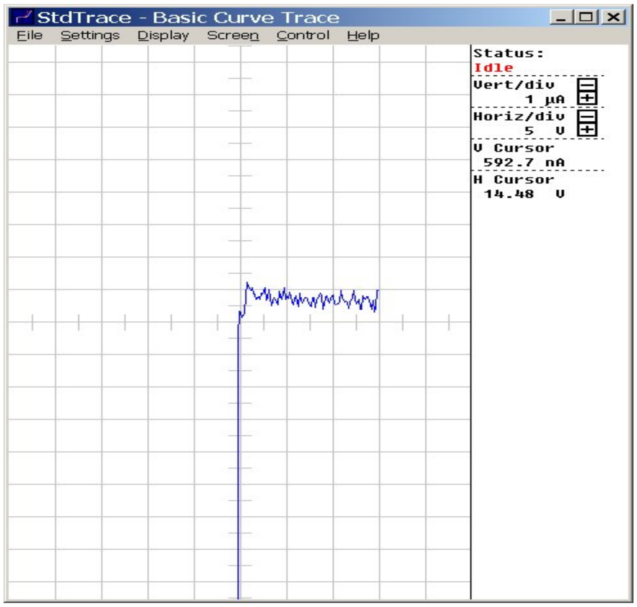
Status: Idle
Vert/div 1 µA
Horiz/div 5 V
V Cursor 592.7 nA
H Cursor 14.48 V

Sample 1 Base - collector



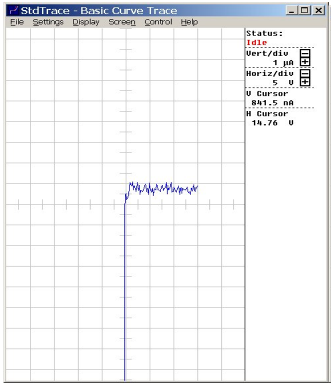
Status: Idle
Vert/div 1 µA
Horiz/div 5 V
V Cursor 92.68 nA
H Cursor 15.04 V

Sample 2 Base - Collector



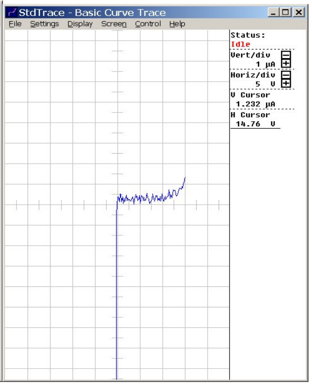
Status: Idle
Vert/div 1 µA
Horiz/div 5 V
V Cursor 592.7 nA
H Cursor 14.48 V

"Gold" emitter to collector



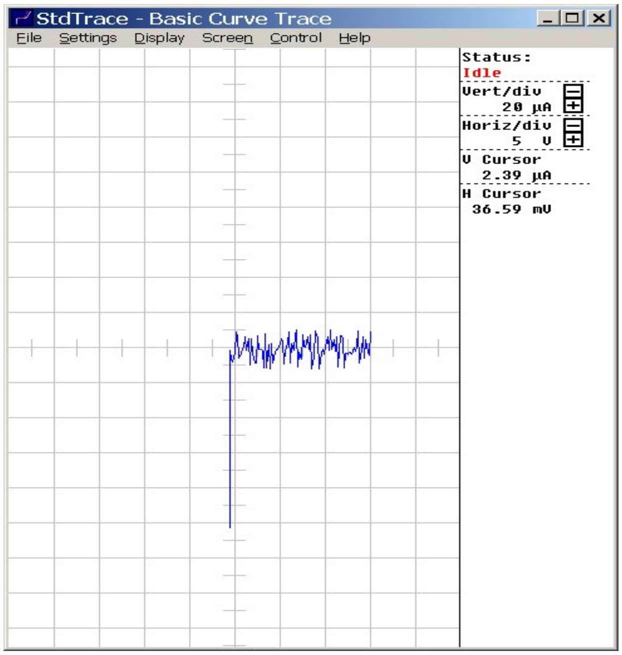
Status: Idle
Vert/div 1 µA
Horiz/div 5 V
V Cursor 841.5 nA
H Cursor 14.76 V

Sample 1 emitter - collector



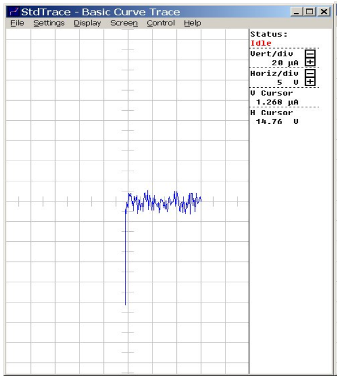
Status: Idle
Vert/div 1 µA
Horiz/div 5 V
V Cursor 1.232 µA
H Cursor 14.76 V

Sample 2 emitter - collector



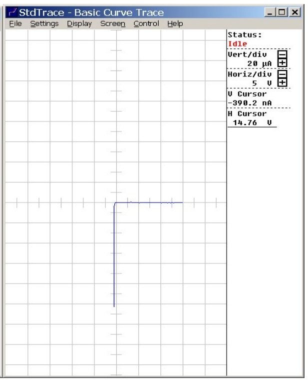
Status: Idle
Vert/div 20 µA
Horiz/div 5 V
V Cursor 2.39 µA
H Cursor 36.59 mV

"Gold" (base to emitter)



Status: Idle
Vert/div 20 µA
Horiz/div 5 V
V Cursor 1.268 µA
H Cursor 14.76 V

Sample 1 base - emitter

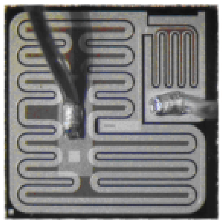


Status: Idle
Vert/div 20 µA
Horiz/div 5 V
V Cursor -390.2 nA
H Cursor 14.76 V

Sample 2 base - emitter

Sample part 1 was consistent with the gold part, but Sample 2 is clearly faulty, with high emitter to collector leakage, and open connection between base to emitter.

All three parts were de-lidded to examine the surface of the silicon chips. No part number or lot code markings were found on any of the chips. Surface coloration was different for all three, but circuit artwork was similar for all.



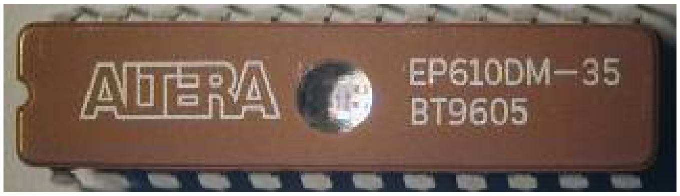
"Gold" chip

Sample 1 Chip

Sample 2 Chip

It was concluded that both sample parts were genuine, with sample 2 being an electrical failure.

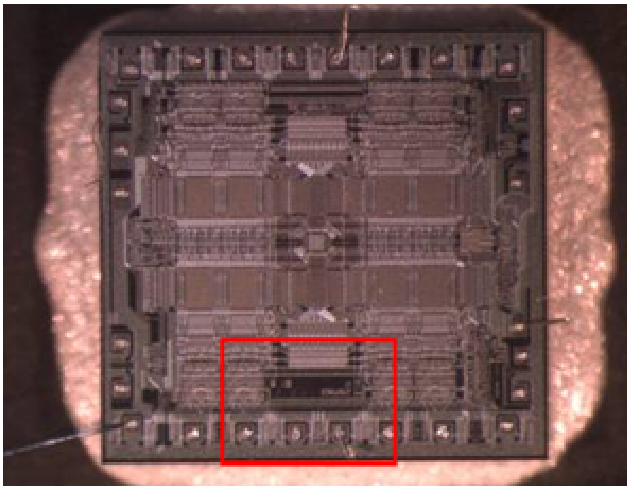
Example 2
Two plastic DIP packages were received for evaluation. No evidence was found of tampering, and the markings passed permanency testing.



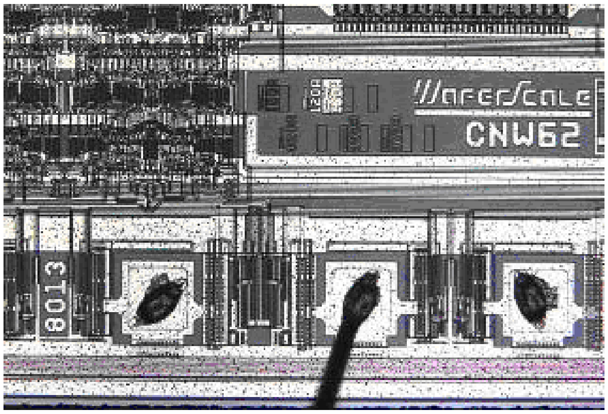
Component As Received

The packages were decapped in order to examine the surface of the Silicon chips. The chips were found to be almost identical, except for the area shown in the close up pictures.

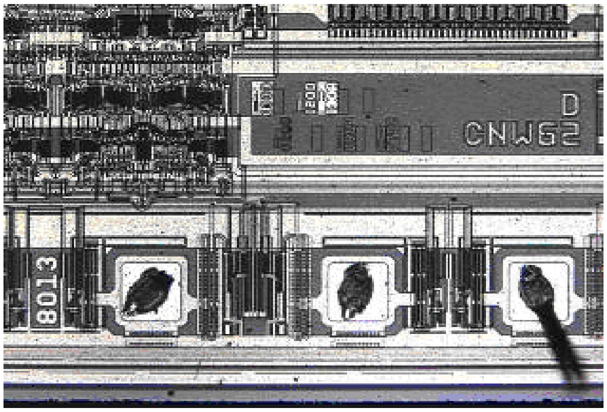
In package number 1, the chip includes *"*WaferScale*"* in the artwork, while the second chip has only the letter *"D."* This indicates that the chips are probably from different fabs or from different revisions. Ordinarily, packaging houses do not mix chips from different fab lines or different revisions without changing the lot code, as this practice compromises traceability.



Chip Surface



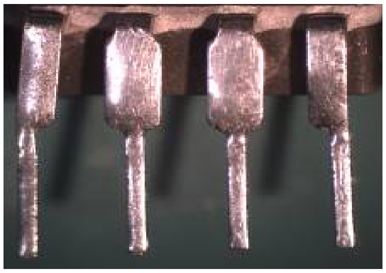
Package 1 Chip Marking Close-Up (Red Square)



Package 2 Chip Marking Close-Up (Red Square)

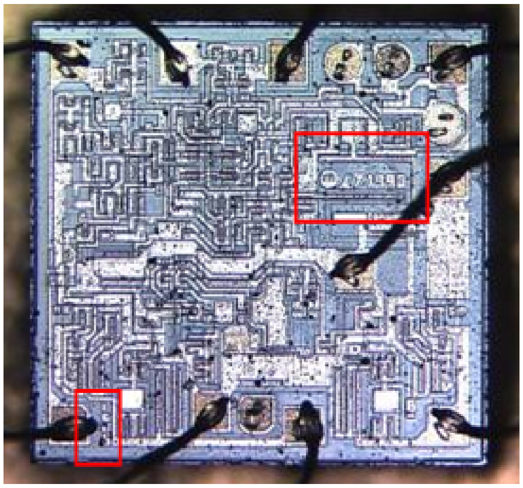
Example 3
One 8-pin DIP package was received for evaluation. The package markings passed marking permanency testing. However, the leads were non-uniform, with evidence of re-tinning.

Component Topside Markings

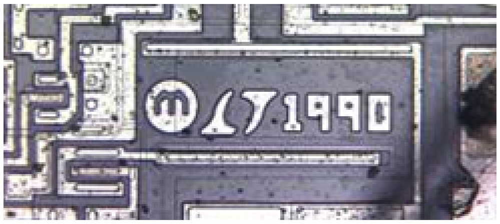


Component Leads

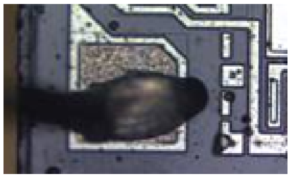
Following decapping, the chip manufacturer's logo, date code, and part number were identified. The first close-up picture shows a chip date code of 1990, and the second shows a chip ID of *"1016."*



Chip Surface



Chip Manufacturer Logo and Date Code



Chip ID Number

These correspond directly to an earlier Maxim part number LT1016, which was replaced with an improved part, designated AMX913. The data from the chip surface indicates that this part is an LT1016 that has been remarked to a MAX913.

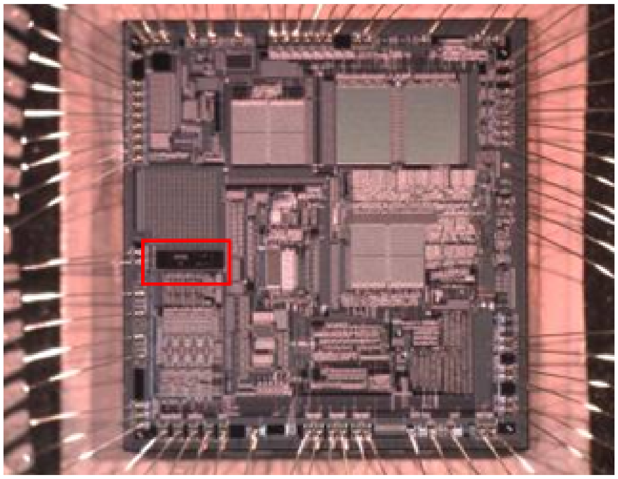
Example 4

Two 68-pin PLCC components were received for evaluation. Both parts had the same markings, etched into the top surface. Acetone removed the textured surface on both components, thus indicating that the parts have been black-topped and remarked.

Component As-Received

After Solvent Test

Following decapping, both parts were found to have the same chip, with the Philips logo, and the alpha-numeric marking *"*V83C592VO*"* which corresponds to a portion of the external part number marking. This appears to be the correct die for this part number.



Chip Surface

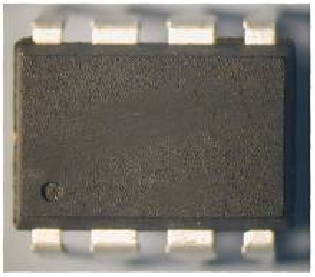
Chip Marking Close-Up (Red Square)

However, black-topping of the components indicates that the part has been remarked, possibly to alter the date code, or to show a different variant of this part type.

Example 5

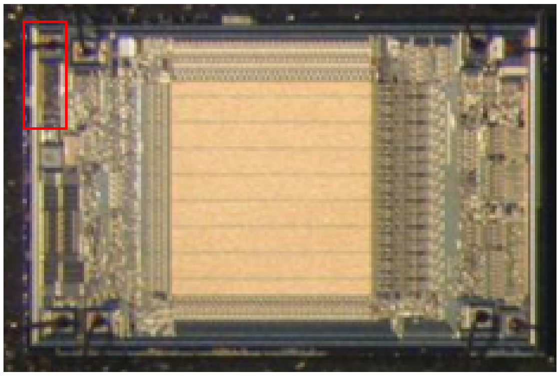
Two 8-pin DIP packages were received for analysis. Acetone testing completely removed all markings and the textured surface, indicating the part has been black topped.

Component As-Received

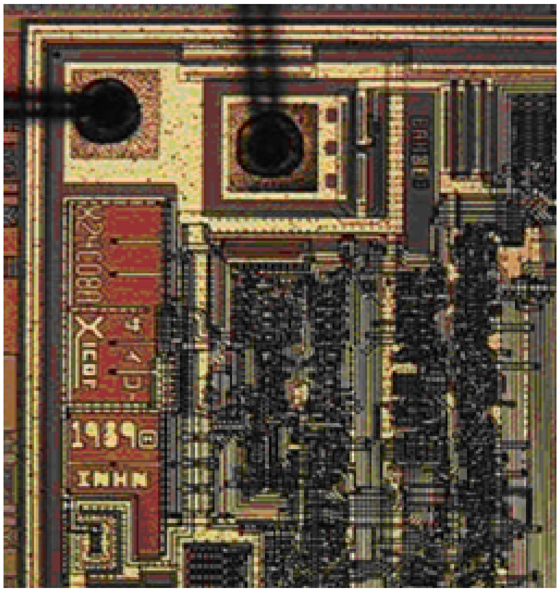


After Solvent Test

Decapping found that both components had identical chips, marked with the Xicor logo and the lettering *"X24C08A."*



Chip Surface



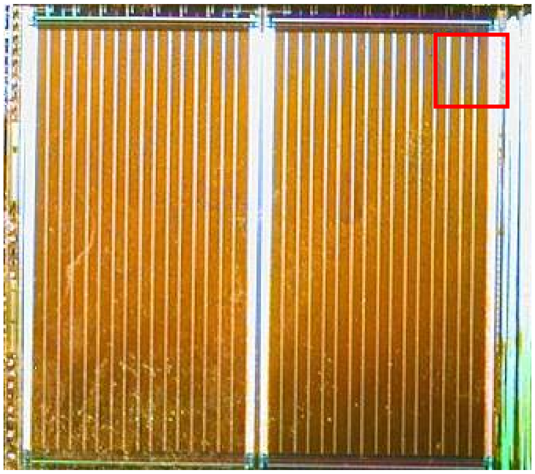
Chip Markings Close-Up (Red Square)

This marking partially corresponds to the external part number, so the remarking may reflect a different Xicor part number variant or date code.

Example 6
Two 48-pin TSOP packages were received for analysis. Both packages had the same markings (laser etched), and showed no signs of tampering.

Top Markings

Following decapping, both parts were found to have the same die.

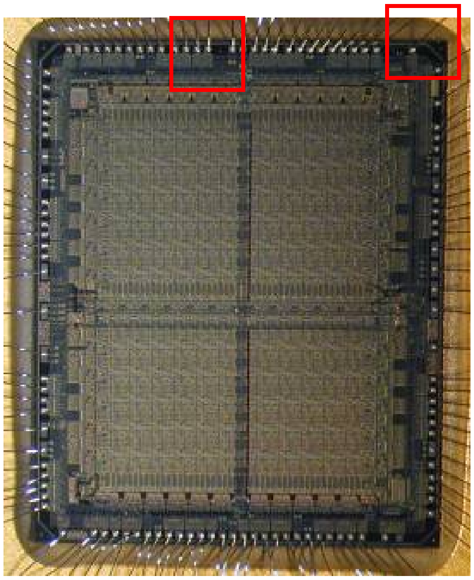


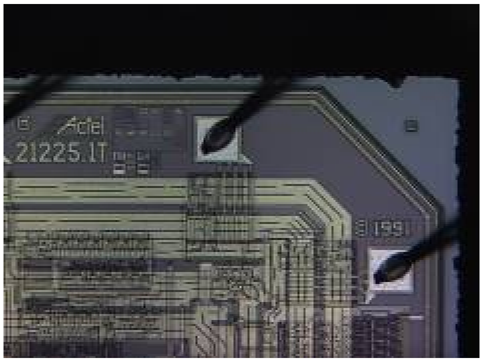
Chip Surface

Chip Markings Close-up (red square)

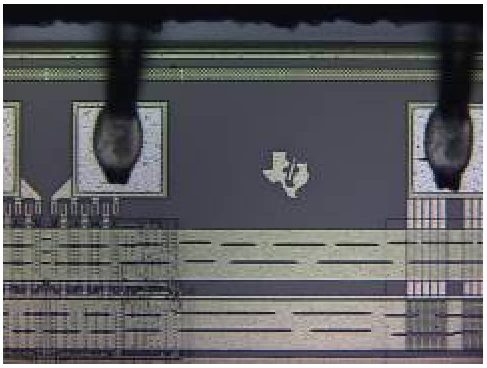
Close inspection revealed Samsung part number K9F5608U0A. This is a valid Samsung part number for 32M x 8 Bit NAND Flash Memory. The package marking (K9K1208UOA) is for 64M x 8 Bit NAND Flash Memory. These memory chips are 32M parts that have been remarked as 64 M.

Example 7
One 101-pin Ceramic PGA package was received for analysis. The package showed no signs of tampering, and part markings passed permanency testing.


Chip Surface



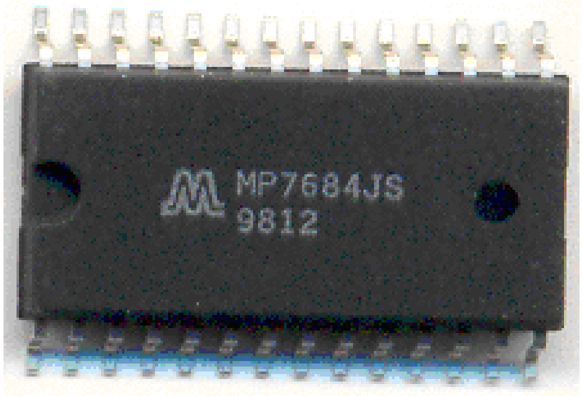
Top Edge Close-Up (Red Square)


Upper Right Corner Close-Up (Red Square)

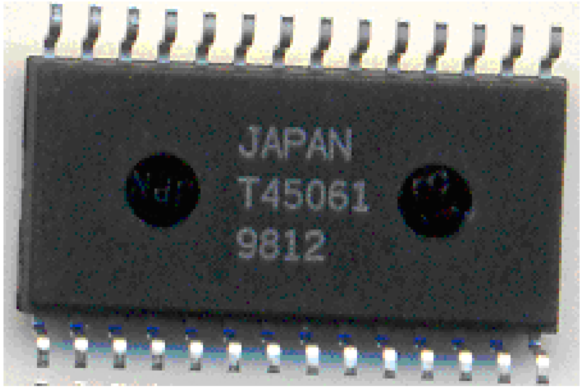
The alpha-numeric 21225 partially matches with the external component marking.

Die markings also include Actel and the Texas Instruments logo. TI manufactured ICs for Actel in the 1980 s, and sold the manufacturing operation to Actel in 1995. There are no indications that this is a counterfeit component.

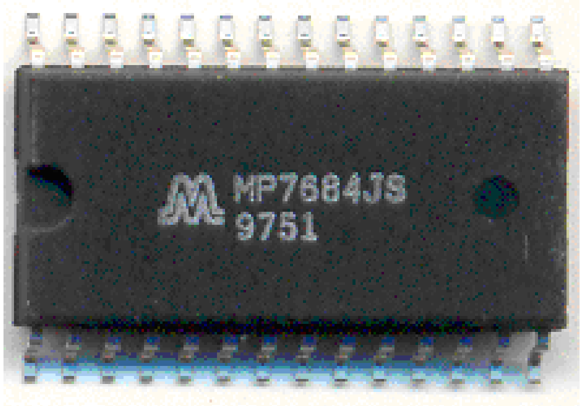
Example 8
Four 48-pin SOIC packages were received for analysis. There were two each of date codes 9812 and 9751.



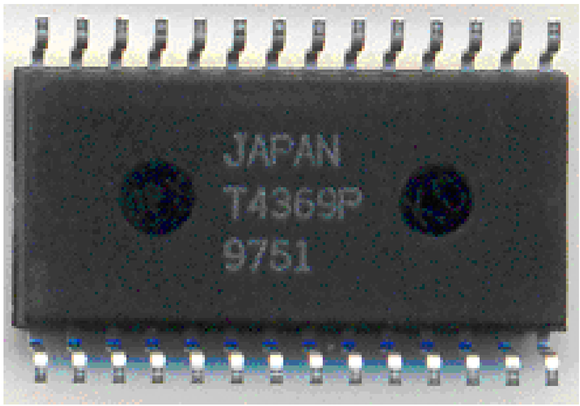
Date Code 9812 Top Side Markings



Date Code 9812 Bottom Side Markings



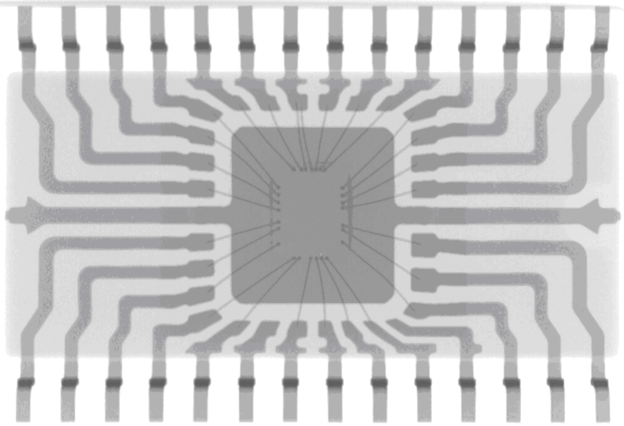
Date Code 9751 Top Side Markings



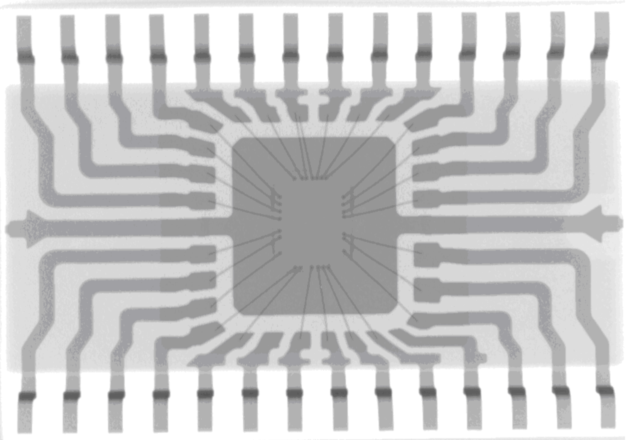
Date Code 9751 Bottom Side Markings

The packages showed no signs of tampering, and all part markings passed solvent testing.

X-ray inspection verified that the lead frames were identical, with all bond wires intact

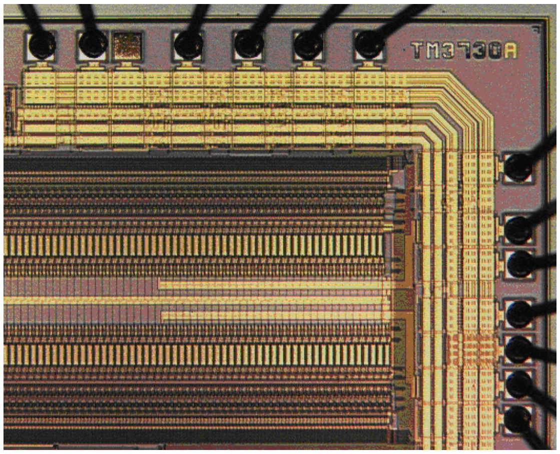


X-ray Image - 9812 date code

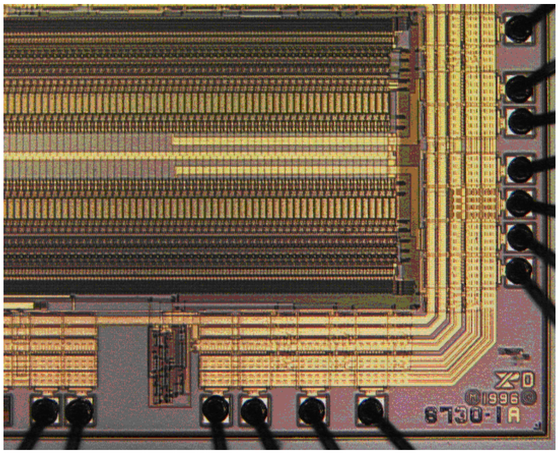


X-ray Image - 9751 date code

After decapsulation, all parts were found to have identical die markings, which were located in the upper right and lower right corners.

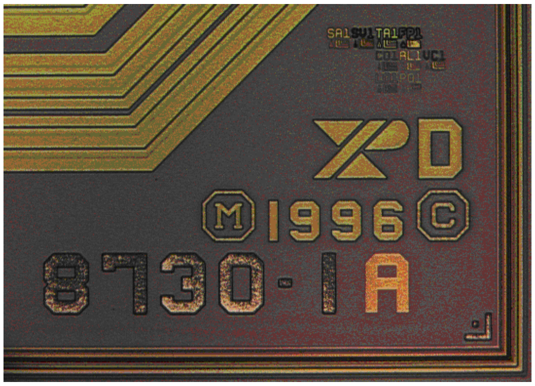


Chip Surface – Upper Right Corner



Chip Surface – Lower Right Corner

Chip Markings Close-up – Upper Right Corner



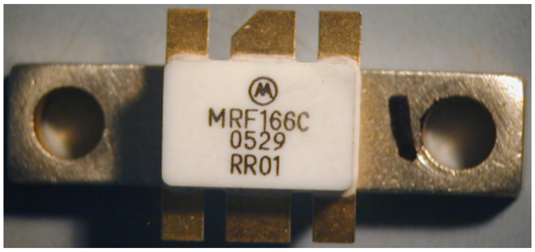
Markings Close-up – Lower Right Corner

The die surface is marked with an Exar logo, and the date 1996. Since Exar acquired Micro Power Systems (represented by the M logos on the package and the die) in 1994, these markings are consistent with authentic Micro Power Systems parts.

Example 9

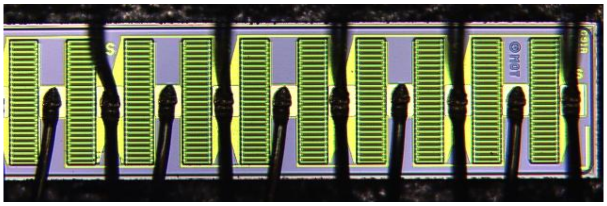
Three microwave transistors were received for analysis. One of these (number 3) was known to be good.

The packaging and external markings on all parts were identical.

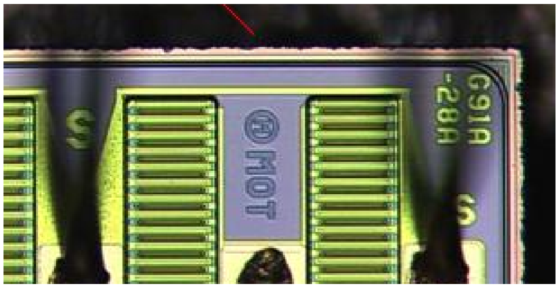


Component As-Received

After the components were decapped, sample number 3 was found to have the Motorola logo and MOT.

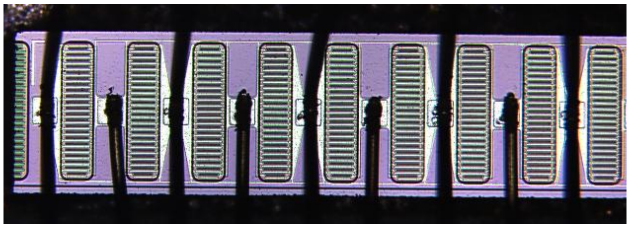


Sample 3 Chip surface



Close-up of logo and lettering

The other samples were found to have identical dies, with a different surface color (as compared to sample 3), and no logo or lettering.



Sample 2 Chip surface

Samples 2 and 3 are counterfeit components.

Conclusion

Counterfeiting will continue as an ongoing concern for the electronics industry. As these examples illustrate, electrical and physical testing (both destructive and non-destructive) can provide a cost-effective means to verify component authenticity.

References

Rob Spiegel, Counterfeit Components Find New Markets, EDN Website, 4/9/2009