Latest Electrical Test Methods for Counterfeit Detection

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INTEGRA TECHNOLOGIES

Your Source for Test & Evaluation

Outline

- Industry Standards
- Counterfeit Types
- Counterfeit Examples
- Types of Electrical Test
- Testing Requirements – What's needed

Key Industry Specifications

- **AS5553**
  - Industry Standard on dealing with the risk of counterfeit devices
  - Additional Standards in process
  - For Buyers AS5553 (released)
  - For Distributers AS6081 (Near release)
  - For Laboratories AS6171 (In development)
    http://standards.sae.org/as5553/
- **IDEA-1010**
  - Methods to detect counterfeit devices
  - Great color photos and guidance
  - In a major update (Rev B out 6-2011)
    http://www.idofea.org/products
- **CCAP-101**
  - Procedure / program to inspect and test for counterfeit parts
    http://www.cti-us.com/pdf/CCAP101Certification.pdf

Non-Functional Counterfeits

- **Marking Quality can be excellent even better than the original**
  - Generally done with ink mark
  - Can use the same ink as the manufacturer
  - Include: logos date codes and lot codes
    - Vendor part marking information available on the WEB
- **What's inside**
  - Derived from scrap parts or be made from scratch
  - Wrong DIE
    - Counterfeiter finds the package
    - Removes the marking
    - Re-marks to the device in demand
  - No DIE inside
    - Counterfeiter acquires blank packages from an assembler
    - Marks to the desired device
- **Removing the Marking**
  - Blacktopping is often easy to spot
  - Laser marking is very shallow (shave, sand, sandblast, etch or polish off a layer)
  - Chemically wash off or etch the ink
- **Re-Marking**
  - Simulated laser mark is impact-printed with laser colored epoxy ink
  - Some have true laser marking
  - Ink mark can be easily duplicated (many manufacturers use ink on some of their products)

- **These parts are usually easily detected**

Functional Counterfeits

- **Up-Marking**
  - Processor or memory speed markings are stepped up to add premium value
  - Similar function changed to high spec parts (standard op-Amp to high performance)
  - Transform standard parts to more valuable industrial, military or space rated parts
  - These parts function correctly but may fail at temperature extremes
  - Testing may be the only way to know
- **Date Code update**
  - Old parts remarked with a current date codes
- **Lead-free remarking**
  - Pb-free parts marked as the Pb types
- **Knock-off Parts or Substitutions**
  - True counterfeit devices
  - Part Substitutions (Attempt to find a pin-for-pin compatible device)
  - Functional and carry the labels of well-known component manufacturers
  - “Third rate makers" built product and label with a reputable manufacturer
  - Some devices can’t possibly work at the rated power levels
  - Parts are flawed and may fail immediately or in the field
  - Can be functional, but will have quality and reliability issues
- **Failed Real Parts**
  - Parts are already marked by the manufacturer
  - Parts that failed manufacturer testing, were rejected and scrapped
    - Retrieved from dumpster, smuggled by employees, etc
    - Destruction of rejects in ASIA test houses is hard to guarantee
  - Show up on market may be sold as new
  - Often high percentages of failed parts may appear to work in applications
    - Leakage failures, elevated power supply currents, speed failures, single bit/gate failures, etc
  - Difficult to detect without full testing and pose a major quality and reliability risk

- **These are the most dangerous type of counterfeits since they may escape detection even in the system**

Detection Methods

Counterfeit Type		External Visual & Phys Dim	XRF Analysis	Mark Perm	Internal Visual	Basic DC Test	Min Func Test 25C	Full Spec Extended Temps	Test & Qual
Non Functioning Devices	No Die	Possible	No	Possible	Yes	Yes	Yes	Yes	Yes
	Wrong Die Re-Marked	Possible	No	Possible	Likely	Yes	Yes	Yes	Yes
	Board Pulls	Possible	No	No	No	Possible	Likely	Yes	Yes
Functioning Devices	Failed Real Parts	No	No	No	No	Possible	Likely	Yes	Yes
	Speed up-marking	Possible	No	Possible	No	No	Possible	Yes	Yes
	Spec up-marking	Possible	No	Possible	No	No	Possible	Yes	Yes
	Temp up-range	Possible	No	Possible	No	No	No	Yes	Yes
	Pb Free Re-marked	Possible	Yes	Possible	No	No	No	No	No
	Lesser part (knock-off)	Possible	No	Possible	Possible	Possible	Possible	Likely	Yes

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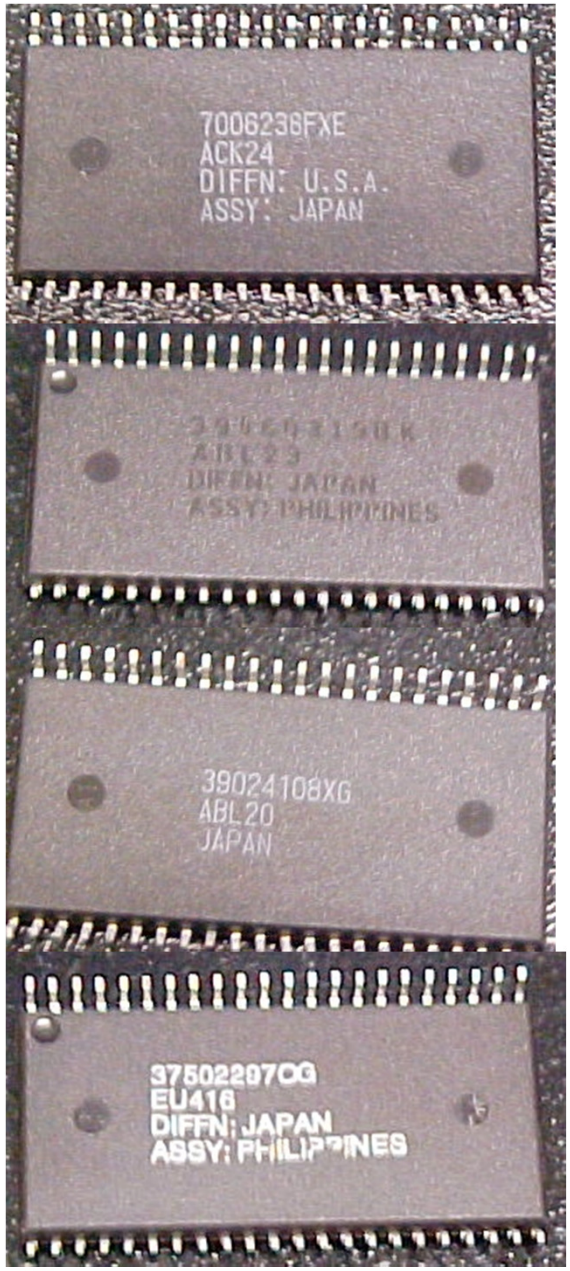
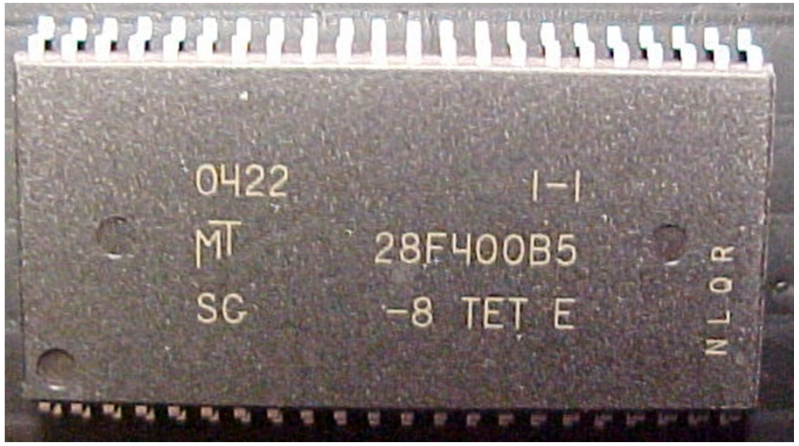


FLASH Memory

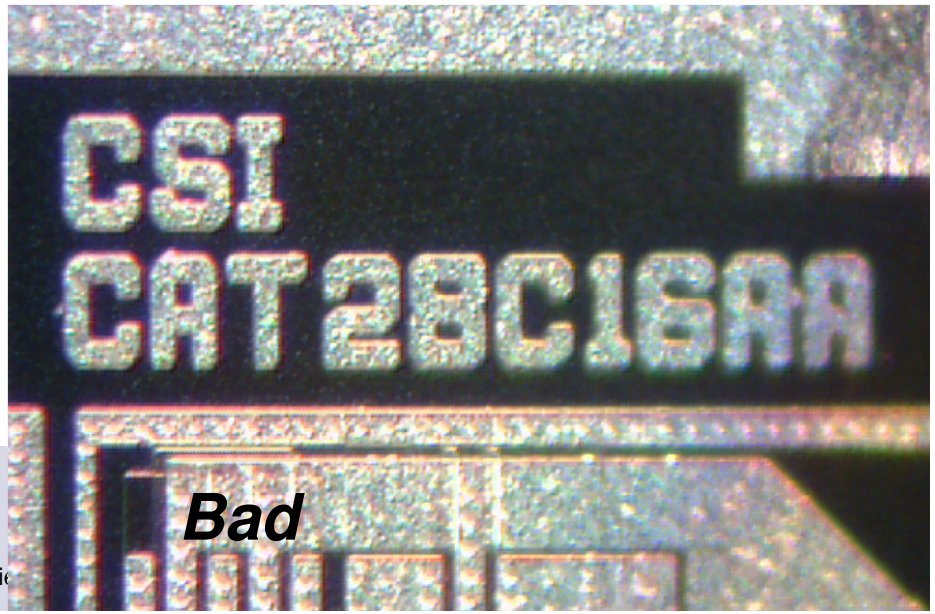
- **All parts are laser marked with the same date code and manufacturer on the topside**
- **Multiple sources on the backside**



Substitution of Same Functionality of Device

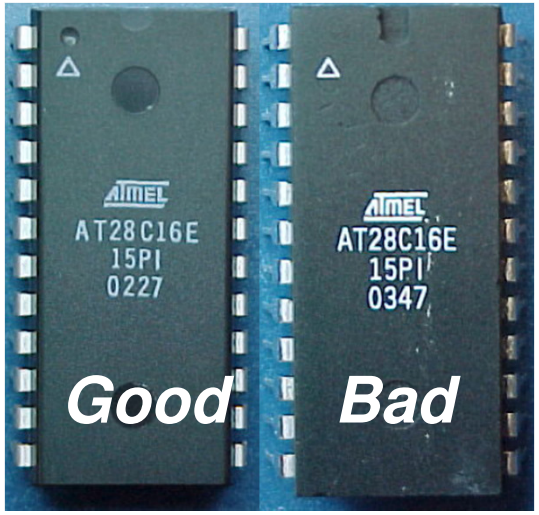
- **Visual Inspection (no clear issues)**
- **Marking testing passed**
- **Die inspection found the correct generic but wrong manufacturer**
  - Catalyst acquired by On Semi
- **Testing Results**
  - All units passed functionally
  - Only failure was one parameter

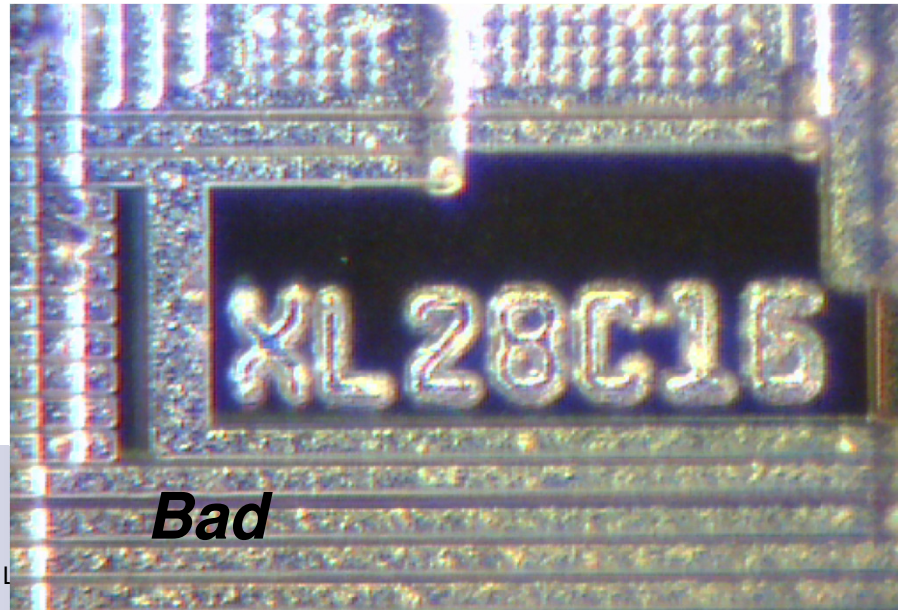
    Slower TWC (write cycle) then the Atmel data sheet



Substitution of Same Older Generation of Device

- **Visual Inspection (no clear issues)**
- **Marking testing passed**
- **Die inspection found the correct generic and manufacturer**
  - However die architecture was wrong
- **Testing Results**
  - Units passed functionally
  - Only failure power supply current differences
  - Die were older generation of the correct device



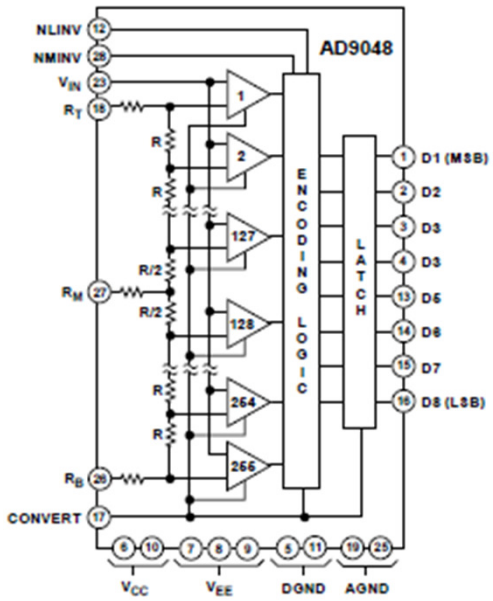


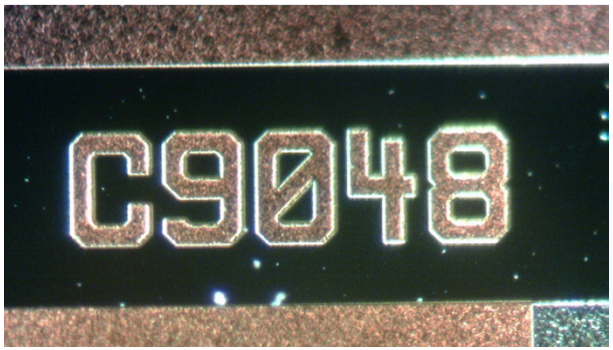
Substitution of very similar DIE

Monolithic 8-Bit Video A/D Converter

AD9048

FUNCTIONAL BLOCK DIAGRAM

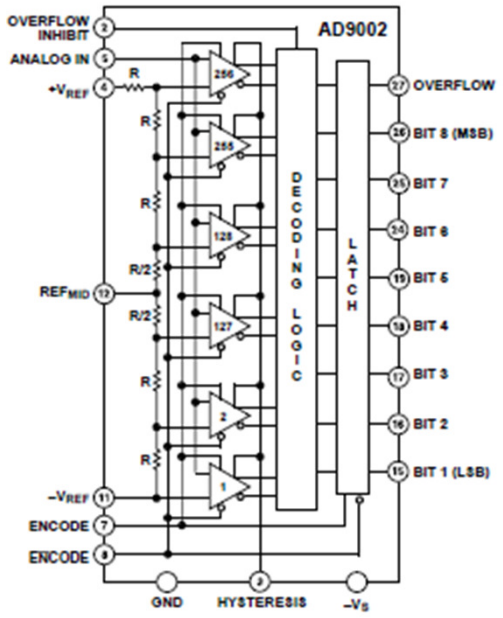




High Speed 8-Bit Monolithic A/D Converter

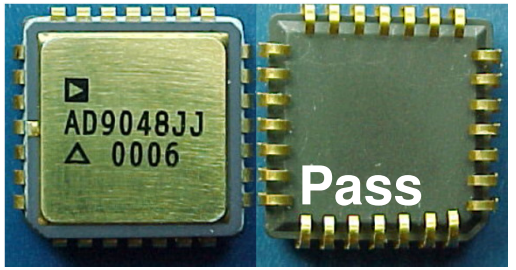
AD9002

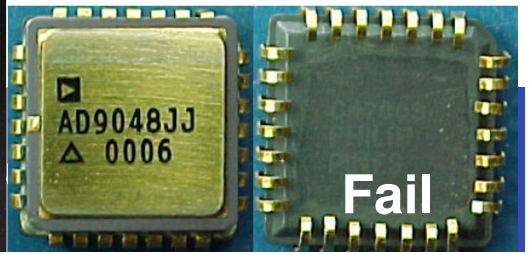
FUNCTIONAL BLOCK DIAGRAM



Very Close Substitution

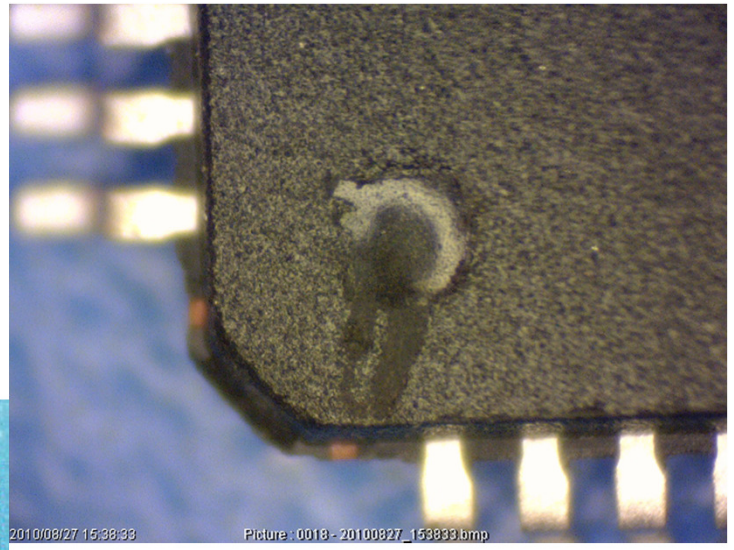
- Similar function
- Same 8 bit and A/D
- Same Manufacturer
- Slight pinout variation

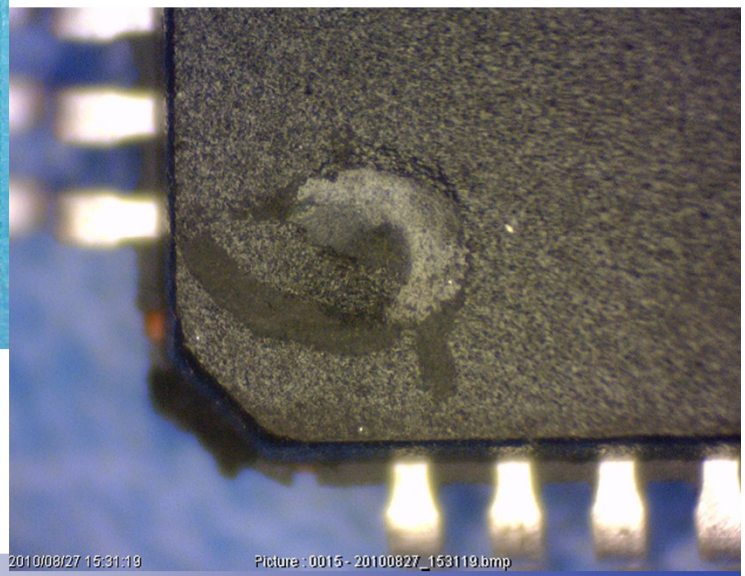




Parts Clearly Remarked – However Most units Pass

- **Marking Permanency Passed**
- **Correct Cypress Die**
- **Clear Indication of Blacktopping**
- **>50% Units Passing Electrical Testing**
- **Fails were typically Dead Parts**





- **Likely Board pulls**
- **Parts Damage**
  - Handling
  - Storage
  - Board Removal
- **Recommended scrap all parts**
- **Passing Parts were used**

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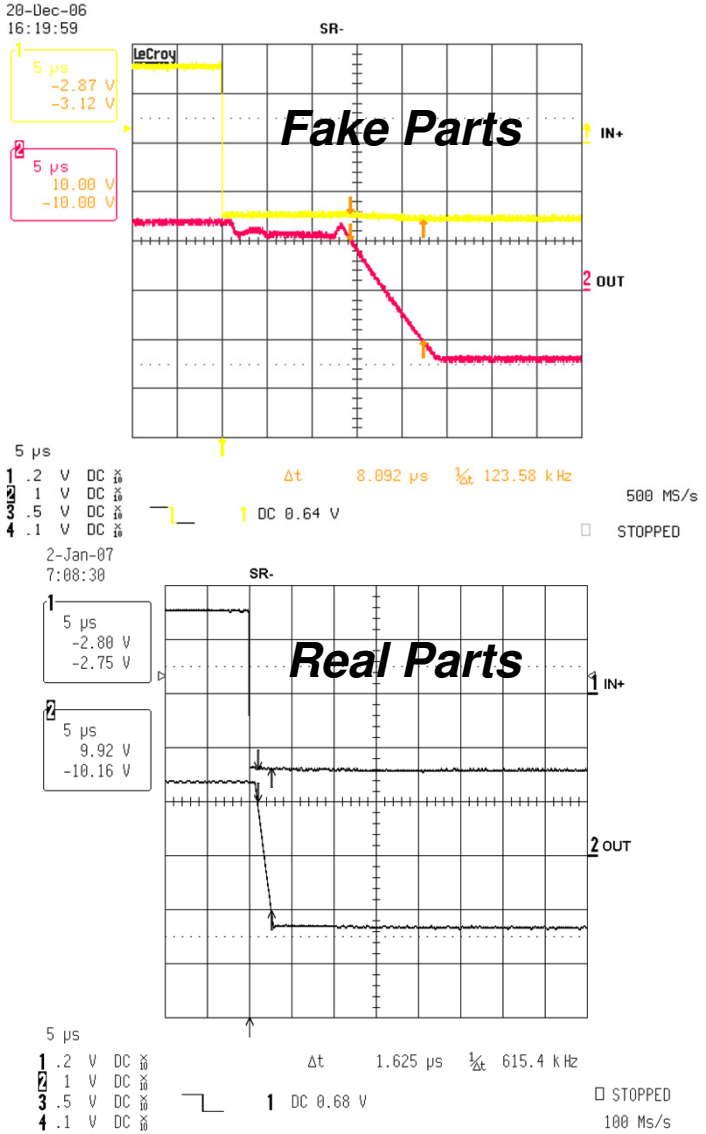
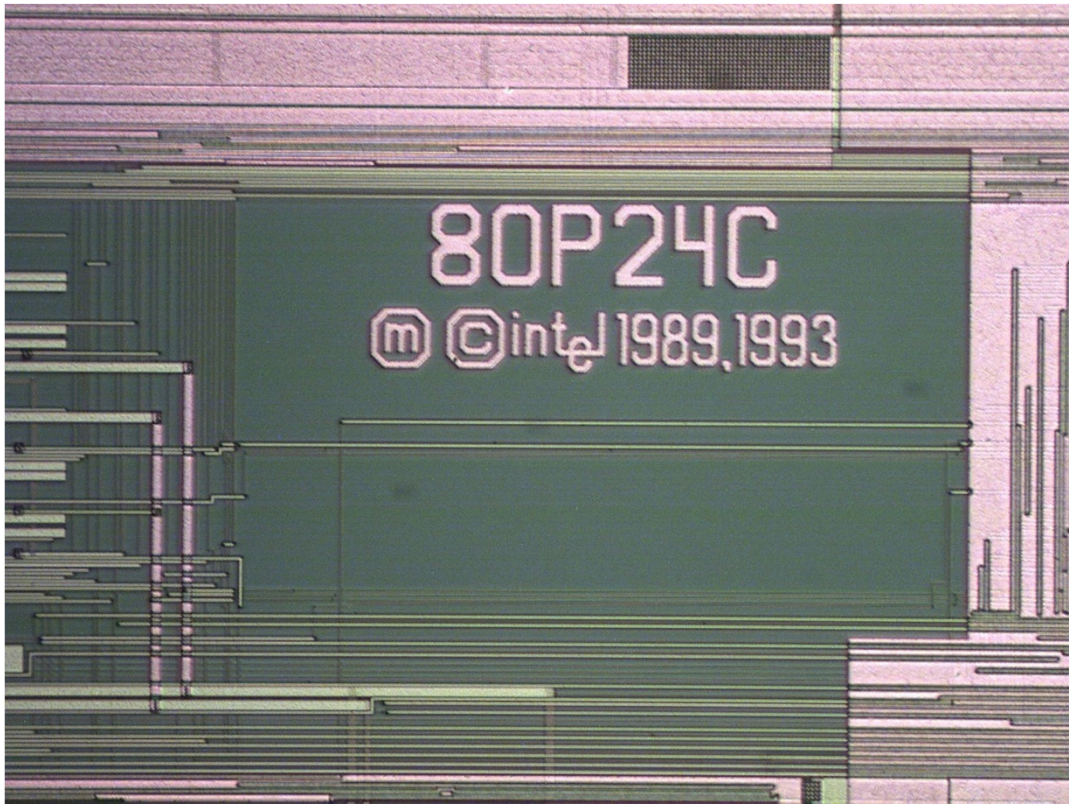
Close Substitution

- **Linear Tech Mil-Std OpAmp in metal can**
  - High performance OpAmp
  - Broker requested testing before completing sale transaction
  - One week turnaround time
  - Very high cost obsolete device did not want to decap
  - High quality Ink Mark on can, no scratches
  - Testing showed device was a functional Op-Amp
  - DC OpAmp parameters passed
  - AC OpAmp parameters failed at 25C
    - Device failed slew rate testing by 10x
  - 100 % failure rate
  - Parts were likely Linear Tech OpAmps remarked to a higher grade
  - Only a comprehensive test including AC's could identify the fakes



Some Detection Examples of Counterfeits Seen by Integra

- **Intel Logo inside an AMD Package**
  - Fake! … Real! … NO Fake!



  - Identified as a Fake by parametric testing

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Some Detection Examples of Counterfeits Seen by Integra

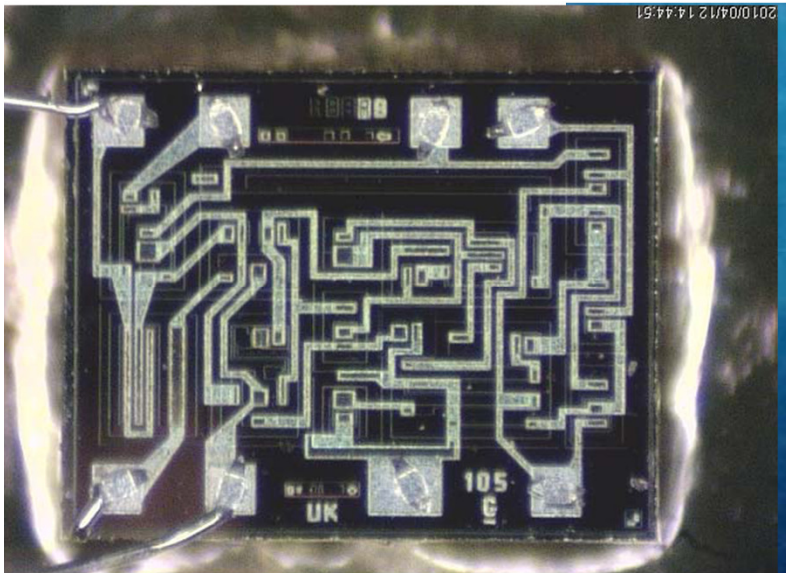
- **Cypress complex digital device**
  - Expensive obsolete device
  - Purchased from a broker
  - Ceramic Mil Temp range part
  - Many parts passed functionally at room
  - Only 3 out of 200 passed testing at 125C temp
  - Were original Cypress parts but failures
  - 3 passing parts were probably marginal or contact related failures
  - Only a full extended temp test could find these failed devices

False Detections

- **Vendor's easy answer is to say the marking does not look exactly right.**
  - Several times we have been fairly certain that the vendor is wrong and the parts are legitimate
  - Parts are often old and factory practices have changed.
  - Vendors often don't have records or knowledge of how processing was done
  - National Response:

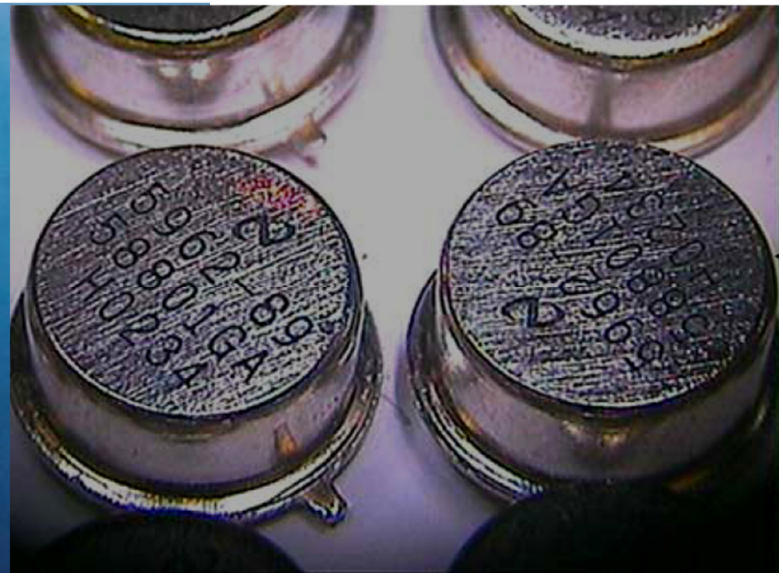
    "does not match National's date code format for mil products"

Correct Die

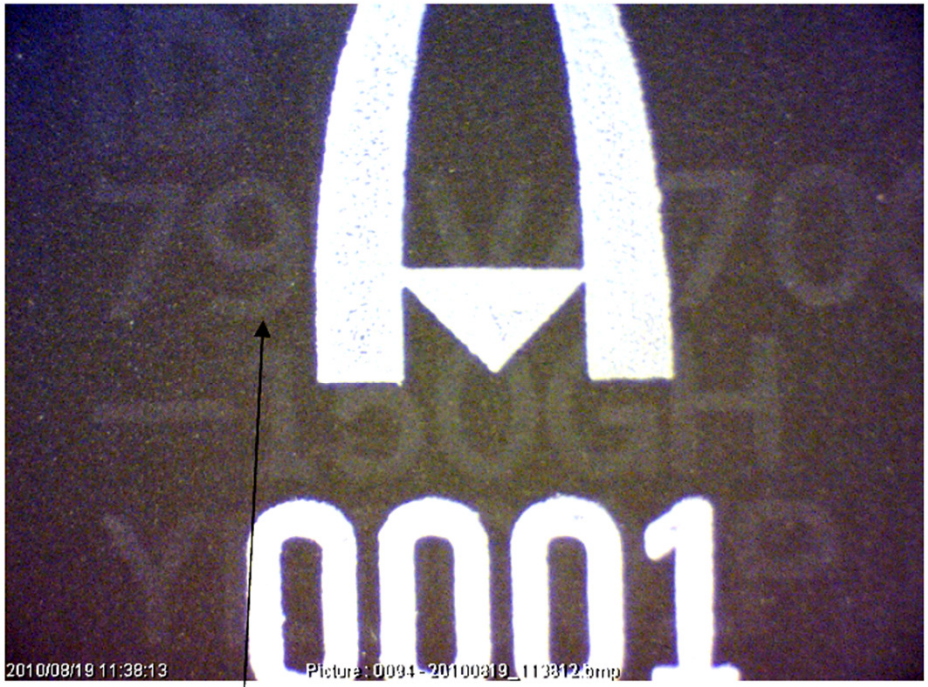


Rejected but is Valid Part

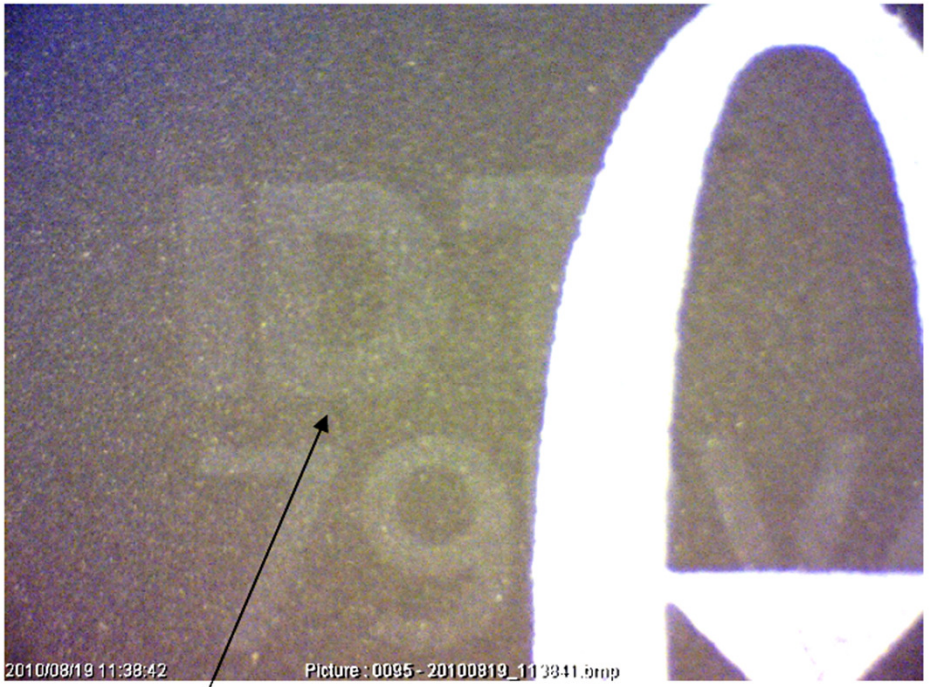
Real Counterfeit Same Device Type



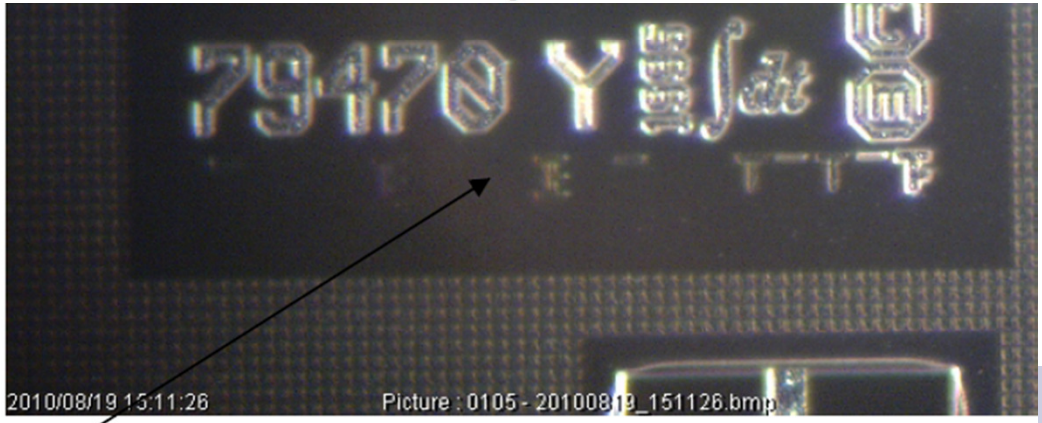
Ghost Marking OK – Aeroflex Remarking



Ghost markings



IDT Manufacturer



IDT logo and part number

New Blacktop Materials

- **Resistant to marking permanency and acetone**
- **Similar appearance to plastic**
- **Material composition similar**
  - Likely resin mixed with shavings from sanding
- **Detection Methods**
  - Careful visual inspection for defects in the top coat
  - Honeywell developed technique
    - High temp dangerous chemical soak process
  - Scratching or scribing also somewhat effective
  - CSAM can typically see the overcoat
  - Material analysis can identify small chemical differences
- **Warning: False Detections Possible**
  - Aggressive solvents can sometime soften the plastic
  - Material can come off that is part of the authentic package
  - Removal of markings and plastic is not always a clear indicator
  - As always review the complete inspection results

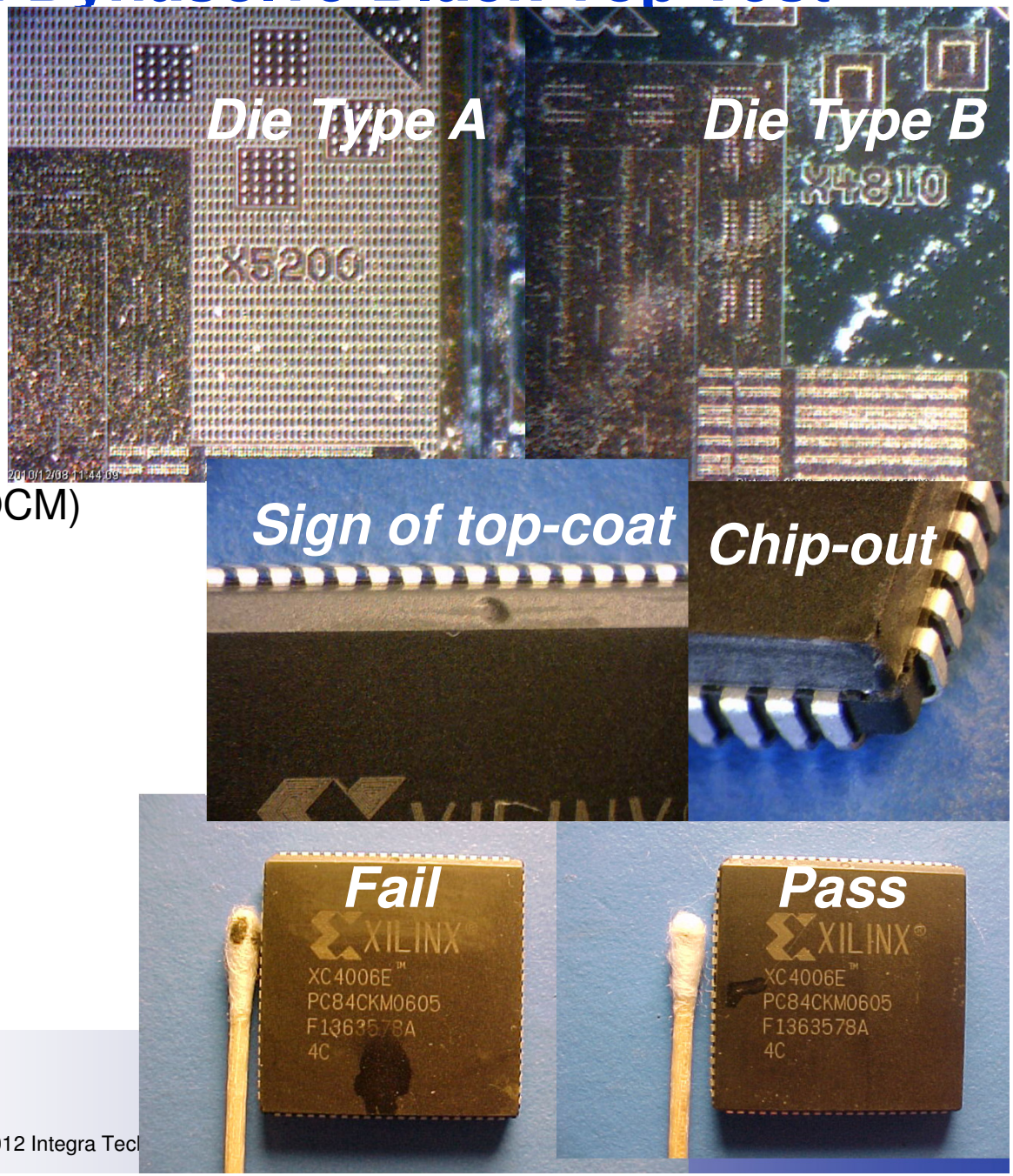
Only Failed Dynasolve Black Top Test

Results:

Visual (some concerns)
Marking Permanency (pass)
Acetone Test (pass)
Mixed Die (OK per OCM)
Mixed Assembly sites (OK per OCM)
Same Date Code (OK per OCM)
Laser Mark (OK per OCM)
Electrical Test (pass)

Dynasolve (**FAIL**)

Counterfeit Parts!



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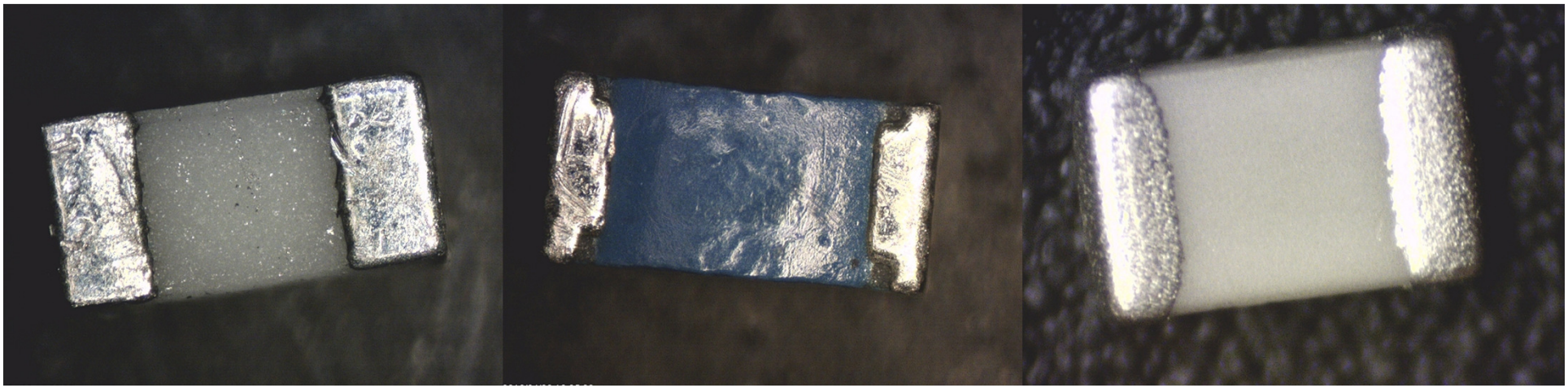
Passives

- **Capacitors and Resistors are one of the most easily counterfeited device types**
- **A lower cost part with the same value can be substituted**
- **Markings not available, colors and mechanical dimensions not enough**
- **Test to rated currents and voltage levels**
- **Room temp test is not good enough**
  - Must test over temp range for tolerance validation
- **Burn-in or Qualification may be necessary to prove robust**
  - High temp, max voltage burn-in (check for weak parts)



Direction for Electrical Test

- **Typical Test Request from an Independent: (Confusing & No spec's provided)**
  - Group A Test
  - Pin Verification Test
  - Functional Test
  - Datasheet Test
- **Unclear direction (Parameters & methodology are not defined)**
  - Group A = Electrical Test (Subgroup? Temp?)
  - Pin Verification Test = Check to see if the pins are connected
  - Functional Test = Provides some definition but unclear parameters
  - Datasheet Test = Open for interpretation to the amount of parameters tested.
- **Labs typically have various interpretations of the tests to be performed**
  - One lab may quote – minimal testing
  - Another lab may quote - comprehensive as speed testing
- **Typical decision process is to go with the lowest price**
  - Minimal consideration for test quality
  - Drives the test labs to go for less and less test coverage
- **Result is a minimally tested component**
- **Who and how you choose to test is important!**

Three Levels of Electrical Test

- **Basic DC Validation**
  (Most often provided, the lowest cost)
  – Minimal Test
- **Basic Functional Test**
  – Little more test
- **Functional Test to Specification with Parametric Testing**
  (What OEM's want)
  – Comprehensive Test

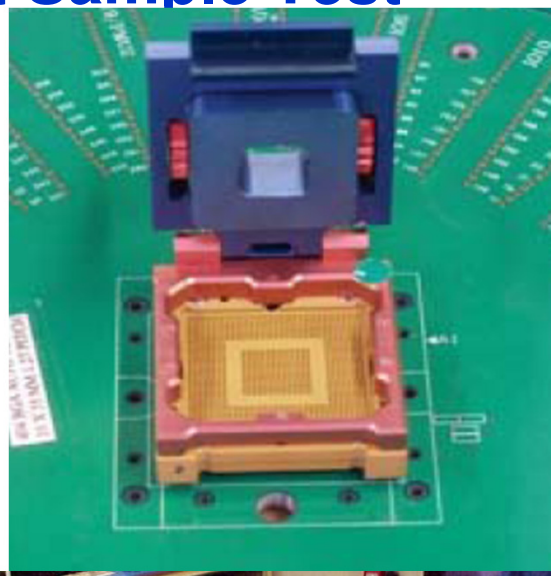
Detection Methods
Minimum Cost Sample Test

- Basic DC test
  - Pin Verification Test
  - Curve Tracer Test
  - DC only Test
  - Could be a sample Test

- IC Device
  - DC test of all pins
  - Check Continuity and Shorts on all pins
    - Make sure input/outputs and power/ground pins are in the right places
    - Make sure all power pins are correctly connected
  - Check leakage currents on input and output pins
  - Linear pins check basic pin characteristics
  - Static power supply current measurement is also possible
  - Typically will not include a functional test
- Transistor and Diodes
  - Test Basic DC device parametric values
- Capacitors and Resistors
  - Measure component value

- Will find wrong die some electrically failing parts (ESD…)

- Typical costs : $300 to $800.



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Your Source for Test & Evaluation

Detection Methods
Basic Functional ATE Test

- **Basic Electrical test**
  - Production test of the entire lot
  - Add NRE costs if fixtures are not available
- **Simple Device**
  - Functionally test the device
  - Limited parameter measurements are performed
  - Tested at 25C
- **Complex Device**
  - Power up the device
  - Validate some limited DC measurements
    - Minimal functional test
  - Tested at 25C
- **Will find wrong die and empty parts**
  - As well as non-functional parts
- **Typical costs: NRE $1-2K and $1/unit @25C**
  - Cost dependent on unit volume and complexity

Detection Methods
Full Specification Test

- **Test the device as it is used**
  - Functional at-speed
  - Comprehensive functional testing
  - All reasonably possible patterns with memories
  - AC go-no-go of key parameters
  - Selected AC characterization measurements
  - DC measurements to the full specified limits and accuracies
  - Test all pins even with high pin count devices
- **Match the right tester to each device**
  - Tester should match the testing needs of the device
  - Use specialized engineers with test expertise in each technology commodity (Digital, RF, Mixed-signal, Analog, Memory, Discrete)
  - Tester optimized to the needs of each device technology
- **Testing will be similar to the original manufacturers test**
- **Full testing will find most types of counterfeit devices**
- **Add extended temp testing to assure operation over the operating range**
  - Existing test software will have minimal NRE costs
  - **Typical costs** (simple): NRE $3K-$5K @ hot/cold $2-$5 each device
  - **Typical costs** (complex) NRE $5K-$20K+ @ hot/cold $3-$10 each device

Test Lab Cost Drivers

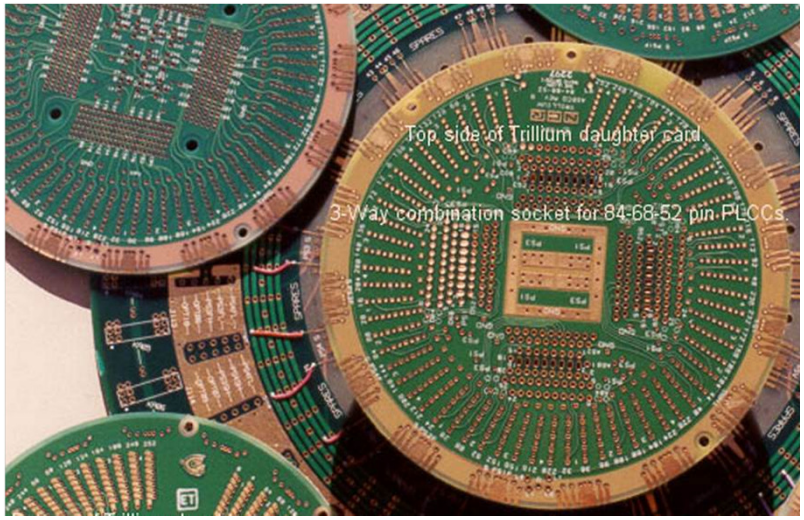
- **Software Development NRE**
  - Complexity of device → Costs
  - Engineering rates
    $100/hr to $200/hr
  - Tester charges
    $50/hr to $300/hr
  - Loadboard & socket NRE
    $300 to $10,000
- **Production Test**
  - Volume
    - >1000pc lots (automated handling)
  - Data Collection
    - Adder for data more for serialization
  - Test flow
    - Hot & Cold tests are more costly

Loadboard / Hardware costs

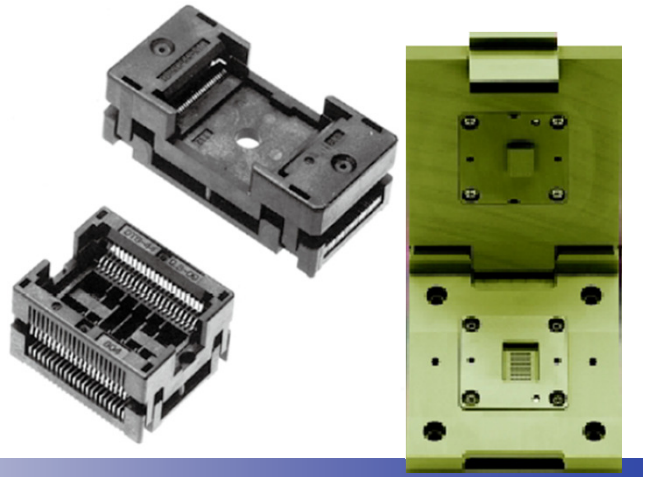
- **Loadboards**
  - Originally tester interface boards had device loads on them.
  - Now testers implement this function internally
  - The name stuck

- **DUT Boards**
  - Smaller low cost board piggyback on top of a larger loadboard
  - Can save significant cost
  - Increases setup issues and degrades signal quality

- **Board Costs**
  - Low pin count hand wired DUT Boards ($100 to $800)
  - Semi custom loadboards boards for typical packages $1500
  - Full custom boards (high pinout or complex hardware) $10K



- **Socket Costs**
  - Basic off the shelf molded burn-in type socket ($20 to $500)
    - Very limited numbers of test insertions (100 to 10K typically)
    - Poor electrical performance
  - Custom made production sockets ($1500 to $5000)
    - Higher test insertions and reparable (>100K insertions typically)
    - Electrical performance needed for high speeds, accuracy or RF testing



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High Volume Throughput (Parts Per Hour)
Semiconductor Manufacturer Handler Example

Single Site Hand Test
Test time = 10 sec.
n = 1
Hand Index = 15 sec.
Soak Time = 60 sec
Utilization = 0.75

$$PPH = \frac{3600*1*0.75}{10+15+60}$$

PPH = 32
@$100/hr
$3.13/device

Single Site
Test time = 10 sec.
n = 1
Index = 0.3 sec.
Utilization = 0.85

$$PPH = \frac{3600*1*0.85}{10 + 0.3}$$

PPH = 297
@$100/hr
$0.34/device

Dual Site
Test time = 13 sec.
n = 2
Index = 0.35 sec.
Utilization = 0.85

$$PPH = \frac{3600*2*0.85}{13+0.35}$$

PPH = 458
@$100/hr
$0.22/device

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Questionable Testing of Counterfeit Parts

- **Some Test Labs are not performing the needed testing**
- **Problems are with broker/distributor directed component screening**
  - Conflict of interest with provider responsible for test
  - Nonexistent lab oversight
    - No Audits/Reviews/Checks
  - Total focus on price
    - No consideration for test coverage or quality of test
  - Unreasonable expectations for testing costs
    - Typically looking for NRE and testing at $500 or less
  - Signs of questionable testing practices
    - Ridiculous test pricing
    - Turn-times beyond possible run-rates
    - Drastic price differences from reputable test labs
    - No documentation of testing coverage or test equipment
  - How do you ensure proper testing being performed?

Take Control of the Test Lab Selection

- **Many Independents and Distributors will only consider cost in the selection**

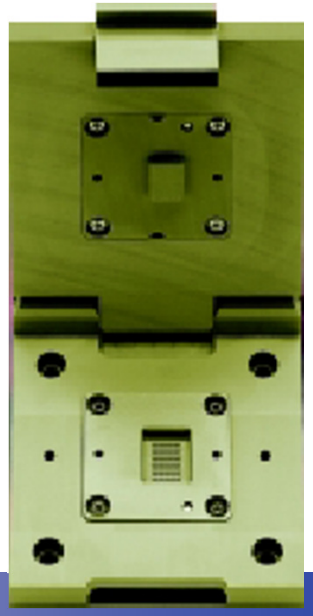
- **Direct the Lab selection**
  - Identify, qualify and select test and evaluation labs

- **Define the process**
  - Develop a risk mitigation process document
  - Define the Testing Flow
    - Test Temps (25C only or Temps: 85C, -55 …)
    - Sample sizes
    - Environmental Stresses (burn-in, temp-cycle …)
    - Special Tests (de-cap, marking, solderability …)
  - Identify the parameters to test if possible
    - Write a testing spec … or
    - Circle or mark the critical parameters on the Manufacturer's datasheet
  - Define the Type of test coverage
    - Basic DC Validation
    - Minimal Functional Testing
    - Parametric Testing

- **Get Feedback from your test lab**
  - Request Tester used
  - Listing of the Parameters Tested
  - Datalogs (after test is complete)
  - Have a conference call with the lab
    - To clarify the requirements

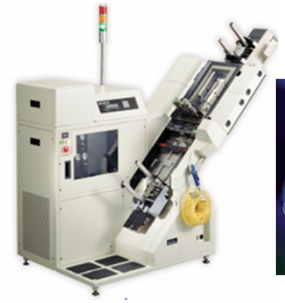
Recommended Test Methodology

- **Test the device as it is used**
  - Functional at-speed
    - Application speed at a minimum may not need spec speed
    - Test frequency is a major tester cost driver
  - Comprehensive functional testing
    - Test all device functionality
    - Fault grading is not possible
      Only the manufacturer has device modeling capability
  - Test key AC parameters
    - Key parameters are usually referenced to device clocks
      Propagation delay
      Setup and hold times
      Extra parameters are often listed for designer reference
    - Use go-no-go testing to cover most AC parameters
      Tested over the entire functional pattern
    - Selected AC characterization measurements can be made
  - DC measurements to the full specified limits
    - Attempt to test 25C parameters at extended temperatures
    - Limit adjustments may be required after testing
  - Select the appropriate tester
    - No one tester can effectively test all technologies



Integra Test Engineering
Summary

- Test Facilities in Kansas and California
  - 48k sq ft (KS), 3k sq ft (CA)
- 28 Year History as a Testing Lab
- 24 Hours/Day x 7 Days/Week Operations
- 200 Employees, 26 Test Engineers & 38 Testers
- Broad tester and test technology capabilities
  - Memory, Digital, Linear, Mixed Signal, RF, FPGA
- Engineering expertise in every technology
  - Greater than 10,000 test programs developed locally
- >200 Active Customers Mil/Space & Semi-manufacturer
- Operations ISO-9001, AS9100, ITAR, DSCC Registered & Trusted
- On-Time Delivery Performance of 96%
- Customer Satisfaction Rating of 98%







INTEGRA TECHNOLOGIES