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1. Abstract

This report documents the results of a multi-lab round robin evaluation of counterfeit detection testing methods defined in SAE AS6171 (slash sheets 2-11). Seven laboratories, spanning commercial independents, supplier-owned, and government facilities, tested ten part numbers with known or suspected counterfeit attributes. Two universities contributed enhanced electrical and design recovery testing to gain additional insights into these test methods. The university testing results are not included in this report. The university testing results will be included in a subsequent project report.

The objective was to assess laboratory proficiency, quantify variability, and evaluate the effectiveness of standardized test methods in identifying counterfeit related defects. Comparative analysis across labs enabled the establishment of a "ground truth" consensus, against which individual lab results were benchmarked.

Results highlight both strengths and limitations of current practices. Certain methods consistently identified high-risk defects, while others showed variability in sensitivity or interpretation. Lab-to-lab differences also illuminated challenges in defect categorization and underscored the importance of broader consensus frameworks for consistent outcomes.

These findings provide actionable insights into the reliability of AS6171 methods and suggest opportunities to refine slash sheet processes for improved repeatability and industry confidence. By quantifying test performance across diverse organizations, this study advances the collective capability to detect and mitigate counterfeit electronic components.

2. Purpose and Background

This report serves as the Phase II milestone 9 deliverable under XXXXXXXXXXXXXXXXXXXXX. Its purpose is to evaluate the results of a multi-laboratory round robin exercise, compare lab performance, and assess the effectiveness of standardized methods in detecting counterfeit-related defects.

This documents the lab proficiency evaluation portion of the overall project scope. The objective of the proficiency evaluation is to evaluate the results provided by each of the participating test labs in the round robin testing phase of the project, provide comparatives of the labs, and assess the overall effectiveness of the labs to accurately identify potential counterfeit related defects.

During Phase I of the project, suspect counterfeits were obtained from various sources and characterized nondestructively to determine their suitability as representative test samples. From this population, ten part numbers were selected for Phase II testing based on the quantity of samples available, diversity of counterfeit related attributes, and variation in device and package types.

Sample sizes were tailored to achieve a high probability (>90%) of including defects which would produce the greatest defect diversity in each lab's subpopulation. The intent was to expose labs to a broad variety of defect types while maintaining statistical confidence. Desired defects are those that may be seen in a few part samples. The intent was to create as large of variety of counterfeit related defects as possible in the test population.

Labs were requested to identify the defects in accordance with the list of counterfeit defects published in AS6171. A spreadsheet was provided for this purpose. This step is unique to this project. Labs do not typically categorize the observed defects, so this proved to be challenging for most labs requiring some additional communications with the labs to validate findings. While categorization accuracy is distinct from a lab's technical capability, the breadth of defect identification plays a critical role in drawing sound conclusions about part acceptability.

It is important to emphasize that categorizing defects accurately and completely has no correlation to a lab's ability to properly test parts and reach an appropriate conclusion. However, the scope of defects identified can be critical to arriving at an appropriate conclusion. For example, many of the identified defects could result either from counterfeiting actions, manufacturing processes, or related to quality control (e.g., is oxidation on the leads due to counterfeiting actions or just an artifact of long term part storage?). The combination of several defects might steer an analyst toward interpreting the data as counterfeit related. However, without the broad range of data points, the analyst may consider a defect to be a quality outlier which may still result in acceptable use of the parts in products.

Part Number	Manufacturer	# Provided	Description
IS41LV16256B-35TL	Integrated Silicon Solution Inc. (ISSI)	5	EDO DRAM, 256KX16, 35ns, CMOS, PDSO40
AD8616ARMZ-REEL	Analog Devices	10	Precision op amp. 2 per package (8 pin MSOP)
AM28F020-120PI	Advanced Micro Devices (AMD)	5	2 Megabit (256 K x 8-Bit) CMOS 12.0 Volt, Bulk Erase Flash Memory
IS61WV25616BLL-10BLI	Integrated Silicon Solution Inc. (ISSI)	5	IC SRAM 4MBIT PARALLEL 48TFBGA Digi-Key (authorized distributor for ISSI). This is a new authentic part with known pedigree which was included in the project as a control.
TPS7A4901DGNT	Texas Instruments	5	Linear regulator (8 pin MSOP-PowerPAD, leadless)
VN10KLS	Vishay	6	N-channel MOSFET discrete. TO-92 package
XCS30-3TQ144C	Xilinx	5	FPGA, 576 CLBs, 10000 Gates, 125MHz, 576-Cell, CMOS, PQFP144
IDM2901AJC	National Semiconductor	5	Bit-slice processor

Part Number	Manufacturer	# Provided	Description
ERJ-3EKF3302V	Panasonic Industry	6	RES SMD 33K OHM 1% 1/10W 0603
K9F4G08U0D-SIB0	Samsung Electronics Co., LTD.	5	4G-bit NAND Flash Memory with spare 128M-bit

Table 1 Round Robin Test Parts

The testing approach utilized in the round robin testing was to provide each lab with a sample of parts from a single lot of each part number shown in Table 1. This gives the greatest probability of parts exhibiting the same defects. The probability of this was further enhanced through sample size adjustments to variability within the lot. Ideally, having each lab test the exact same parts would provide the best comparative data, but due to the destructive nature of the required testing, this approach was not possible. Round robin lab participants are shown in Table 2 along with the scope of testing each performed.

Lab Name	/2 – General EVI	/2 - Detailed EVI	/2 - Remarking	/2 - Resurfacing	/2 - Dimensions	/2 – SEM Surface Insp.	/3 - XRF	/4 – Internal Visual	/5 - X-ray	/6 – Acoustic Microscopy	/7 - Electrical	/8 - Raman	/9 - FTIR	/10 - TGA	/11 – Design Recovery
Lab 1	X	X	X	X	X	X	X	X	X	X			X	X	
Lab 2		X													
Lab 3	X	X	X	X	X	X	X	X	X	X	X	X	X		
Lab 4	X	X	X	X	X		X	X	X		X				
Lab 5	X	X	X	X	X		X	X	X						
Lab 6	X	X	X	X				X	X						
Lab 8	X	X	X	X	X	X	X	X	X						
Lab 9	X	X	X	X	X		X	X	X						

Table 2 Round Robin Lab Participants

The participating labs represent a wide range of testing options commonly used for counterfeit evaluation. Supplier labs (i.e., independent distributors), Commercial test labs and Government test labs. The project also included two specialty labs intended to provide unique insights into alternative test strategies.

2.1. Lab 2

Lab 2 utilizes a tool that provides an alternative test strategy. This approach is intended to provide an automated approach to the identification of potential defects typically identified during the Detailed EVI testing (which is the most encompassing test method relative to the potential number of defects that can be discovered from an individual test method). This tool is still under development so it is currently being used as a guidance tool to target areas for further inspection as opposed to drawing absolute conclusions based on the anomalous attributes the tool identifies. As the tool improves, it may be able to assess the inherent risk of a part and, by identifying high-risk items early and at low relative cost, reduce the need for more extensive testing through early rejection of suspect material. Since the Lab 2 method is not intended to fully replace all AS6171 testing, it was not compared to all test methods. Comparisons were only done to the Detailed EVI results. It should be noted that Lab 2 does not currently evaluate lead attributes, so lead related anomalies identified in traditional AS6171/2 Detailed EVI testing would not align with Lab 2 test capabilities.

2.1.1. Process Overview (description provided by Lab 2)

The purpose of this alternative test strategy is to provide an objective and standardized approach for evaluating the authenticity and physical integrity of the component. By leveraging systematic image analysis and quantitative metrics, the goal is to assist operators in identifying high-risk features and making informed decisions during inspection.

The analysis includes the following areas:

Structure Analysis: Assessing dimensional ratios and geometric properties to identify abnormal patterns that may indicate potential tampering or manufacturing inconsistencies.
Texture Analysis: Evaluating surface uniformity and detecting texture inconsistencies that may indicate nonoriginal processing or other factors leading to potential quality issues.
Pinhole Analysis: Analyzing localized features both internally and externally to assess structural integrity and identify anomalies, such as texture deviations or abnormal coating issues.
Font Analysis: Verifying the consistency of marking styles within the same component to identify irregularities that may indicate remarking or non-original processing.

This report builds upon the principles outlined in AS6171, with a focus on digitizing and operationalizing these standards to enable objective, repeatable, and data-driven analysis.

2.2. Lab 9

Lab 9 employes a hybrid approach to counterfeit detection, combining traditional AS6171 methodologies with its proprietary comparative analysis against authenticated “golden samples” of known good devices (see section 2.2.1 for “golden sample” definition). Central to this strategy is their collaborative cloud-sharing database, which enables members to compare images of current lots with previously validated golden samples. The database retains the essential characteristics of the component for future access at any time. The data records include part traceability data in addition to external and internal imagery. Viewable database content includes both the owner’s uploaded data as well as anonymous peer data. Golden samples are procured only from authorized distributors or OCMs to ensure traceability and authenticity.

The Lab 9 solution incorporates traditional test methodologies to augment and support device comparisons. Lab 9 has been building a comprehensive database of part imagery to serve as “golden samples” for future analyses which includes multiple revisions of the parts when available. For the round robin activity, 4 of the 10 parts in the test had “golden samples” imagery available in their database. For the remaining 6 parts, Lab 9 performed standard AS6171 testing without “golden samples” imagery. This is contrary to Lab 9’s standard business model where they limit analysis to devices which have golden samples. Because Lab 9 executed the standard AS6171 methods on all 10 parts, they are included both as a standard test lab in the round robin and as a provider of the alternative “golden sample”-based comparative method.

Having the golden-sample imagery proved to be very useful in those analyses where it was available, particularly in terms of part-marking verification, die topography, and detecting discrepancies that may not be evident through standard AS6171 methods alone. Further details will be provided in the part summary sections of this report.

2.2.1. Process Overview (description provided by Lab 9)

SCOPE

Lab 9 employs the SAE AS6171 Revision A standard as a framework for conducting counterfeit mitigation inspections. However, it is important to note that Lab 9 does not strictly adhere to this standard as a mandatory requirement for inspections. Instead, the inspection test plan is tailored selectively according to each customer's specific requirements. Lab 9's counterfeit inspection services presently focus exclusively on active complex and active simple components due to their heightened susceptibility to counterfeiting, as they are frequently targeted commodities.

REQUIREMENT

Lab 9 places significant importance on the quality of its inspection reports. To ensure accurate and high-level confident comparisons, it is mandatory for all customers to provide a golden sample reference for inspection purposes. If a golden sample is already available in Lab 9's database or has been previously provided, it will be utilized for comparison. Lab 9 will not proceed with the inspection unless a golden sample reference is available. The suspected counterfeit detection sequence has been established based on inspection and testing of parts by selecting the least costly inspections that are most effective, and easiest to perform first, and then to build upon results of previous testing in accordance with the sequence to build confidence in the results. All test data and test reports supplied to the Requester shall be retained by Lab 9 for a minimum of 5 years, or longer if specified by agreement with the Requester, in a manner to protect against damage from fire, flood, and other environmental hazards.

Note: In this test report, the term "golden sample" refers to a Known Good Device (KGD) obtained either directly from the Original Component Manufacturer (OCM) or from the authorized distribution channel, accompanied by Chain of Custody documents to ensure traceability.

3. LAB COMPARISON DATA

3.1. Final Part Disposition Results

Each lab was requested to derive a final conclusion on each part's potential authenticity as a result of their testing. It should be noted that testing does not assure part authenticity or establish pedigree. It provides a risk-based assessment on the likelihood that a part is authentic. AS6171 concludes if a part is "acceptable" or "not acceptable" based on test results since no amount of testing can authenticate a part with unknown pedigree. Round robin results showed some variability between participating labs. Additional details into the observations and conclusions which drove to these dispositions are included in the detailed test analysis data contained in this report. Table 3 summarizes the overall results.

Blue highlight indicates that imagery of known pedigree parts were available **Lab Name**	**IS41LV16256B-35TL**	**AD8616ARMZ-REEL**	**AM28F020-120PI**	**IS61WV25616BLL-10BLI**	**TPS7A4901DGNT**	**VN10KLS**	**XCS30-3TQ144C**	**IDM2901AJC**	**ERJ-3EKF3302V**	**K9F4G08U0D-SIB0**
Lab 3	Suspect	Acceptable	Suspect	Suspect	Suspect	Suspect	Suspect	Suspect	Acceptable	Suspect
Lab 4	Suspect	Suspect	Suspect	Acceptable	Suspect	Suspect	Suspect	Suspect	Acceptable	Suspect
Lab 1	Suspect	Suspect	Suspect	Suspect	Suspect	Suspect	Suspect	Suspect	Suspect	Suspect
Lab 6	Suspect						Suspect			
Lab 5					Suspect					
Lab 8	Suspect	Acceptable	Suspect	Acceptable	Suspect	Suspect	Suspect	Suspect	Acceptable	Suspect
Lab 9	Suspect	Acceptable	Suspect	Acceptable	Acceptable	Suspect	Suspect	Suspect	Suspect	Suspect
Consensus Conclusion*	**Suspect**	**Acceptable**	**Suspect**	**Acceptable**	**Suspect**	**Suspect**	**Suspect**	**Suspect**	**Suspect**	**Suspect**

Table 3 Reported Part Disposition

*The consensus conclusion takes into account the combined results from each lab as well as the quality of evidence provided by the labs in reaching their conclusion. For example, if only 1 or 2 labs were to identify a part as suspect, but had very strong evidence supporting this conclusion, then the overall consensus conclusion would be considered suspect even if the majority of labs considered the part to be authentic.

3.1.1. Rationale for the Final Part Dispositions

Round Robin testing was used exclusively for determination of each part's final disposition. Additional electrical testing and design recovery is being performed as supplemental project work which could contribute additional information on the part's acceptability beyond what the round robin testing provides. If any of that data impacts the overall conclusions, that will be documented in subsequent project reporting. The determining rationale for each part's final disposition is as follows:

IS41LV16256B-35TL – Suspect – Multiple signs of counterfeiting including multiple die versions, multiple lead frames, blacktopping with evidence of sanding, and ghost markings.

AD8616ARMZ-REEL – Acceptable – There were many observations suspecting possible blacktopping due to the unusually rough surface texture and what appeared to be blacktop overflow on the edges, none of the blacktopping tests confirmed the presence of a coating and subsequent cross-sectioning of additional samples also did not support concerns of blacktopping. There were findings indicating contamination and corrosion, but these are also common quality related concerns and not sufficient without additional supporting evidence to conclude suspect counterfeit. Several labs also had concerns about the variability in the positioning of part markings. This by itself was also not considered a conclusive finding since the part drawing indicates that the pin 1 marker can be placed anywhere within the respective quadrant of the part (which all parts were in compliance with). This is an unusual part specification which points to the relative variability of the part markings, raising question about the marking placement as being an absolute criteria for determining suspect counterfeit status.

AM28F020-120PI – Suspect – These parts exhibited visible parallel striations due to sanding underneath a blacktopped surface. This is a clear indication of device alteration with the intention of deception warranting a suspect counterfeit disposition. Additionally, there were many quality related defects identified that further support the suspect disposition such as heavily corroded leads, contamination, tin whiskers, electrical test failures and the presence of both AMD and Intel die. There were few samples which contained the Intel die, so this was not observable by most labs. During the time frame these devices were manufactured, second source agreements were used specific to the Intel die. For example, the Catalyst Semiconductor CAT28F020 uses the Intel die in their equivalent part (https://datasheet4u.com/pdf-down/C/A/T/CAT28F020-CatalystSemiconductor.pdf). It is unclear if a second source agreement was also in place between AMD and Intel at this time. If AMD had a second source agreement with Intel for the use of Intel die in this device, finding Intel die would not be a sign of counterfeiting of this part. But the presence of mixed die and multiple die revisions within a single lot are positive indicators.

IS61WV25616BLL-10BLI – Authentic – The test lot for this part number was procured by Aerocyonics from Digi-Key who is an authorized distributor for this part. This was included in the round robin to serve as a controlled sample for assessing the potential of false positive results. The parts were received from Digi-Key in the ISSI factory sealed packaging. They were unpackaged at UConn during phase 1 of this project, then sent to Auburn as one of the suspect counterfeit part population collected during phase 1. The parts were segregated and prepared for shipment to individual labs at Auburn. This level of handling at both UConn and Auburn accounts for the package contamination and bent leads noted by a couple labs. However, these “one-off” observations did not support suspect counterfeit findings in that they are common quality indicators and occurred with very low frequency.

TPS7A4901DGNT – Suspect – These parts exhibited parallel striations and blacktopping which are clear indicators of counterfeiting activity. Sanding was extensive enough to result in uneven thinning to the device top when observed from the side. Manufacturers can sometimes blacktop a part, but sanding is considered a high risk process due to charge buildup and is not done by manufacturers. Manufacturers will sometimes blacktop to allow for part remarking, but given their intentions, do not try to hide the presence of their coating. There were also several quality related observations which further support the suspect counterfeit disposition.

VN10KLS – Suspect – These parts exhibited 3 different possible die and lead frame configurations, as well as lead reattachment. Both of these conditions are clear indications of suspect counterfeit activity. Additionally, blacktopping and variations in the body molding were also present which are also very strong indicators.

XCS30-3TQ144C – Suspect – The presence of sanding and blacktopping were considered to be clear evidence of suspect counterfeit activity. Some samples exhibited ghost markings from the original markings which further supported the blacktopping observation. There were also numerous issues with the device leads including replating, severe damage, whiskers and lack of tooling marks. These type of defects are not conclusive indicators of suspect counterfeit activity, but coupled with the sanding and blacktopping, they further support the device disposition.

IDM2901AJC – Suspect – Surface analysis of these parts indicated significant differences in the top and bottom surfaces which was observed through several different test methods. There were also marking differences within the lot (missing and visibly altered markings in some cases). These parts were not blacktopped, but the top surface appears to have been reconditioned (possibly sand or bead blasted). The terminations showed many indications of quality issues such as refinishing, damaged leads, and oxidation which supports the other observed inconsistencies of these parts.

ERJ-3EKF3302V – Suspect – These parts exhibited very few observable defects. However, two observations clearly support suspect counterfeit activity. The parts were marked with EEE on the top surface. This was confirmed by the manufacturer to be incorrect for this part. There should be no markings on this part. The end metal was also formed incorrectly. The metallization on the top surface should have defined notches on each side. The bottom surface should have continuous metal from side to side with no notches per the manufacturer's part drawing. This part had notches on both the top and bottom metal. Another attribute which was a clear indicator was the dimensional characteristics of the end metal. The manufacturer is very specific about the distance the metal encroaches into the center of the part. Many of these parts appear visually to exceed this specification, but unfortunately, none of the test labs verified this characteristic during their dimensional analysis.

K9F4G08U0D-SIB0 – Suspect – The presence of sanding marks and blacktopping were clear evidence of suspect counterfeit activity. Ghost markings were present which further supports the surface alteration evidence. Device leads had clear indicators of refurbishment and were in poor condition. Attributes included bent leads, lack of tooling marks, plating thickness variation, and oxidation. These conditions further support the suspect counterfeit disposition.

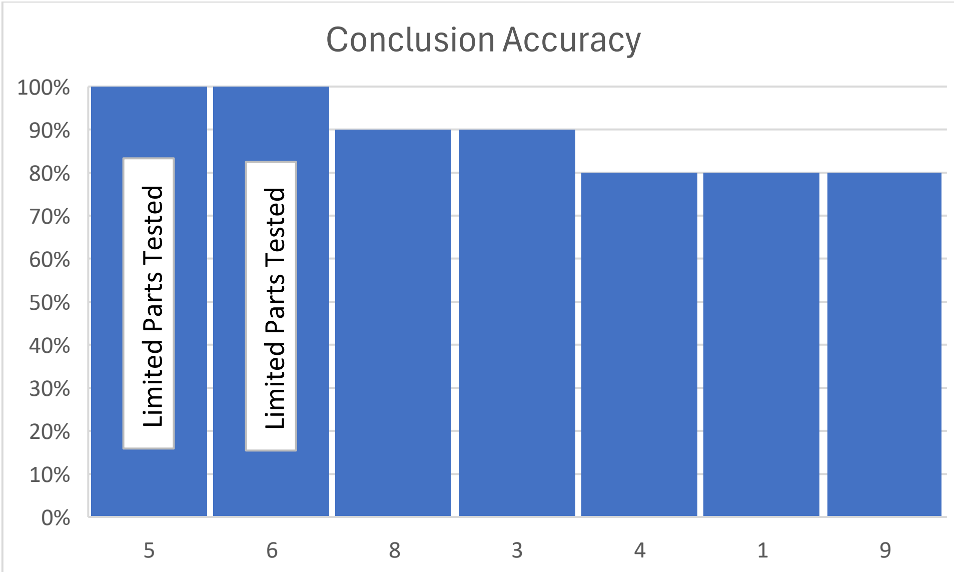


Figure 1 Conclusion Alignment with the Consensus Conclusion

3.1.2. Determination of Observed Defects

Each part summary in the following sections provides a summary of observed defects by each lab and an assessment of the supporting evidence provided. Two tables are presented for each lab. The first table identifies defects which were reported by a high percentage of the labs (>60% reporting). This highlights the test methods which were highly effective at observing specific defects. The second table identifies all defects which were observed by each lab using any of the test methods which the lab performed. This addresses overall recognition of defects. This table also includes a column titled “Supporting Evidence”. This column addresses whether any of the lab(s) demonstrated evidence of the identified defect. Additional notes are provided to clarify observations. The objective is to establish a ground truth based on the data presented by all of the labs. Statistics are provided to show how well each lab aligned with the ground truth. This data gives a strong indication of each lab’s ability to identify and interpret part observations, but should not be considered a precise scoring of each lab’s observations. Parts provided to each lab were taken from the same lots of parts and effort was made to assure each lab received similar parts. However, there can still be variations within the sublots of parts. This is particularly true of defects which are not visually identifiable, and therefore not observed during the phase I part characterization. To attempt to minimize the risk of the sublot variations, the frequency of occurrence of defects based on the phase 1 characterization testing was used to target a high probability of occurrence of defects within a sublot. 90% confidence was the target threshold used for the presence of key defects when achievable. There are some instances where this was not possible due to low frequency of occurrence and a limited number of sample parts available. Within the data provided in the tables, there will be situations where one lab observed a defect and another did not have that same defect within their sublot. When sufficient data was provided by the labs to discern this situation, it was noted in the table. In other cases, insufficient data was provided to make this determination conclusively. In those cases, the relative frequency for which a defect was observed was taken into account when determining whether a defect was likely to be present in another lab’s sublot. For example, if lab A observed a specific defect in 4-5 parts of a 5 piece sublot, then it is very probable that the same defect would be present in other sublots as well. This method of inferred recognition of defects will have errors, this is unavoidable. There will be instances where a defect was noted as not having been detected by a lab when it was not present in their sublot. Regardless, the overall observation rate is still indicative of the scope of observed defects identified by each lab. Assessment of outlier detections was also performed. In many instances, a single lab may identify a defect. This could mean the lab had a unique part in their sublot, made a unique observation, or the lab may have misinterpreted an observation. Based on the evidence provided by the labs, each of these outliers was evaluated for accuracy and likelihood of the same defect being present in other sublots. These distinctions are noted in the tables.

Defect detection data is provided for each part in the subsequent sections. The overall detection results are shown in Figure 2 Combined Detection Results for All Round Robin Test Parts below. These charts provide three data components. The blue bar shows the number of counterfeit related defects each lab identified through all testing they performed. These defects represent the defects which had clear supporting evidence of their presence. This evidence could be provided by any of the labs, not just limited to the reporting lab. For example, if one lab reported observing tin whiskers and provided a photo showing the presence of tin whiskers, then this defect was considered validated. If another lab also reported tin whiskers but did not provide substantiation, they would still get credit for this observation since the presence of tin whiskers had already been verified. The second data component are unsupported defects shown in orange. These are the observations reported by a lab that could not be substantiated. This can occur for several reasons. A lab may indicate the presence of a defect that they, or any other lab did not show supporting evidence for. Another possible cause would be misinterpretation of a test finding. Rationale for test result findings is included in the following sections of this report. The third component is shown with a green bar. This indicates the most possible observations a lab may have had. This number will vary for each lab due to variances in the test sublots (known presence of a defect) and the test capabilities of each lab. For example, if a lab does not have electrical test capability, then there would be no expectation for a lab to be able to identify an electrical performance issue, so these type of defects would be undetectable for that lab and not included in the total possible supported defects.

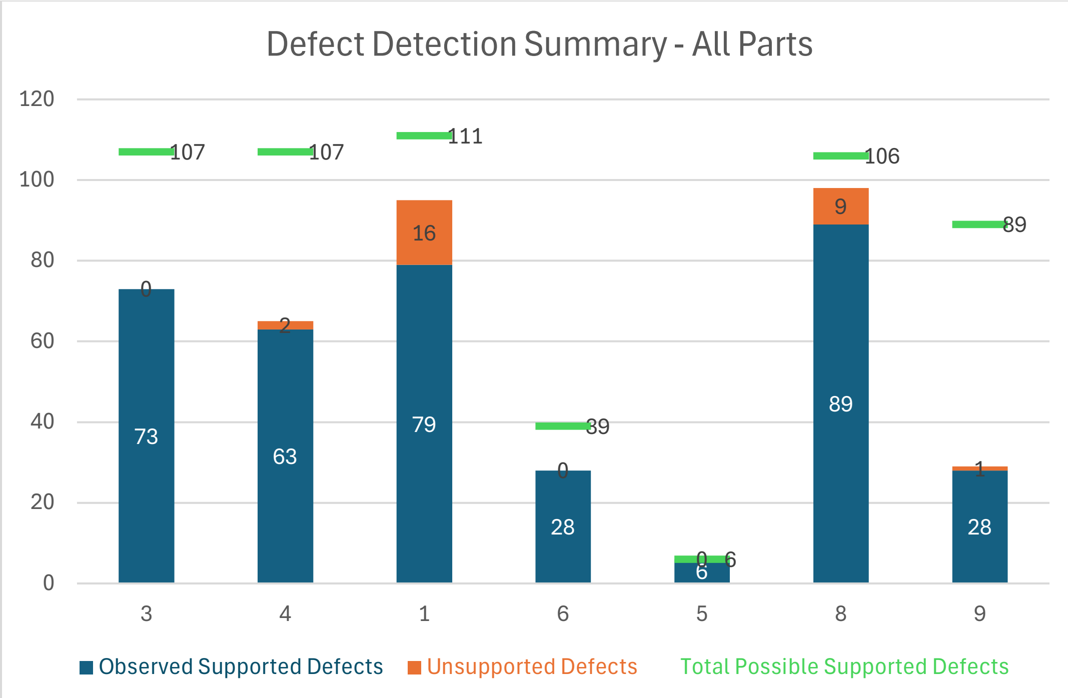


Figure 2 Combined Detection Results for All Round Robin Test Parts

The test labs identified 28 unique counterfeit defects as defined in AS6171 among the 10 part numbers assessed for this project. A complete list of the AS6171 defects highlighting the defects represented in the round robin test is shown in Table 4.

Property Category	Defect	Present in Round Robin Parts
Physical - Extensive Properties	Incorrect Part Package Outline Dimensions	Yes
	Incorrect Part Weight	
Physical - Terminations	Damaged Terminations	Yes
	Refinished Terminations	Yes
	Incorrect Termination Dimensions	Yes
	Incorrect Termination Materials	Yes
	Color Variations on Terminations	Yes
	Missing or Unexpected Tooling Marks on Terminations	Yes
	Missing or Unexpected Terminations	
	Termination Re-Attachment	Yes
	Oxidation/Corrosion of Terminations	Yes
Physical - Surface	Modified or Improper Surface Texture (physical alteration)	Yes
	Modified or Improper Markings on Package	Yes
	Heat Exposure	
	Ghost Markings	Yes
	Color Variations	Yes
	Improper Package Surface Textures (inconsistent packages)	Yes

Property Category	Defect	Present in Round Robin Parts
	Unexpected or Extraneous Marks on Package	Yes
	Package Fracture Damage	Yes
	Evidence of Resurfacing/Blacktopping	Yes
	Altered or Added Pin One Marker	Yes
	Whiskers	Yes
	Contamination or Corrosion on External Surface(s)	Yes
	Improper Material Composition of the External Surface(s)	Yes
Physical - Internal	Missing Bond Wires	
	Open Internal Interconnect	
	Inconsistent Wire Bond Pattern	Yes
	Defective Wire Bonds	
	Inadequate Wire Bond Strength	
	Contamination of Die Surface or Functional Passive Element	
	Missing Die or Functional Passive Element	
	Wrong Die or Functional Passive Element	Yes
	Delamination of Internal Layers	Yes
	Improper or Missing Die Markings	Yes
	Internal Damage	
	Defective Die Attach	
	Inconsistent or Incorrect Lead Frame	Yes
	Misaligned or Missing Contact Windows	
	Passivation Damage	
	Corrosion of Die Surface or Functional Passive Element	
	Impurities in Dielectric	
	Degradation of Die Metallization	
	Contamination of Internal Interconnect(s)	
	Contamination of Internal Cavity	
	Not Hermetic	
	Impurities in Semiconductor	
	Improper or Incorrect Internal Material	
Electrical	Out of Specification Static Electrical Characteristic(s)	Yes
	Out of Specification Dynamic Electrical Characteristic(s)	
	Out of Specification Electrical Functional Characteristic(s)	Yes
	Out of Specification Electrical Switching Time Characteristic(s)	
	Unexpected Degradation of Electrical Characteristics in Response to Stress or Aging	
	Out of Specification or Unexpected Electrical Characteristic(s) at Over Temperature	
	Unexpected or Incorrect Programming State	
	Unexpected or Incorrect Thermal Characteristics	

Property Category	Defect	Present in Round Robin Parts
	Electrical Intermittency	
Tampered	Unintended Communication	
	Unexpected or Altered Netlist	
	Exploitable Test Feature	
	Unexpected Test Sequence Outcome	
	Die Level Hardware Modification	
	Unexpected Software Function and/or Performance	
	Unexpected Software Code	
	Unexpected Firmware Operation	
	Unexpected Security Vulnerability	
	Unexpected Emission or Signature	

Table 4 Round Robin Test Parts Defect List

3.1.3. IS41LV16256B-35TL

DRAM CHIP EDO 4MBIT 256KX16 3.3V 40-PIN TSOP-II

All labs identified this part as suspect counterfeit. Table 5 summarizes the test methods and specific defects which had high correlation (>60%) between the test labs. Table 6 lists the defects identified by each lab and whether there was strong evidence presented to validate the presence of this defect (by any lab). Strong evidence was used as a criteria for establishing the Consensus Conclusion for each part. This evidence also corresponds to defects which if present, should have been identifiable by test labs.

Test Method	Defect	% Labs in Agreement
/2 – General EVI	Damaged Terminations	60
/2 - Detailed EVI	Oxidation/Corrosion of Terminations	86
/2 - Resurfacing	Evidence of Resurfacing/Blacktopping	83
/4 – Internal Visual	Wrong Die or Functional Passive Element	67
/5 - X-ray	Inconsistent Wire Bond Pattern	67
/5 - X-ray	Inconsistent or Incorrect Lead Frame	83
/10 - TGA	Improper Material Composition of the External Surface(s)	100 (only 1 lab performed TGA)

Table 5 High Correlation Lab Findings for IS41LV16256B-35TL

Defect	Supporting Evidence	Lab 3	Lab 4	Lab 1	Lab 6	Lab 5	Lab 8	Lab 9	%
Incorrect Part Package Outline Dimensions	No (measurements in spec except for 1 lab)			X					17
Damaged Terminations	Yes (High % occurrence)		X	X	Not present		X		50

Defect	Supporting Evidence	Lab 3	Lab 4	Lab 1	Lab 6	Lab 5	Lab 8	Lab 9	%
Refinished Terminations	Yes (plated lead tips and no tooling marks)	X					X	X	50
Incorrect Termination Dimensions	No (measurement in spec except for 1 lab)			X					33
Incorrect Termination Materials	No (materials correct, only thickness variation)						X (high plating thickness variation)		17
Color Variations on Terminations	Yes (Observable in photos from most labs)				X		X		33
Missing or Unexpected Tooling Marks on Terminations	Yes (Observable in photos from most labs)						X	X	33
Oxidation/Corrosion of Terminations	Yes (visible on all samples)	X	X	X	X		X	X	100
Modified or Improper Surface Texture (physical alteration)	Yes (sanded and recoated surfaces)	X	X	X	X		X		67
Modified or Improper Markings on Package	Yes (mold markings obscured)			X	X		X		33
Heat Exposure	No (speculative FTIR observation)			X					17
Ghost Markings	Yes (Clear marks visible on bottom)		X	X					33
Color Variations	Yes (coating color variations)			X	X		X		50
Improper Package Surface Textures (inconsistent packages)	Yes (sanding marks)		X	X	X		X		67
Unexpected or Extraneous Marks on Package	Yes (sanding scratches under coating)			X			X		33
Evidence of Resurfacing/ Blacktopping	Yes (coating removed showing under features)	X	X	X	X		X		83
Altered or Added Pin One Marker	Yes (marks recoated)	X	X	X	X		X		83
Whiskers	Yes (Observable in numerous	X							17

Defect	Supporting Evidence	Lab 3	Lab 4	Lab 1	Lab 6	Lab 5	Lab 8	Lab 9	%
	photos from several labs)								
Contamination or Corrosion on External Surface(s)	Yes (May not be on all samples)		X	X	X		X		50
Improper Material Composition of the External Surface(s)	Yes (TGA weight variances)	(No TGA)	(No TGA)	X	(No TGA)		X (miscategorized for coating, no TGA)	(No TGA)	33
Inconsistent Wire Bond Pattern	Yes (due to lead frame differences)	X	X		X		X	Not present in sample	80
Wrong Die or Functional Passive Element	Yes (2 die revs in some samples)	Not present in sample	Not present in sample	Not present in sample	X		X (die same, but questioned ICSI 2001 marking)	Not present in sample	50
Delamination of Internal Layers	Yes (observed with AM)	X	(No AM)		(No AM)		(No AM)	(No AM)	50
Improper or Missing Die Markings	Yes (2 die revs in some samples)	Not present in sample	Not present in sample	Not present in sample	X (2 die revs)		X (questioned ICSI 2001 marking)	Not present in sample	33
Inconsistent or Incorrect Lead Frame	Yes (3 possible)	X	X	X	X		X	Not present in sample	100
Correlation with Supported Evidence		0.50	0.59	0.68	0.89		0.89	0.20	
Unsupported Observations		0.00	0.00	0.75	0.00		0.25	0.00	

Table 6 Defects Identified by Test Labs for IS41LV16256B-35TL (considers all test methods)

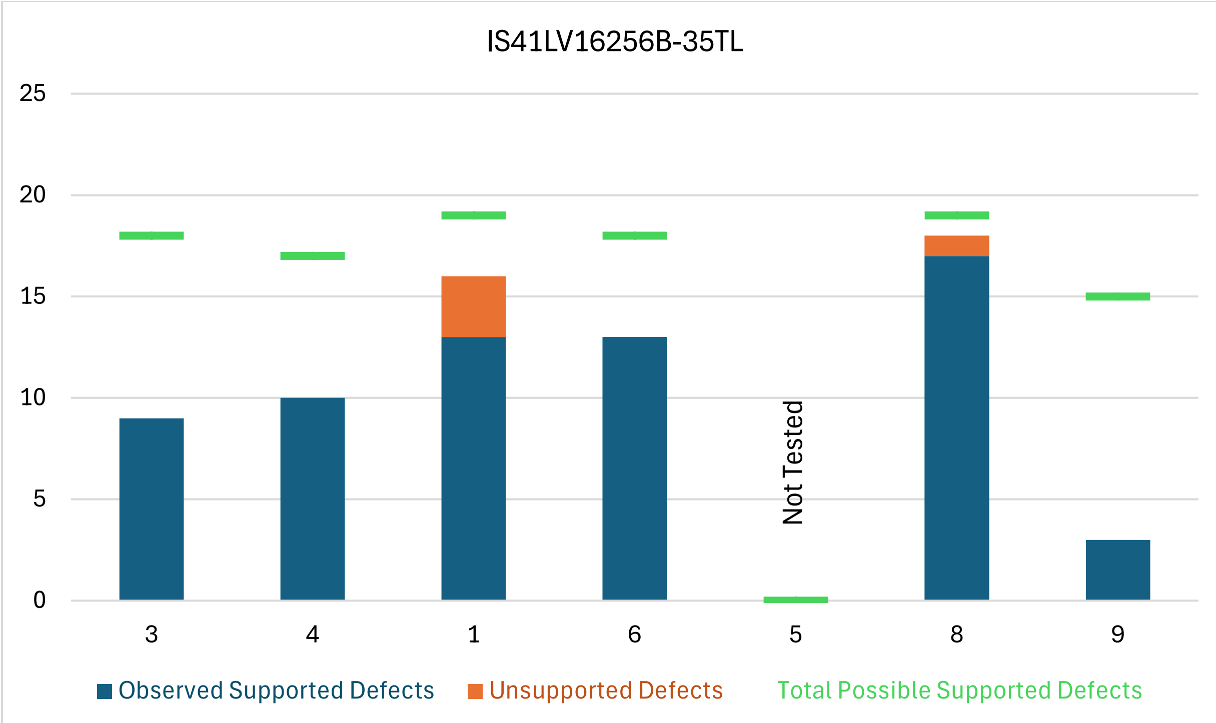
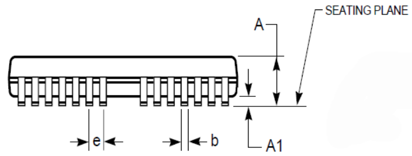


Figure 3 IS41LV16256B-35TL Defect Detection

3.1.3.1. Miscellaneous Observations

- Identification of whiskers on the leads was only noted by Lab 3, but photos of leads from several labs had multiple whiskers visible. Presence of this defect can be critical for reliable operation of hardware that parts may be used in.
- Labs performed solvents testing for resurfacing almost exclusively on the top surface only. Lab 4 was the only lab which also tested the backside of the parts, so they were the only lab to identify ghost markings on the backside via the resurfacing tests. Resurfacing tests should consider both sides of the part when testing. Additionally, areas where coating is removed should be extensive enough to reveal underlying attributes such as ghost markings.
- Part dimension measurements were within specification for all labs except Lab 1. Lab 1 performed some measurements using calipers whereas all other labs utilized optical measurement techniques exclusively. AS6171/2 specifically requires the use of non-contact optical measurement tools for this test. This could account for some of the differences. Another contributor is the use of derived specifications. The manufacturer specifies the overall device height (A) as A ≤ 1.20mm (see Figure 4). The lead standoff height specified as dimension A1 is 0.05<A1<0.15. The package thickness is not a controlled parameter. Lab 1 derived a package thickness (T) from these values as 1.05<T<1.15. As an example, device 1 measured T=1.00mm which is outside the derived limits. Standoff height (A1) and total height (A) were not measured. In comparison to

other labs which measured both (A) and (A1), no parts were outside either specification limit.

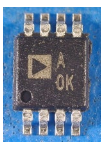


Plastic TSOP (T - Type II) (MS 24)				
	Millimeters		Inches	
Symbol	Min	Max	Min	Max
Ref. Std.				
N	40/44			
A		1.20		0.0472
A1	0.05	0.15	0.002	0.0059
b	0.30	0.45	0.012	0.0157
c	0.12	0.21	0.005	0.0083
D	18.31	18.51	0.721	0.7287
E_1	10.06	10.26	0.396	0.4040
e	0.80 BSC		0.031 BSC	
E	11.56	11.96	0.455	0.4709
L	0.40	0.60	0.016	0.0236
α	0°	8°	0°	8°

Figure 4 IS41LV16256B-35TL Dimensions

3.1.4. AD8616ARMZ-REEL

OP AMP DUAL PRECISION AMPLIFIER R-R I/O 5V 8-PIN MSOP T/R



Labs were divided on whether this part was acceptable or suspect with 3 of 5 labs which tested the part declaring it acceptable. The primary area of discrepancy was the top surface finish which was unusually rough and appeared to have a coating on it when observed along the edge. Even though the part visually appeared to be coated, the parts passed resurfacing tests. To better understand the nature of this part's finish, Aerocyonics requested the University of Michigan to perform a cross section analysis to inspect for potential coatings. A resurfaced part will show a clear change in the grain structure of the encapsulant at the material transition boundary if a coating is present. None was observed. See Appendix 1 for the University of Michigan analysis. Table 7 summarizes the test methods and specific defects which had high correlation (>60%) between the test labs. Table 8 lists the defects identified by each lab and whether there was strong evidence presented to validate the presence of this defect (by any lab). Strong evidence was used as a criteria for establishing the Consensus Conclusion for each part. This evidence also corresponds to defects which if present, should have been identifiable by test labs.

Test Method	Defect	% Labs in Agreement
/8 - Raman	Contamination or Corrosion on External Surface(s)	100 (1 lab performed test method)

Table 7 High Correlation Lab Findings for AD8616ARMZ-REEL

Defect	Supporting Evidence	Lab 3	Lab 4	Lab 1	Lab 6	Lab 5	Lab 8	Lab 9	%
Oxidation/Corrosion of Terminations	Yes (minor some samples, quality issue)	None observed	X	None observed			None observed	None observed	20
Modified or Improper Surface Texture (physical alteration)	No (some marking and texture variances observed, but no evidence of surface modification)			X					20
Modified or Improper Markings on Package	No (variance in marking			X					20

Defect	Supporting Evidence	Lab 3	Lab 4	Lab 1	Lab 6	Lab 5	Lab 8	Lab 9	%
	placement but no indications of alteration or remark)								
Improper Package Surface Textures (inconsistent packages)	No (possible coating related texture observed, but not supported by resurfacing tests)		X						20
Evidence of Resurfacing/ Blacktopping	No (visual appearance of a coating, but not supported by resurfacing tests or cross-section)		X	X					40
Altered or Added Pin One Marker	No (pin 1 marker placement varied, but no indication of alteration)			X					20
Contamination or Corrosion on External Surface(s)	Yes (contamination observable, some devices)			X					20
Wrong Die or Functional Passive Element	No (part markings were misinterpreted. Date code is not 1193)			X					20
Correlation with Supported Evidence		0.00	0.50	1.00			0.00	0.00	
Unsupported Observations		0.00	0.33	0.83			0.00	0.00	

Table 8 Defects Identified by Test Labs for AD8616ARMZ-REEL (considers all test methods)

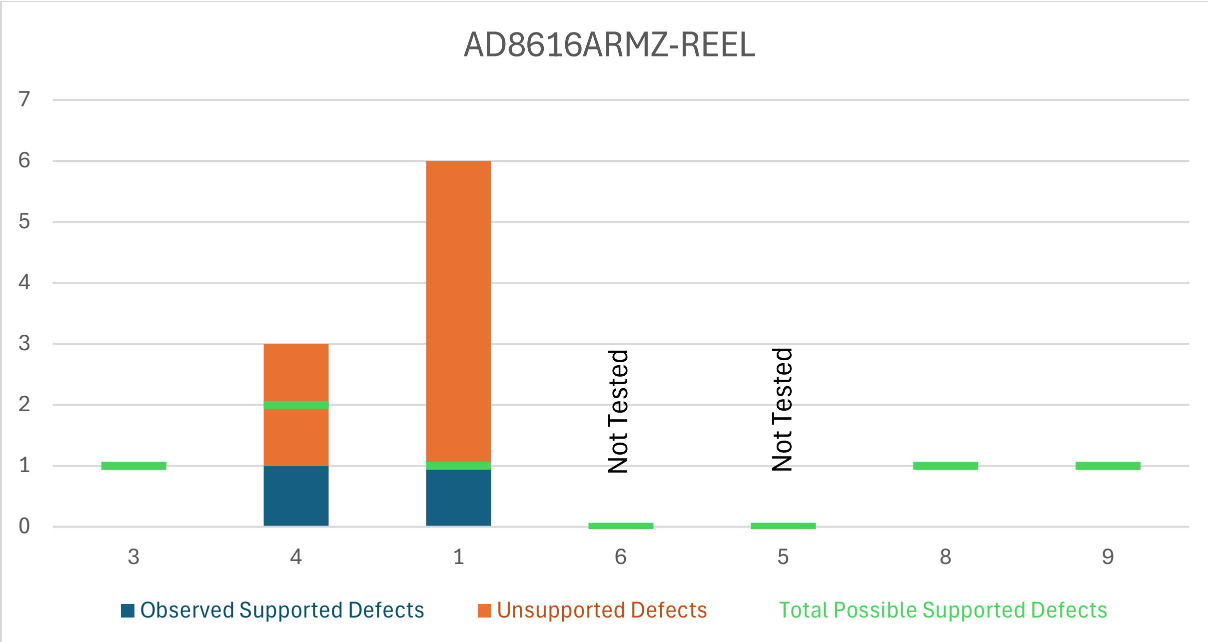


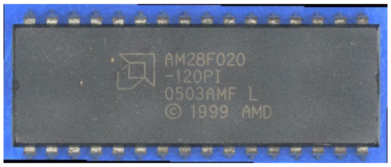
Figure 5 AD8616ARMZ-REEL Defect Detection

3.1.4.1. Miscellaneous Observations

- The surface texture of the device was concerning to several labs since it was noticeably rougher than the bottom surface and "appeared" to have coating overflow along the top edge. This led to blacktopping conclusions from several labs. However, solvent and scrape tests did not support this conclusion. Further analysis performed by the University of Michigan further supported that the parts had not been resurfaced.
- The Lab 1 report stated that the 2008 date on the die was inconsistent with the package date code. Part markings on the back of the device show #141 and 1193. The top surface does not include any marks that could be interpreted as a date code. The lab interpretation of the marking was that the parts were made in week 11 of 1993 meaning that the die date code is later than the package date (not possible, if authentic). The date code is actually indicated by #141. The # symbol indicates this is a ROHS compliant part. The date code is 141 indicating week 41 of a year ending in "1", so theoretically 2001, 2011, or 2021. The initial release of the datasheet for this part was January 2004 (See the revision history on the revision 1 datasheet (https://docs.rs-online.com/9a03/0900766b804ffe3f.pdf), so that means the manufacture year could be 2011 or 2021, which both are subsequent to the 2008 die date. Additionally, Lab 9 has this part number in their database of devices with full traceability. Their device is marked #248. The authorized distributor, DigiKey, stated on the traceability paperwork that the device date code is 2248 (week 48 of 2022) which conforms to the date code decoding stated above. This device contained the same 2008 die revision as the project sample parts. If these devices had been remarked, then the date code used was properly formatted and the internal die is correct for the date code shown on the package.

3.1.5. AM28F020-120PI

NOR FLASH PARALLEL 5V 2M-BIT 256K X 8 120NS 32-PIN PDIP



All labs identified this part as suspect counterfeit. Table 9 summarizes the test methods and specific defects which had high correlation (>60%) between the test labs . Table 10 lists the defects identified by each lab and whether there was strong evidence presented to validate the presence of this defect (by any lab). Strong evidence was used as a criteria for establishing the Consensus Conclusion for each part. This evidence also corresponds to defects which if present, should have been identifiable by test labs.

Test Method	Defect	% Labs in Agreement
/2 - Detailed EVI	Oxidation/Corrosion of Terminations	83
/2 - Detailed EVI	Modified or Improper Surface Texture (physical alteration)	67
/2 - Detailed EVI	Altered or Added Pin One Marker	67
/2 - Resurfacing	Evidence of Resurfacing/Blacktopping	80
/3 – XRF	Incorrect Termination Materials	60
/4 – Internal Visual	Wrong Die or Functional Passive Element	80
/4 – Internal Visual	Improper or Missing Die Markings	80
/5 - X-ray	Inconsistent or Incorrect Lead Frame	60
/7 - Electrical	Out of Specification Static Electrical Characteristic(s)	100 (2 labs performed test method)
/8 - Raman	Improper Material Composition of the External Surface(s)	100 (1 lab performed test method)
/9 - FTIR	Improper Material Composition of the External Surface(s)	100 (2 labs performed test method)
/10 - TGA	Improper Material Composition of the External Surface(s)	100 (1 lab performed test method)

Table 9 High Correlation Lab Findings for AM28F020-120PI

Defect	Supporting Evidence	Lab 3	Lab 4	Lab 1	Lab 6	Lab 5	Lab 8	Lab 9	%
Incorrect Part Package Outline Dimensions	No (measurements were performed on bent leads)						X		20
Damaged Terminations	Yes (some parts only)	Not present	X	Not present			X	Not present	100
Refinished Terminations	No (no clear evidence of refinish, just heavy oxidation)						X (on checklist, but not in report, considered a checklist entry error)		20
Incorrect Termination Dimensions	No (dimension errors reflect bent pins, not construction abnormalities)						X		20

Defect	Supporting Evidence	Lab 3	Lab 4	Lab 1	Lab 6	Lab 5	Lab 8	Lab 9	%
Incorrect Termination Materials	Yes (severely degraded plating results in improper composition & thickness)	X	X				X		60
Color Variations on Terminations	Yes (due to oxidation)						X		20
Missing or Unexpected Tooling Marks on Terminations	No (not substantiated in reports)						X		20
Oxidation/Corrosion of Terminations	Yes (extensive oxidation on all parts)	X	X	X			X	X	100
Modified or Improper Surface Texture (physical alteration)	Yes (sanding marks visible)	X	X	X			X	X	100
Modified or Improper Markings on Package	Yes (presence of resurfacing supports part remarking)	X	X	X			X		80
Color Variations	Yes (color shift between coated and uncoated areas)	X					X		40
Improper Package Surface Textures (inconsistent packages)	Yes (variability due to recoating/sanding)	X		X			X		60
Unexpected or Extraneous Marks on Package	Yes (sanding striations)			X			X		40
Package Fracture Damage	Yes (small chipouts, few parts with defect)	Not present	X	Not present			Not present	Not present	100
Evidence of Resurfacing/Blacktopping	Yes (observed and validated by multiple labs)	X	X	X			X		80
Altered or Added Pin One Marker	Yes (marks coated and/or damaged by sanding)	X	X	X			X	X	100
Whiskers	Yes (visible on several lab's photos)	X							20
Contamination or Corrosion on External Surface(s)	Yes (random contamination on some parts)			X			X		40

Defect	Supporting Evidence	Lab 3	Lab 4	Lab 1	Lab 6	Lab 5	Lab 8	Lab 9	%
Improper Material Composition of the External Surface(s)	Yes (inconsistent materials due to resurfacing)	X		X			X		60
Inconsistent Wire Bond Pattern	Yes (wire bond pattern change when AMD and Intel die present)	Not present	Not present	X			X	Not present	100
Wrong Die or Functional Passive Element	Yes (AMD & Intel die, multiple die revisions)	X	X	X			X	Not present	100
Delamination of Internal Layers	Yes (requires AM to detect)		No AM	X			No AM	No AM	50
Improper or Missing Die Markings	Yes (AMD & Intel die, multiple die revisions)	X	X	X			X	Not present	100
Inconsistent or Incorrect Lead Frame	Yes (visible in x-ray in some sample groups)	Not present	X	X			X	Not present	100
Out of Specification Static Electrical Characteristic(s)	Yes (validated by multiple labs)	X	X	No electrical test			No electrical test	No electrical test	100
Correlation with Supported Evidence		0.76	0.63	0.78			0.94	0.23	
Unsupported Observations		0.00	0.00	0.00			0.75	0.00	

Table 10 Defects Identified by Test Labs for AM28F020-120PI (considers all test methods)

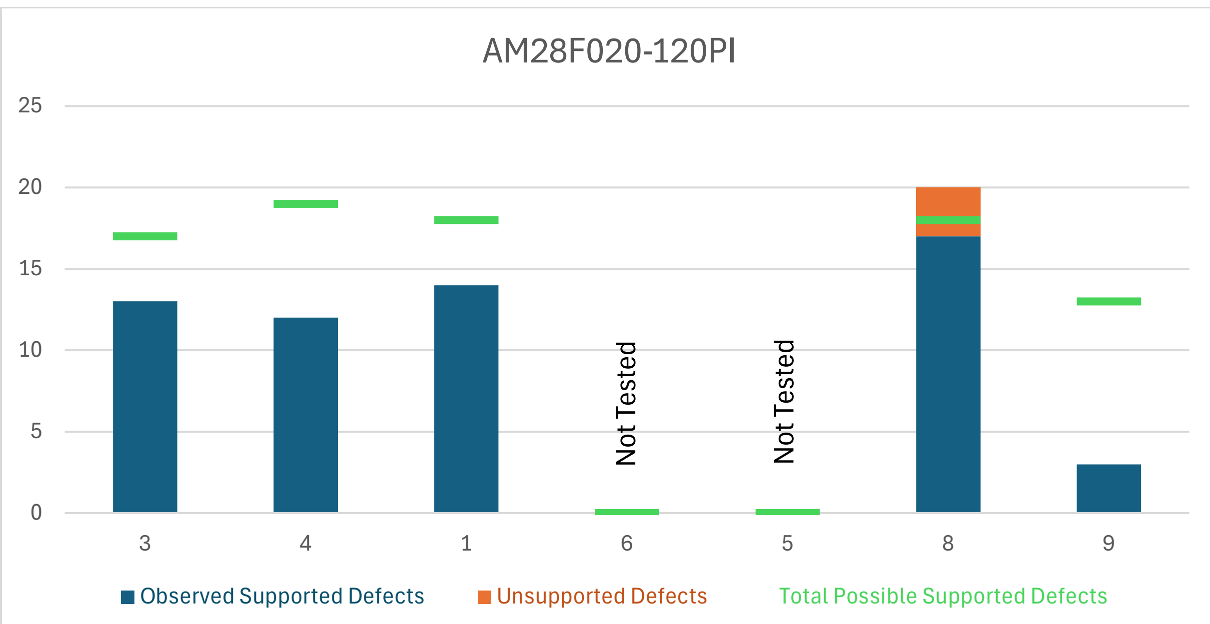


Figure 6 AM28F020-120PI Defect Detection

3.1.5.1. Miscellaneous Observations

- Several instances of Intel die were found in inspected devices. Some indicated that this was not expected since AMD and Intel were competitors. However, during the time frame these devices were manufactured, second source agreements were used specifically for the Intel die. For example, the Catalyst Semiconductor CAT28F020 uses the Intel die in their equivalent part (https://datasheet4u.com/pdf-down/C/A/T/CAT28F020-CatalystSemiconductor.pdf). It is unclear if a second source agreement was also in place between AMD and Intel at this time. If AMD had a second source agreement with Intel for the use of Intel die in this device, finding Intel die would not be a sign of counterfeiting of this part. But the presence of mixed die and multiple die revisions within a single lot are positive indicators.

3.1.6. IS61WV25616BLL-10BLI

SRAM CHIP ASYNC SINGLE 2.5V/3.3V 4M-BIT 256K X 16 10NS 48-PIN TFBGA

40% of the labs identified this part as suspect counterfeit. Table 11 summarizes the test methods and specific defects which had high correlation (>60%) between the test labs. Table 12 lists the defects identified by each lab and whether there was strong evidence presented to validate the presence of this defect (by any lab). Strong evidence was used as a criteria for establishing the Consensus Conclusion for each part. This evidence also corresponds to defects which if present, should have been identifiable by test labs. This part is a known authentic device. Aerocyonics purchased the part direct from Digi-Key who is an authorized distributor for ISSI (https://www.issi.com/WW/SalesNetwork/USSalesNetwork/Sales_Network.aspx?MID=Disti). The parts were received in factory sealed packaging. Defects found with this part should have been attributed to quality issues as opposed to counterfeiting.

Test Method	Defect	% Labs in Agreement
/8 - Raman	Improper Material Composition of the External Surface(s)	100 (1 lab performed test method)

Table 11 High Correlation Lab Findings for IS61WV25616BLL-10BLI

Defect	Supporting Evidence	Lab 3	Lab 4	Lab 1	Lab 6	Lab 5	Lab 8	Lab 9	%
Incorrect Part Package Outline Dimensions	No (Failed derived spec for thickness which isn't a controlled parameter)			X					20
Damaged Terminations	Yes (likely handling damage)	None found	X (1 part)	None found			None found	None found	100
Modified or Improper Markings on Package	No (minor marking variations within manufacturing variability)			X					20

Defect	Supporting Evidence	Lab 3	Lab 4	Lab 1	Lab 6	Lab 5	Lab 8	Lab 9	%
Package Fracture Damage	Yes (likely handling damage)	None found	X (1 part)	None found			None found	None found	100
Evidence of Resurfacing/Blacktopping	No (Package degradation from solvent misinterpreted as resurfacing)			X					20
Contamination or Corrosion on External Surface(s)	Yes (random surface contamination)		FTIR and Raman not performed	X			FTIR and Raman not performed	FTIR and Raman not performed	50
Improper Material Composition of the External Surface(s)	Yes (random surface contamination)	X	FTIR and Raman not performed				FTIR and Raman not performed	FTIR and Raman not performed	50
Correlation with Supported Evidence		0.50	1.00	0.50			N/A	N/A	
Unsupported Observations		0.00	0.00	1.00			0.00	0.00	

Table 12 Defects Identified by Test Labs for IS61WV25616BLL-10BLI (considers all test methods)

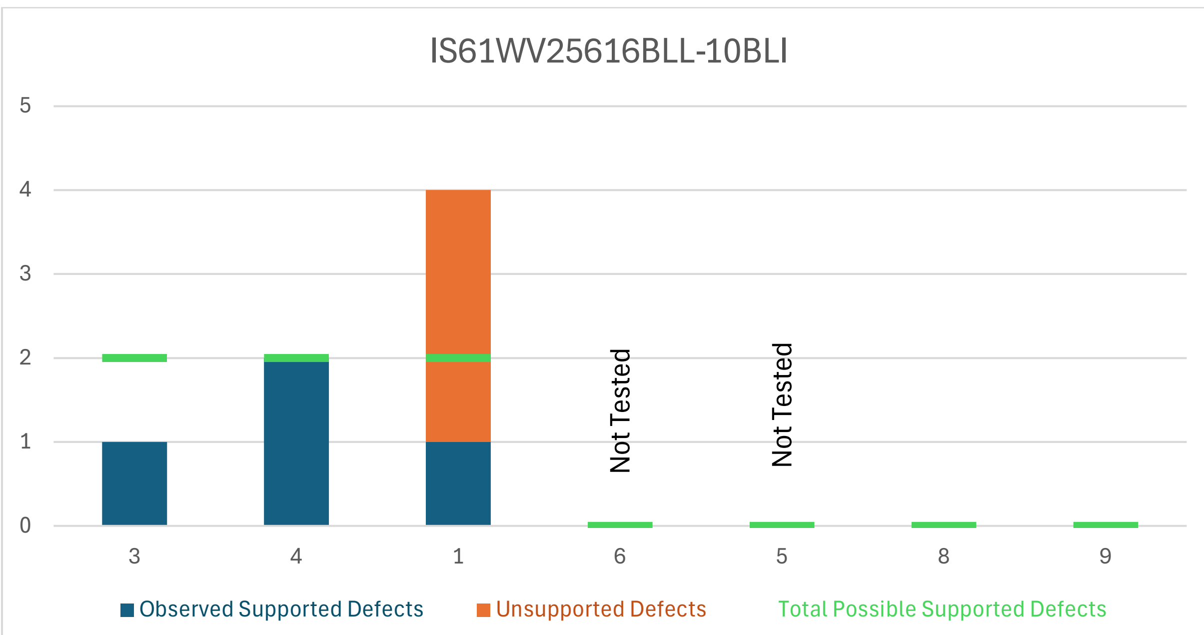


Figure 7 IS61WV25616BLL-10BLI Defect Detection

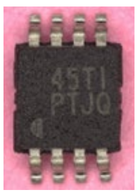
3.1.6.1. Miscellaneous Observations

- This part having a known authentic pedigree provided insight into interpretation of observations which can be associated with either counterfeiting or quality/handling related issues. Given the objective of this project was to evaluate parts using AS6171 test methods, this may have led to preconceived interpretations of any findings which surfaced during testing.
- FTIR and Raman both revealed random instances of contamination on devices. Each lab categorized the finding differently (contamination vs. improper material composition) but

both labs were observing the same basic issue. This type of finding needs to be considered in context with the environment in which the parts have existed. For example, parts in this test were all handled during preliminary evaluations, sorting and repackaging for this project, plus any handling prior to preparing for this project. There is ample opportunity for random contamination. The observed contamination had a low rate of occurrence. In the broker market, many (if not most) parts will be handled for inspection purposes and for repackaging. These type of details should be considered in the overall assessment of parts.

3.1.7. TPS7A4901DGNT

LDO REGULATOR POS 1.194V TO 33V 0.15A 8-PIN HVSSOP EP T/R



5 of 6 labs reported this device as suspect counterfeit. Table 13 summarizes the test methods and specific defects which had high correlation (>60%) between the test labs. Table 14 lists the defects identified by each lab and whether there was strong evidence presented to validate the presence of this defect (by any lab). Strong evidence was used as a criteria for establishing the Consensus Conclusion for each part. This evidence also corresponds to defects which if present, should have been identifiable by test labs.

Test Method	Defect	% Labs in Agreement
/2 - Detailed EVI	Modified or Improper Surface Texture (physical alteration)	71
/2 - Detailed EVI	Evidence of Resurfacing/Blacktopping	71
/2 - Resurfacing	Evidence of Resurfacing/Blacktopping	67
/8 - Raman	Improper Material Composition of the External Surface(s)	100 (1 lab performed the test method)
/9 - FTIR	Improper Material Composition of the External Surface(s)	100 (2 labs performed the test method)

Table 13 High Correlation Lab Findings for TPS7A4901DGNT

Defect	Supporting Evidence	Lab 3	Lab 4	Lab 1	Lab 6	Lab 5	Lab 8	Lab 9	%
Incorrect Part Package Outline Dimensions	No (Measurements should exclude flash and thickness is not specified)			X					17
Damaged Terminations	Yes (bent pins on some samples)	None present	None present	X		None present	None present	None present	100
Color Variations on Terminations	Yes (present on some samples)	None present	X	None present		None present	None present	None present	100
Oxidation/Corrosion of Terminations	Yes (present on some samples)	None observed	None observed	None observed		None observed	X	X	100

Defect	Supporting Evidence	Lab 3	Lab 4	Lab 1	Lab 6	Lab 5	Lab 8	Lab 9	%
Modified or Improper Surface Texture (physical alteration)	Yes (sanding, uneven top surface)	X	X	X		X	X		83
Modified or Improper Markings on Package	Yes (laser marking burns) No (Inconsistency of marking placement, but was in dimensional spec range)			X (marking placement, excluded from stats, see note)		X (laser marking burns)			33
Improper Package Surface Textures (inconsistent packages)	Yes (Uneven top surface from sanding)	X				X	X		50
Unexpected or Extraneous Marks on Package	Yes (sanding marks)			X		X	X		17
Evidence of Resurfacing/Blacktopping	Yes (visible and confirmed removal)	X	X	X		X	X		83
Altered or Added Pin One Marker	Yes (inconsistency of marking placement)	Placement varied but within spec	Placement varied but within spec	X		X	Placement varied but within spec	Placement varied but within spec	33
Contamination or Corrosion on External Surface(s)	Yes (random contamination on some parts)	None noted	X	X		None noted	X	None noted	100
Improper Material Composition of the External Surface(s)	Yes (contamination found through surface analysis)	X	FTIR and Raman not performed	X		FTIR and Raman not performed	FTIR and Raman not performed	FTIR and Raman not performed	100
Defective Wire Bonds	No (Noted as observation, but not supported with evidence or correlation)						X		17
Wrong Die or Functional Passive Element	No (Some size variation noted in AM and x-ray, but not supported by internal visual)			X					17
Improper or Missing Die Markings	No (No mfg marking but correct die family ID)			X			X		33
Correlation with Supported Evidence		0.67	0.57	0.86		0.83	0.86	0.17	
Unsupported Observations		0.00	0.00	0.60		0.20	0.40	0.00	

Table 14 Defects Identified by Test Labs for TPS7A4901DGNT (considers all test methods)

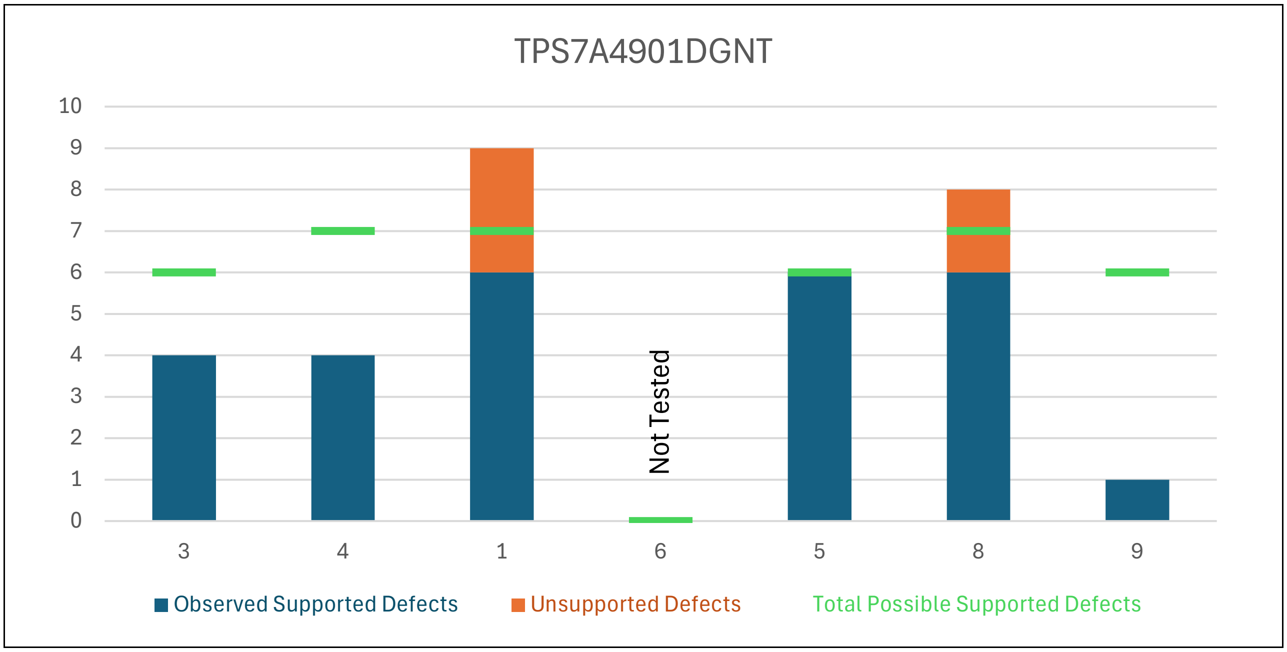


Figure 8 TPS7A4901DGNT Defect Detection

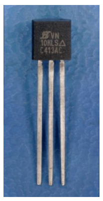
3.1.7.1. Miscellaneous Observations

- These parts had significant amounts of flash present around the perimeter. The drawing notes specifically exclude flash from dimension measurements. Lab 1 is the only lab which performed some measurements using a caliper. It is very difficult to exclude flash from the measurements when measured mechanically. This resulted in oversize measurements for both X and Y orientations. Lab 1 also inferred a specification for package thickness based on the total height specification (includes package thickness and lead standoff) minus lead standoff. The manufacturer only specifies total height with a maximum limit (no minimum). Lab 1 derived a minimum specification from the standoff tolerance which measurements did not conform with. All thickness measurements taken conform to the product specification as defined on the package drawing. Note that standoff was not measured.
- Several labs noted that the die did not have any manufacturer markings. It did have a die version mark which was TPS7A49C which corresponds with the device part number. Lab 9 had imagery of a known pedigree part for this device. Comparisons of the die imagery between the known good die and the parts under analysis showed the same die markings and die layout. The lack of manufacturer branding is not considered a counterfeit defect by itself, as this is often left off of small die.
- Marking placement varied from part to part. This was most noted with regard to the pin one marker placement. However, the part drawing identified an area where the marking could be placed (lower left quadrant) indicating there is a range of variability in the mark placement. No labs noted placement outside of the designated area per the drawing. Lab

1 and Lab 5 considered the variability a defect. Others did not. This observation could be considered correct with either response (yes, the placement varies or no, placement is within specification so there is no abnormal variance). For this reason, this issue is excluded from statistical calculations.

3.1.8. VN10KLS

TRANS MOSFET N-CH 60V 0.31A 3-PIN TO-92S



All labs reported this device as suspect counterfeit. Table 15 summarizes the test methods and specific defects which had high correlation (>60%) between the test labs. Table 16 lists the defects identified by each lab and whether there was strong evidence presented to validate the presence of this defect (by any lab). Strong evidence was used as a criteria for establishing the Consensus Conclusion for each part. This evidence also corresponds to defects which if present, should have been identifiable by test labs.

Test Method	Defect	% Labs in Agreement
/2 - Detailed EVI	Improper Package Surface Textures (inconsistent packages)	67
/2 - Resurfacing	Modified or Improper Surface Texture (physical alteration)	60
/2 - Resurfacing	Evidence of Resurfacing/Blacktopping	80
/4 – Internal Visual	Wrong Die or Functional Passive Element	60
/5 - X-ray	Inconsistent Wire Bond Pattern	60
/5 - X-ray	Wrong Die or Functional Passive Element	80
/5 - X-ray	Inconsistent or Incorrect Lead Frame	100
/7 - Electrical	Out of Specification Static Electrical Characteristic(s)	67
/8 - Raman	Improper Material Composition of the External Surface(s)	100 (1 lab performed test method)
/9 - FTIR	Improper Material Composition of the External Surface(s)	100 (2 labs performed test method)
/10 - TGA	Improper Material Composition of the External Surface(s)	100 (1 lab performed test method)

Table 15 High Correlation Lab Findings for VN10KLS

Defect	Supporting Evidence	Lab 3	Lab 4	Lab 1	Lab 6	Lab 5	Lab 8	Lab 9	%
Incorrect Part Package Outline Dimensions	Yes (some parts out of spec)	X (1 part thickness 0.01mm out)	None present	None present			None present	X (measured face, not full width so measurement unreliable)	50
Damaged Terminations	Yes (observable irregularities from lead reattachment)	X	X						40
Refinished Terminations	Yes (no exposed metal on lead tips)	X		X			X		60

Defect	Supporting Evidence	Lab 3	Lab 4	Lab 1	Lab 6	Lab 5	Lab 8	Lab 9	%
Incorrect Termination Materials	Yes (plating inconsistency some samples)	Some variance noted but deemed acceptable	Consistent plating	Some variance noted but deemed acceptable			X	X	40
Missing or Unexpected Tooling Marks on Terminations	Yes (missing tooling marks from lead trim)						X		20
Termination Re-Attachment	Yes (observable in photos from all labs)	X						X	40
Modified or Improper Surface Texture (physical alteration)	Yes (sanding marks)	X	X	X			X		80
Modified or Improper Markings on Package	Yes (marking inconsistencies)	X	X	X			X	X	100
Color Variations	Yes (visible color delineation from blacktopping)	X					X		40
Improper Package Surface Textures (inconsistent packages)	Yes (part to part variations)	X	X	X			X		80
Unexpected or Extraneous Marks on Package	Yes (sanding scratches)	X	X	X			X		60
Evidence of Resurfacing/Blacktopping	Yes (blacktopping visible and confirmed by test)	X	X	X			X		80
Altered or Added Pin One Marker	Yes (missing COO on some devices, inconsistent mold marks)	X		X			X		40
Contamination or Corrosion on External Surface(s)	Yes (random contamination on some parts)	None found	None found	None found			X	None found	100
Improper Material Composition of the External Surface(s)	Yes (improper coating on top surface)	X		X			X		60
Inconsistent Wire Bond Pattern	Yes (due to lead frame variations	X		X			X	X	80
Wrong Die or Functional Passive Element	Yes (several die versions)	X	Inspected 1 die, no comparisons	X			X	X	80

Defect	Supporting Evidence	Lab 3	Lab 4	Lab 1	Lab 6	Lab 5	Lab 8	Lab 9	%
Improper or Missing Die Markings	No (die not marked, kerf only)	noted not present	noted not present	X (noted not present, unclear if considered an issue)			X (die marking on kerf not consistent)	die marking on kerf not consistent	100
Inconsistent or Incorrect Lead Frame	Yes (multiple variants)	X	X	X			X	X	100
Out of Specification Static Electrical Characteristic(s)	Yes (inconsistent electrical characteristics between some samples)	Passed electrical test, defect not present	X (passed electrical test but flagged for wide part to part variance)	No electrical test			No electrical test	X (passed electrical test but flagged for wide part to part variance)	100
Correlation with Supported Evidence		0.88	0.44	0.63			0.88	0.41	
Unsupported Observations		0.00	0.00	0.00			0.00	0.00	

Table 16 Defects Identified by Test Labs for VN10KLS (considers all test methods)

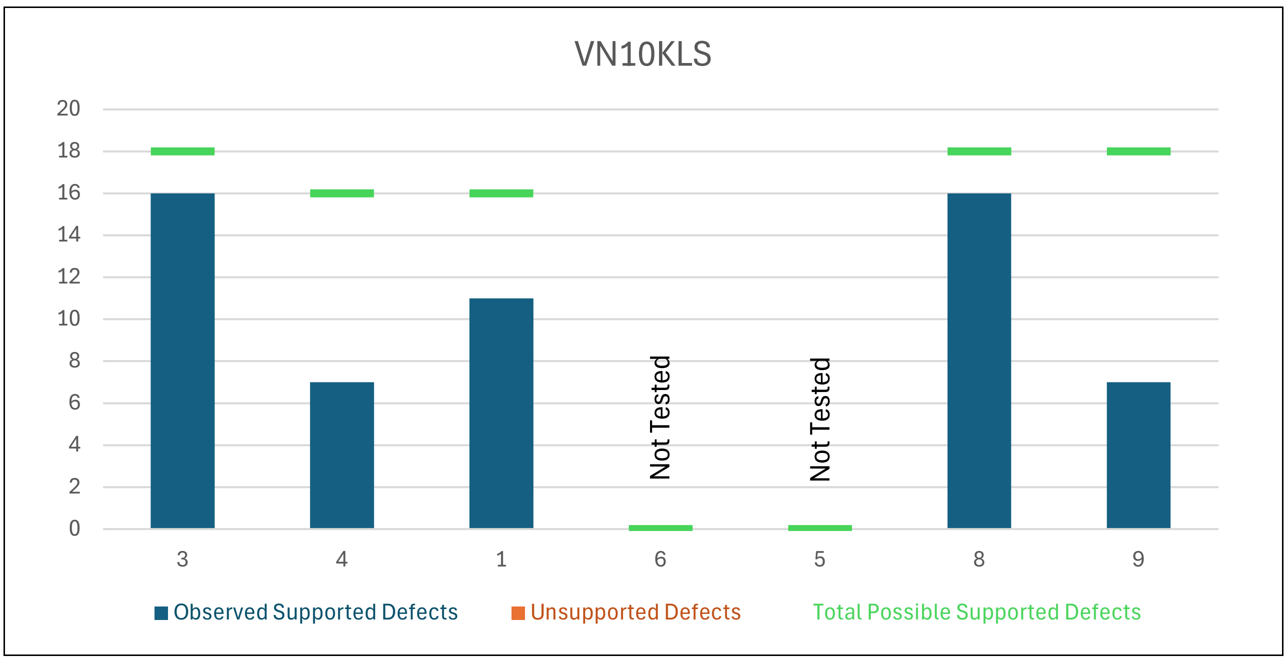


Figure 9 VN10KLS Defect Detection

3.1.8.1. Miscellaneous Observations

- Part dimensional measurements mostly measured within specification. One part measured by Lab 3 showed the thickness to be 0.01mm too thin. Measurement imagery shows the measurements were taken correctly. The wide variation in thickness between samples may be attributable to sanding of the face which was noted by several labs. Lab 9 also noted dimensional issues with the width being significantly under spec. Dimensional imagery shows that the out of specification measurements were taken on the face of the device which is narrower than the body width. One device measured the full width and that measurement was within specification.

- The defect "Altered or Added Pin One Marker" was used by two labs to note irregularities in the mold mark on the back center of the device. Other labs noted these same inconsistencies as "Modified or Improper Markings on Package". The mold mark is not a pin one marker for this device, so these defects would have been better classified as "Modified or Improper Markings on Package". The data is reported as the labs identified the anomalies, but results for these two defects should be considered together since they represent the same underlying issue.
- Die markings are not present on this device, but remnants of die markings found in the kerf area are visible in some imagery. Most are unreadable in that they were damaged during die cleaving. Lack of marking on the die itself is not a defect for this type of device. It is common to see this practice on die such as this. Variations in any residual kerf markings would be an additional indicator of inconsistent die. Labs were inconsistent in identification of "Improper or Missing Die Markings" for this part due to ambiguity of the defect. Some interpreted this defect as a general lack of markings (regardless of whether correct or incorrect for this part). Others considered it only if different than expected for this part type. If labs made note of either lack of marks or the presence of kerf marks, it was considered an observation of this attribute.
- Labs testing electrical characteristics focused on gate threshold voltage ($V_{GS(th)}$) and breakdown voltage $V(BR)_{DSS}$. Parts consistently tested within specification but several labs noted large part to part variations and identified this as a failed condition. The number of outliers in each part sample group varied with Lab 3 not having any outliers, Lab 4 had two, and Lab 9 had 3.

3.1.9. XCS30-3TQ144C

FPGA SPARTAN® FAMILY 30K GATES 1368 CELLS 125MHZ 5V 144-PIN TQFP

All labs identified this part as suspect counterfeit. Table 17 summarizes the test methods and specific defects which had high correlation (>60%) between the test labs. Table 18 lists the defects identified by each lab and whether there was strong evidence presented to validate the presence of this defect (by any lab). Strong evidence was used as a criteria for establishing the Consensus Conclusion for each part. This evidence also corresponds to defects which if present, should have been identifiable by test labs.

Test Method	Defect	% Labs in Agreement
/2 – General EVI	Damaged Terminations	60
/2 - Detailed EVI	Damaged Terminations	71
/2 - Resurfacing	Evidence of Resurfacing/Blacktopping	83
/8 - Raman	Improper Material Composition of the External Surface(s)	100 (1 lab performed the test method)

Table 17 High Correlation Lab Findings for XCS30-3TQ144C

Defect	Supporting Evidence	Lab 3	Lab 4	Lab 1	Lab 6	Lab 5	Lab 8	Lab 9	%
Incorrect Part Package Outline Dimensions	Yes (some parts slightly OOS) No (pin/pin spacing should be measured on unbent pins)	X (1 part thickness too low)	None noted	None noted	None noted		X (failed for lead spacing, but measured on bent pins)	None noted	100
Damaged Terminations	Yes (many bent pins, essentially all parts)	X	X	X	X		X	X	100
Refinished Terminations	Yes (no lead tooling marks, plated lead tips)	X	X		X		X	X	83
Incorrect Termination Dimensions	No (measurements should be measured on unbent pins)						X (failed for lead spacing, but measured on bent pins)		17
Incorrect Termination Materials	Yes (some plating thickness variations)	Composition ok, didn't measure thickness	Showed plating variation but considered acceptable	Plating thickness variation but considered acceptable	Test not performed		X (plating thickness variations)	Composition ok, didn't measure thickness	17
Color Variations on Terminations	Yes (visible in most lead photos)		X	X					33
Missing or Unexpected Tooling Marks on Terminations	Yes (presence of tooling marks is expected)	X (report entry error. Noted no marks and retinning but not marked suspect)	X		X		X	X	67
Oxidation/Corrosion of Terminations	Yes (possible on some leads)	None observed	None observed	X	None observed		None observed	None observed	100
Modified or Improper Surface Texture (physical alteration)	Yes (sanding marks)	X		X			X		50
Modified or Improper Markings on Package	Yes (recoated, different molded fonts)	X	X	X			X		67
Ghost Markings	Yes (some devices, top surface)			X					17
Color Variations	Yes (demarcation line from coating)	X			X				33

Defect	Supporting Evidence	Lab 3	Lab 4	Lab 1	Lab 6	Lab 5	Lab 8	Lab 9	%
Improper Package Surface Textures (inconsistent packages)	Yes (sanding variability, resurfacing)	X	X	X	X		X	X	100
Unexpected or Extraneous Marks on Package	Yes (marking irregularities, random reconditioning artifacts)	X		X			X		50
Evidence of Resurfacing/Blacktopping	Yes (visible and test verified)	X	X	X	X		X		83
Altered or Added Pin One Marker	Yes (mold marks altered by resurfacing process)	X	X		X		X		67
Whiskers	Yes (some devices)	X	Not seen	X	Not seen		Not seen	Not seen	100
Improper Material Composition of the External Surface(s)	Yes (top vs. bottom material difference)	X	Raman and FTIR not performed	X	Raman and FTIR not performed		Raman and FTIR not performed	Raman and FTIR not performed	100
Delamination of Internal Layers	Yes (observable with AM)	X	AM not performed		AM not performed		AM not performed	AM not performed	100
Inconsistent or Incorrect Lead Frame	Yes (multiple lead frames possible, some parts)	X	Not observed (58% probability defect wasn't present)	X	Not observed (58% probability defect wasn't present)		Not observed (58% probability defect wasn't present)	X	100
Out of Specification Static Electrical Characteristic(s)	Undetermined (possible boundary scan failure)	X (failed electrical test)	X Passed electrical test	Electrical test not performed	Electrical test not performed		Electrical test not performed	Electrical test not performed	N/A
Correlation with Supported Evidence		0.84	0.64	0.67	0.58		0.77	0.38	
Unsupported Observations		0.00	0.00	0.00	0.00		1.0	0.00	

Table 18 Defects Identified by Test Labs for XCS30-3TQ144C (considers all test methods)

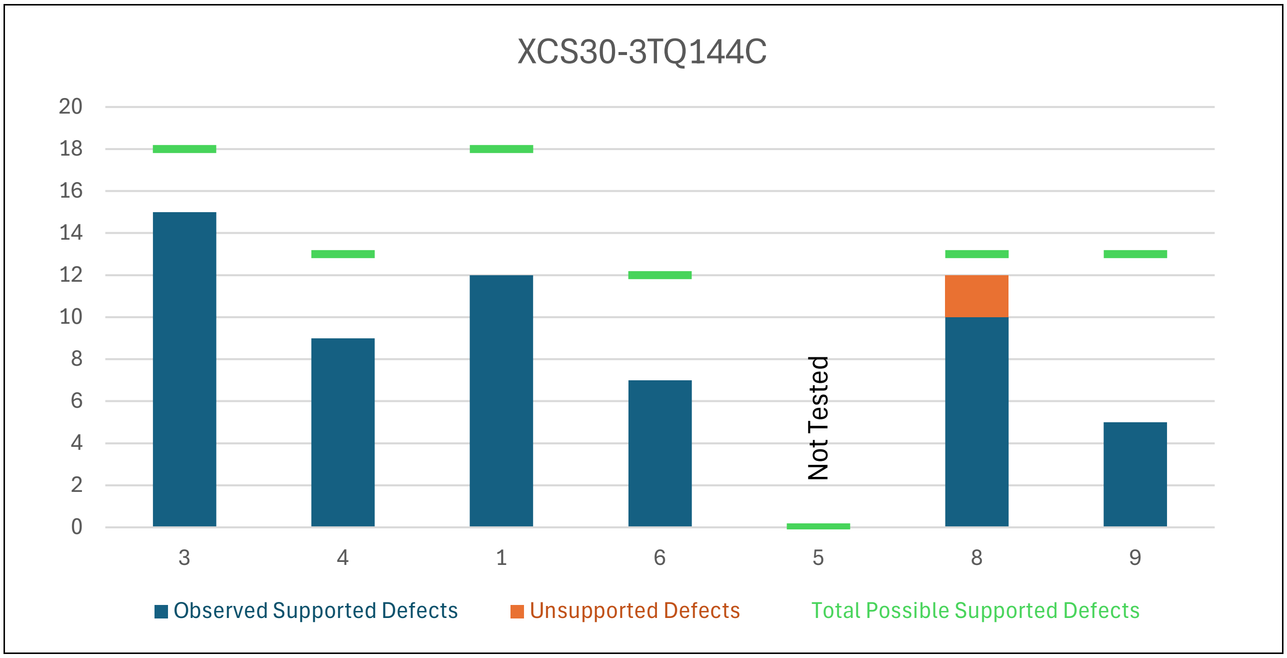


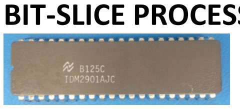
Figure 10 XCS30-3TQ144C Defect Detection

3.1.9.1. Miscellaneous Observations

- Electrical test procedures for both Lab 3 and Lab 4 were similar, but one lab failed all parts and the other passed all parts. This seems statistically unlikely that this would occur (0.39% chance that Lab 3 had 5 bad parts and Lab 4 had 5 good parts) but it is not clear which lab accurately evaluated the parts. Further verification is necessary to determine which result is accurate. Therefore, neither result was considered in determining the statistical results for this part.

3.1.10. IDM2901AJC

BIT-SLICE PROCESSOR, ECL, CDIP40



All labs identified this part as suspect counterfeit. Table 19 summarizes the test methods and specific defects which had high correlation (>60%) between the test labs. Table 20 lists the defects identified by each lab and whether there was strong evidence presented to validate the presence of this defect (by any lab). Strong evidence was used as a criteria for establishing the Consensus Conclusion for each part. This evidence also corresponds to defects which if present, should have been identifiable by test labs.

Test Method	Defect	% Labs in Agreement
/2 - Detailed EVI	Modified or Improper Surface Texture (physical alteration)	67
/2 - Detailed EVI	Package Fracture Damage	67
/8 - Raman	Improper Material Composition of the External Surface(s)	100 (1 lab performed the test method)
/9 - FTIR	Improper Material Composition of the External Surface(s)	100 (2 labs performed the test method)
/10 - TGA	Improper Material Composition of the External Surface(s)	100 (1 lab performed the test method)

Table 19 High Correlation Lab Findings for IDM2901AJC

Defect	Supporting Evidence	Lab 3	Lab 4	Lab 1	Lab 6	Lab 5	Lab 8	Lab 9	%
Damaged Terminations	Yes (bent leads, scratches, nicks)	Observable in images	Observable in images	X			Observable in images	X	40
Refinished Terminations	Yes (visible in most lead images)						X		20
Color Variations on Terminations	Yes (oxidation related color variation)		X	X					40
Missing or Unexpected Tooling Marks on Terminations	Yes (no tooling marks present)						X		20
Oxidation/Corrosion of Terminations	Yes (most parts)	X	X	X			Oxidation color changes observable	X	80
Modified or Improper Surface Texture (physical alteration)	Yes (varied surface alterations)	X		X			X		60
Modified or Improper Markings on Package	Yes (Evidence of remarking)	X		X			X	X	80
Color Variations	Yes (some samples)		X				X	Not present	50
Improper Package Surface Textures (inconsistent packages)	Yes (variations top to bottom and between parts)			X			X		40
Unexpected or Extraneous Marks on Package	Yes (scuffs, solder splash, frit, etc.)	X	X				X		60
Package Fracture Damage	Yes (chipouts)	X	X	X			X		80
Evidence of Resurfacing/Blacktopping	Yes (resurfaced, but not recoated)	X		X					40
Altered or Added Pin One Marker	No (No traditional pin 1 marker,						X	X	40

Defect	Supporting Evidence	Lab 3	Lab 4	Lab 1	Lab 6	Lab 5	Lab 8	Lab 9	%
	notch only. Separate pin 1 marker is optional and not present on these samples)								
Contamination or Corrosion on External Surface(s)	Yes (random contamination on some parts)	X	X	X					60
Improper Material Composition of the External Surface(s)	Yes (top vs bottom surface variance)	X		X			X		60
Missing Bond Wires	No			X (not visible in x-ray because of Al, not missing)					20
Wrong Die or Functional Passive Element	Inconclusive			X (measurements include bond pad area?)					20
Delamination of Internal Layers	Yes (package voids, not detrimental to operation)	Not observed	No AM	X			No AM	No AM	100
Out of Specification Static Electrical Characteristic(s)	Yes	X	Performed electrical, but only curve trace and ICC	No electrical			No electrical	No electrical	20
Correlation with Supported Evidence		0.60	0.40	0.73			0.71	0.23	
Unsupported Observations		0.00	0.00	0.67			0.33	0.33	

Table 20 Defects Identified by Test Labs for IDM2901AJC (considers all test methods)

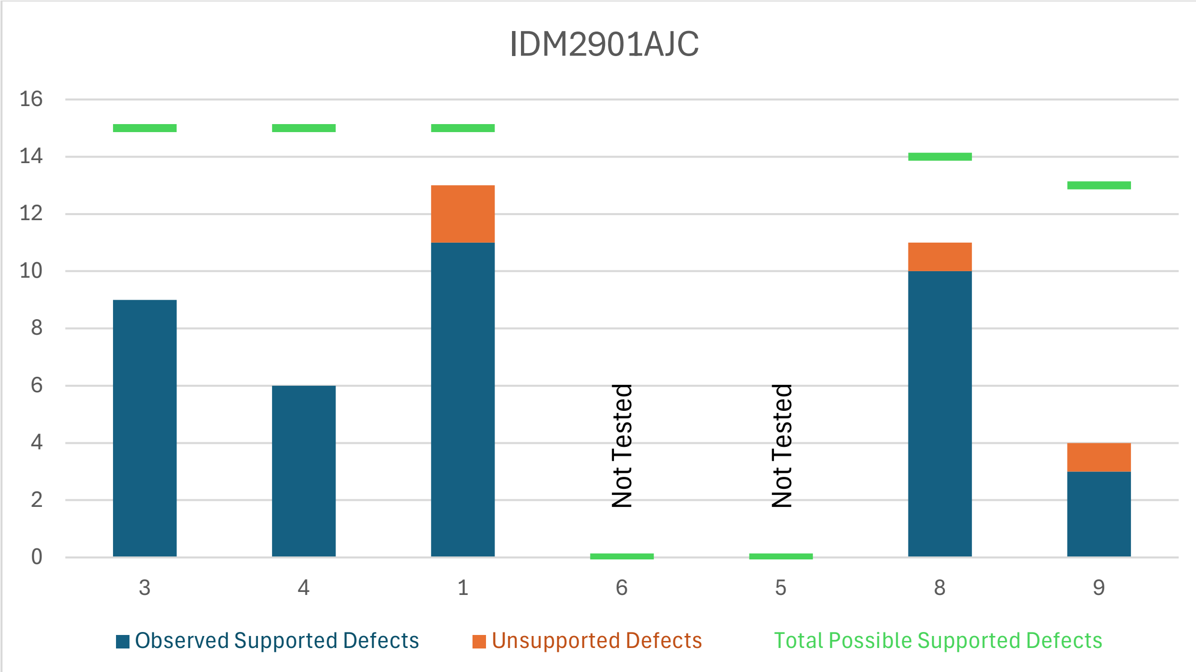


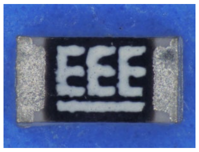
Figure 11 IDM2901AJC Defect Detection

3.1.10.1. Miscellaneous Observations

- These devices have not been recoated as is traditionally done with resurfacing/blacktopping refurbishment. However, multiple tests indicated the top and bottom surfaces to be different from each other. Lab 3 performed high resolution SEM imagery of both the top and bottom surfaces showing a substantially different grain structure between the two surfaces which is often observed if parts had been media blasted. Lab 1 performed FTIR on both top and bottom surfaces showing very different spectral results as well as differences between devices within their sublot. Lab 3 also found similar results with both FTIR and Raman. Lab 3 also noted an area of what appears to be a blacktopping material on one device. It is not clear what this actually is or why it would not be uniform, so this observation may be some form of contaminant as opposed to a deliberate coating.
- The die size variances were observed by Lab 1 using X-Ray and AM, but internal visual die imagery does not support this conclusion. Reporting also indicated die markings were missing, but marking images were captured by other labs. These marks agreed with the package markings. For this reason, this observation is not included in the statistics.

3.1.11. ERJ-3EKF3302V

RES THICK FILM 0603 33K OHM 1% 0.1W(1/10W) ±100PPM/°C PAD SMD T/R AUTOMOTIVE AEC-Q200



Two of five labs identified this part as suspect counterfeit. Table 21 summarizes the test methods and specific defects which had high correlation (>60%) between the test labs. Table 22 lists the defects identified by each lab and whether there was strong evidence presented to validate the presence of this defect (by any lab). Strong evidence was used as a criteria for establishing the Consensus Conclusion for each part. This evidence also corresponds to defects which if present, should have been identifiable by test labs.

Test Method	Defect	% Labs in Agreement
None	None	-

Table 21 High Correlation Lab Findings for ERJ-3EKF3302V

Defect	Supporting Evidence	Lab 3	Lab 4	Lab 1	Lab 6	Lab 5	Lab 8	Lab 9	%
Incorrect Part Package Outline Dimensions	No (no labs consider this defect present. It was identified in one test, but refuted when validated)			X (Identified during x-ray but not in dimensional test. Not considered a true detection)					0
Incorrect Termination Dimensions	Yes (per datasheet, end metal should span full width on back and notched on top)							X	20
Modified or Improper Markings on Package	Yes (part should be unmarked per manufacturer)			X (identified for poor quality markings, not incorrect markings)				X	40
Package Fracture Damage	Yes (handling damage)	Not present	X (chipout, 1 device)	Not present			Not present	Not present	100
Improper Material Composition of the External Surface(s)	Yes	Not present	No FTIR	X (FTIR marking difference, 1 part)			No FTIR	No FTIR	100
Inconsistent or Incorrect Lead Frame	Yes (consistent within lot, but differing from golden sample)	Not detectable without comparative part	Not detectable without comparative part	Not detectable without comparative part			Not detectable without comparative part	X (incorrect in comparison to golden sample)	100
Correlation with Supported Evidence		0.00	0.33	0.33			0.00	1.00	
Unsupported Observations		0.00	0.00	0.00			0.00	0.00	

Table 22 Defects Identified by Test Labs for ERJ-3EKF3302V (considers all test methods)

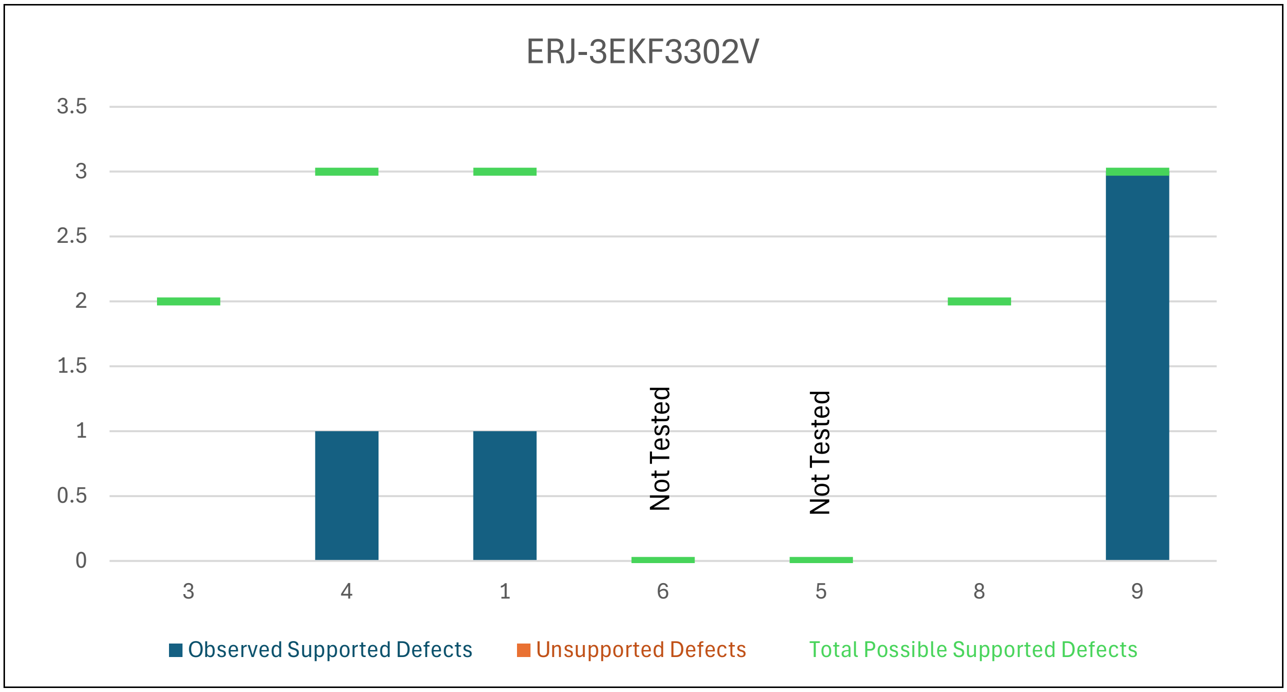


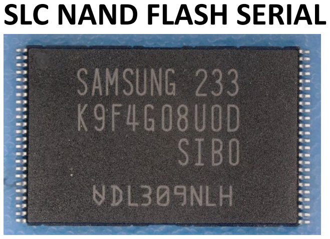
Figure 12 ERJ-3EKF3302V Defect Detection

3.1.11.1. Miscellaneous Observations

- Termination geometry/dimensions were only evaluated by Lab 9. The part datasheet clearly outlines the end metal geometry. Review of the drawings would have shown the backside end metal was shaped incorrectly for this part. Additionally, several parts would have been outside the measurement tolerance for the end metal as well.
- Lab 9 had a sample part with a known authentic pedigree to use as a comparative part. This provided a clear differentiator in the assessment of this part. Additionally, Lab 9 contacted the manufacturer to confirm the proper markings for this part. The manufacturer stated the parts are not marked making the EEE marking invalid. Lab 9 was also able to compare the internal construction of the test samples to their known authentic device. This identified internal construction differences which would not be detectable through intra-lot comparisons.

3.1.12. K9F4G08U0D-SIB0

SLC NAND FLASH SERIAL 3.3V 4G-BIT 512M X 8 25NS 48-PIN TSOP-I



All labs identified this part as suspect counterfeit. Table 23 summarizes the test methods and specific defects which had high correlation (>60%) between the test labs. Table 24 lists the defects identified by each lab and whether there was strong evidence presented to validate the presence of this defect (by any lab). Strong evidence was used as a criteria for establishing the Consensus Conclusion for each part. This evidence also corresponds to defects which if present, should have been identifiable by test labs.

Test Method	Defect	% Labs in Agreement
/2 - Detailed EVI	Modified or Improper Markings on Package	83
/2 - Resurfacing	Improper Package Surface Textures (inconsistent packages)	60
/2 - Resurfacing	Evidence of Resurfacing/Blacktopping	80
/8 - Raman	Improper Material Composition of the External Surface(s)	100 (1 lab performed the test method)

Table 23 High Correlation Lab Findings for K9F4G08U0D-SIB0

Defect	Supporting Evidence	Lab 3	Lab 4	Lab 1	Lab 6	Lab 5	Lab 8	Lab 9	%
Incorrect Part Package Outline Dimensions	Yes (possible sanding artifact)	Not present	X (OOS thickness, 3 parts)	Not present	Not tested		Not present	Not present	100
Damaged Terminations	Yes (bent leads)	Not present	X	X	Not present		X	X	100
Refinished Terminations	Yes (no tooling marks, plated lead tips)	X	X		X		X		60
Incorrect Termination Dimensions	Yes (substantial plating thickness variations)			X	Not tested		X	X (variances in elemental composition)	60
Missing or Unexpected Tooling Marks on Terminations	Yes (missing tooling marks from lead forming)		X		X		X		20
Oxidation/Corrosion of Terminations	Yes (oxidation)	None found	None found	None found	None found		X	None found	100
Modified or Improper Surface Texture (physical alteration)	Yes (sanding, recoating)	X	X (sanding)	X	X		X		80
Modified or Improper Markings on Package	Yes (blacktopped, remarked, multiple lots)	X	X	X	X		X	X	100
Ghost Markings	Yes (visible with AM or resurfacing test)	No AM but detectable with resurfacing test	No AM but detectable with resurfacing test	X	X		No AM but detectable with resurfacing test	No AM but detectable with resurfacing test	50
Improper Package Surface Textures (inconsistent packages)	Yes (top vs. bottom)	X	X	X			X		80
Unexpected or Extraneous Marks on Package	Yes (sanding marks)		X	X	X		X		60
Evidence of Resurfacing/Blacktopping	Yes (clear removal of coating)	X	X	X	X		X		80
Altered or Added Pin One Marker	Yes (partially filled marker)		X		X		X		40

Defect	Supporting Evidence	Lab 3	Lab 4	Lab 1	Lab 6	Lab 5	Lab 8	Lab 9	%
Contamination or Corrosion on External Surface(s)	Yes (minor random contamination)	None found	X (1 device)	None found	None found		X (minor contamination)	None found	100
Improper Material Composition of the External Surface(s)	Yes (contamination)	X	None noted	X	None noted		X	None noted	100
Out of Specification Electrical Functional Characteristic(s)	Inconclusive	5 of 5 passed	X (5 of 5 failed programming / verify)	Not tested	Not tested		Not tested	Not tested	N/A
Correlation with Supported Evidence		0.60	0.85	0.75	0.89		0.93	0.43	
Unsupported Observations		0.00	0.00	0.00	0.00		0.00	0.00	

Table 24 Defects Identified by Test Labs for K9F4G08U0D-SIB0 (considers all test methods)

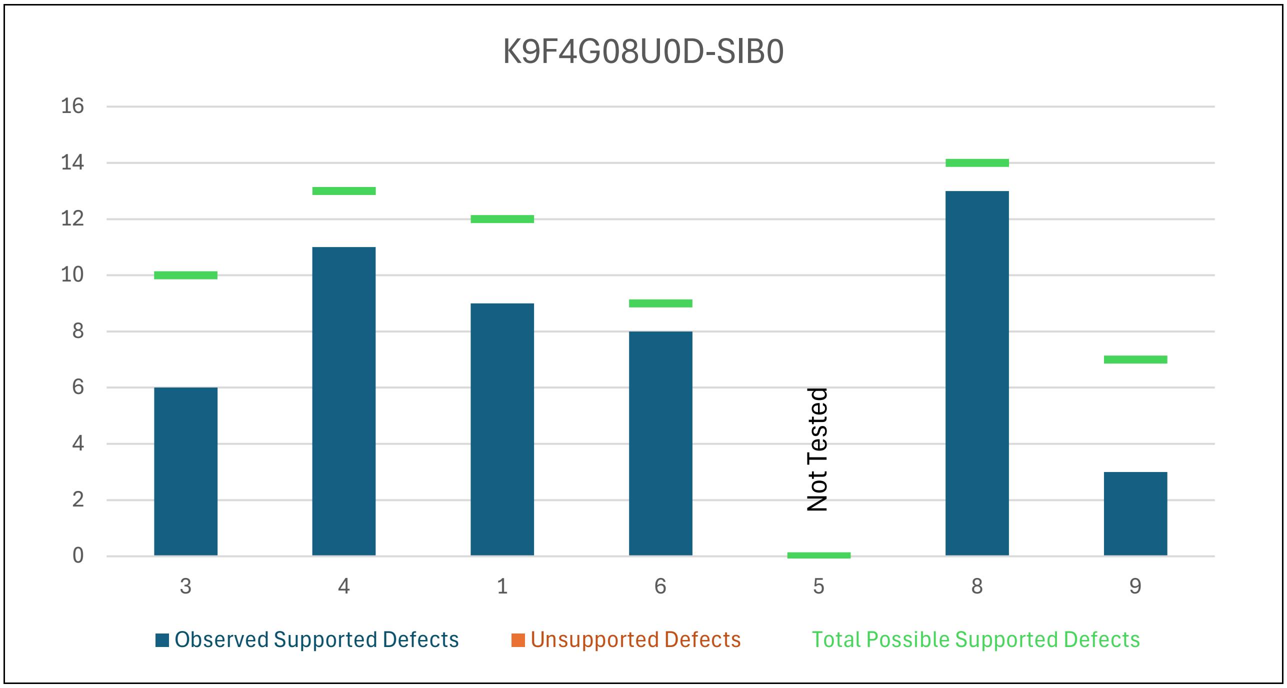


Figure 13 K9F4G08U0D-SIB0 Defect Detection

3.1.12.1. Miscellaneous Observations

- "Incorrect termination dimensions" was used as the closest defect match available for lead plating irregularities. Though this category doesn't explicitly include this type of defect, there is no defined defect that better categorizes this issue. If lab's noted plating thickness issues, then that observation was captured under this defect definition regardless of how they may have categorized it. This was done to create consistency in reporting results since the defect definitions are lacking for this type of defect and labs would try to find a defect category that would somewhat align, but this varied between labs.
- Electrical testing was performed by Lab 3 and Lab 4. Both performed read, program, verify, erase, and blank check. All Lab 3 parts passed and all Lab 4 parts failed verification

testing. One Lab 4 part also failed the max limit for invalid blocks after verification. There is a 0.39% probability that both lab's findings are correct. Further verification is necessary to determine which result is accurate. Therefore, neither result was considered in determining the statistical results for this part.

3.2. General Test Observations

- There is some inconsistency in how defects should be categorized. For example, most labs identified blacktop coating only under the category "Evidence of Resurfacing/ Blacktopping". However, Lab 8 also indicated the category "Improper Material Composition of the External Surface(s)". It should be noted that categorization of defects is not part of typical counterfeit assessment and does not impact a lab's ability to identify suspect material.
- There is significant variance in how each test method is executed regardless of the guidance provided in the AS6171 slash sheets. Examples include observations during General EVI vs. Detailed EVI. Per AS6171, General EVI is intended to be broad overview of the lot as a whole. Parts would be compared side by side to give insight inconsistencies in overall appearance. This would highlight attributes such as color differences, marking differences, gross damage, etc. Detailed EVI is intended to be a part by part inspection under magnification to look for more subtle variations or irregularities. This will often highlight attributes such as termination flaws, contamination, package alterations, marking inconsistencies, etc. Labs clearly perform both inspections, but don't necessarily segregate as separate tests.
- The process and acceptance criteria for performing resurfacing tests using aggressive solvents requires additional clarification since there is a wide range of results on the same population of parts. The most common issue is the interpretation that if any black residue is removed when the part is rubbed with a cotton swab, then there must be a coating present. These solvents are known to degrade molding compounds (noted in AS6171/2A though frequency of occurrence of this condition was stated as "uncommon") resulting in removal of some black material. Inspection of the underlying surface is critical in determining if a coating is actually present. Reliance on black residue alone is often misleading.
- Labs varied in their approach to XRF testing. Typical approaches included: 1) Measurement of composition of the lead including both lead material and plating, 2) Measurement of lead composition and lead plating (composition and/or thickness) as separate measurements, 3) Measurement of the device body composition (generally focused on the device markings as opposed to the encapsulant. It should be noted that EDS was also used for body composition testing in some cases). All labs performed either approach 1 or 2 and some labs did approach 3 as well. Approach 2 is the most revealing approach since it allows for the detection of plating irregularities from part to part. Approach 1 tends to mask these variations since XRF provides relative ratios of elements.

The lead base material tends to dwarf the plating composition masking the variations in the plating.

4. Test Lab Details

Each participating lab performed AS6171 testing commensurate with their lab capabilities and experience. The level of capability varies for each lab with the majority of labs being able to perform General EVI, Detailed EVI, Remarking, Resurfacing, Dimensions, XRF, Internal Visual and X-Ray. Other tests were substantially less supported. For lab specific capability details, see Table 2.

This section of this report compares each lab's findings with those of their peers. Additionally, findings are categorized into supported and unsupported defects. Supported defects are those that had clear supporting confirmation of the presence of that defect. Unsupported defects do not have supporting evidence. Supporting evidence is some form of validation. For example, if a lab states that the leads of a part exhibit tin whiskers and provides a photo of the whiskers, this defect is a supported defect. If any participating lab provides supporting evidence, then it was considered valid for all labs regardless of whether each lab provided evidence or not. If no lab provided any evidence of the existence of a defect, then it was considered unsupported. It is important to emphasize that unsupported defects are not necessarily inaccurate. They just could not be substantiated through any lab's reporting. Total possible supported defects is also provided in this section. This reflects the total number of supported defects found by any lab for a given part number.

4.1. Lab 3

Lab 3 was able to perform a broad range of test capabilities supporting test methods /2 through /9. They do not have capability for /10 (TGA) or /11 (Design Recovery). They evaluated parts using AS6171 defined test methods as well as their own semi-automated process. Further details on this process are covered in the Alternative Test Methods section of this document.

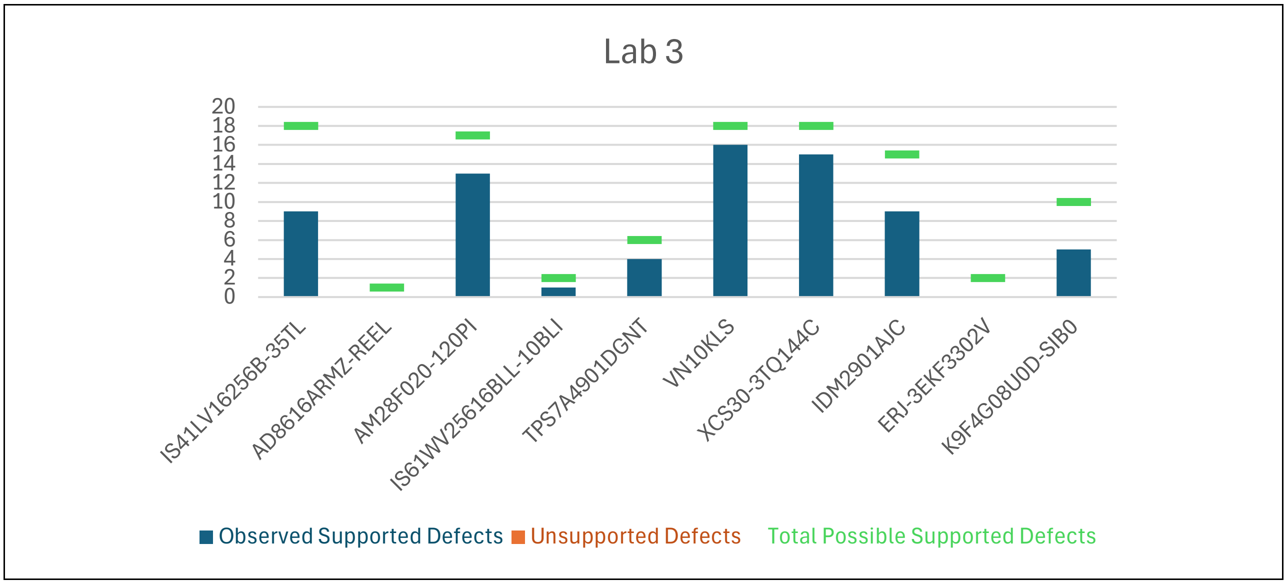


Figure 14 Lab 3 Defect Detection

4.1.1. Unsupported Defects Summary

Unsupported defects reflect observations which could not be substantiated through the data provided by any of the test labs. A lower number reflects well documented supporting evidence for identified defects.

Results: None identified

4.1.2. Supported Defects Summary

Supported defects reflect observations that had supporting evidence. The maximum supported defects are the combined potential defects found by any lab which this test lab has the potential for identifying. This does not mean all of these defects are definitely present in the lab's sublot of parts, but there is a high probability of their presence.

IS41LV16256B-35TL

Observations by peer labs but not noted by Lab 3	Key defects identified by Lab 3	Observations with contradictory evidence
Lead conditions such as damage and color variation	Indications of lead replating	None
Package alterations, particularly mold marks	Presence of blacktopping	
Ghost markings on the backside of the parts	Tin whiskers (only lab to identify, though observable in many photos)	
2 die revisions in the same lot (low frequency of occurrence, so may not be present)		

AD8616ARMZ-REEL

Observations by peer labs but not noted by Lab 3	Key defects identified by Lab 3	Observations with contradictory evidence

Contamination or Corrosion on External Surface(s) (low frequency defect so may not be present in this sublot)	None	None

AM28F020-120PI

Observations by peer labs but not noted by Lab 3	Key defects identified by Lab 3	Observations with contradictory evidence
Termination color variations	Lead plating degradation, oxidation	None
Extraneous marks on the package (sanding artifacts, was identified as improper surface texture)	Blacktopping with alteration of mold marks	
Surface contamination/corrosion	Tin whiskers (only lab to identify, though observable in many photos)	
Internal layer delamination (AM inspection)	Improper die	

IS61WV25616BLL-10BLI

Observations by peer labs but not noted by Lab 3	Key defects identified by Lab 3	Observations with contradictory evidence
Random surface contaminants (identified as improper material composition by Lab 3)	None	None

TPS7A4901DGNT

Observations by peer labs but not noted by Lab 3	Key defects identified by Lab 3	Observations with contradictory evidence
Poor quality markings exhibiting laser burns	Sanding, blacktopping	None
Extraneous marks on the package (sanding artifacts, classified as improper surface texture by Lab 3)		

VN10KLS

Observations by peer labs but not noted by Lab 3	Key defects identified by Lab 3	Observations with contradictory evidence
Plating composition variance (observed by Lab 3 but considered acceptable)	Termination reattachment	Lab 3 measured 1 part out of spec for thickness, not observed by others
Missing tooling marks on leads	Surface modification due to sanding and blacktopping. Also caused coloration variation.	
Inconsistent electrical test results (flagged by others for out of family		

results. May be a limited occurrence defect)		

XCS30-3TQ144C

Observations by peer labs but not noted by Lab 3	Key defects identified by Lab 3	Observations with contradictory evidence
Lead plating thickness	Termination issues – damage, refinishing, lack of tooling marks	Lab 3 measured 1 part out of spec for thickness, not observed by others
Lead color variations	Inconsistent package mold marks	Electrical test (results contradictory between labs. Unclear which results are accurate)
Ghost markings on top surface (low frequency of occurrence, may not be present in this sublot)	Package color variations, texture variations, tin whiskers	
	Blacktopping with altered mold marks	
	Delamination of internal layers	

IDM2901AJC

Observations by peer labs but not noted by Lab 3	Key defects identified by Lab 3	Observations with contradictory evidence
Lead issues – damage, refinishing, color variations, missing tooling marks	Lead oxidation	None
Package color variations (low frequency of occurrence so may not be present in this sublot)	Package irregularities due to blacktopping related alterations	
	Package surface contamination	
	Electrical test failure	

ERJ-3EKF3302V

Observations by peer labs but not noted by Lab 3	Key defects identified by Lab 3	Observations with contradictory evidence
Termination dimensions – end metal incorrect	None	None
Improper markings on package (should have no marking)		

K9F4G08U0D-SIB0

Observations by peer labs but not noted by Lab 3	Key defects identified by Lab 3	Observations with contradictory evidence
Plating thickness variations	Package modifications including modified texture, markings blacktopping	Electrical test (results contradictory between labs. Unclear which results are accurate)
Missing lead tooling marks (identified under lead refinishing by Lab 3)	Surface contamination	
Ghost markings		
Sanding marks		

Table 25 Lab 3 Part Defect Findings

4.1.3. Correlation Analysis

This assessment shows the correlation of the lab's results with their peers. Correlation score values fall between +1 and -1 where positive values indicate agreement with peers and negative values indicate disagreement with peers. The larger the value, the greater the agreement. Scores reflect test method correlation meaning the lab's findings using the specified test method were in agreement with their peers using that same test method. This does not necessarily imply overall consensus agreement. It is important to note that labs tend to have key analysis strengths which they utilize as primary detection methods. These key analyses vary between labs. This can impact the test method correlation but result in the same overall conclusions. This assessment does not evaluate test results accuracy (see section 3 for accuracy details), only alignment with peers. The chart includes items with correlation >0.25 and <-0.25

Note: Scoring excludes the /8 – Raman test method since Lab 3 was the only participating lab with the ability to perform this test as well as /10 – TGA since Lab 1 was the only lab with the capability to perform this test.

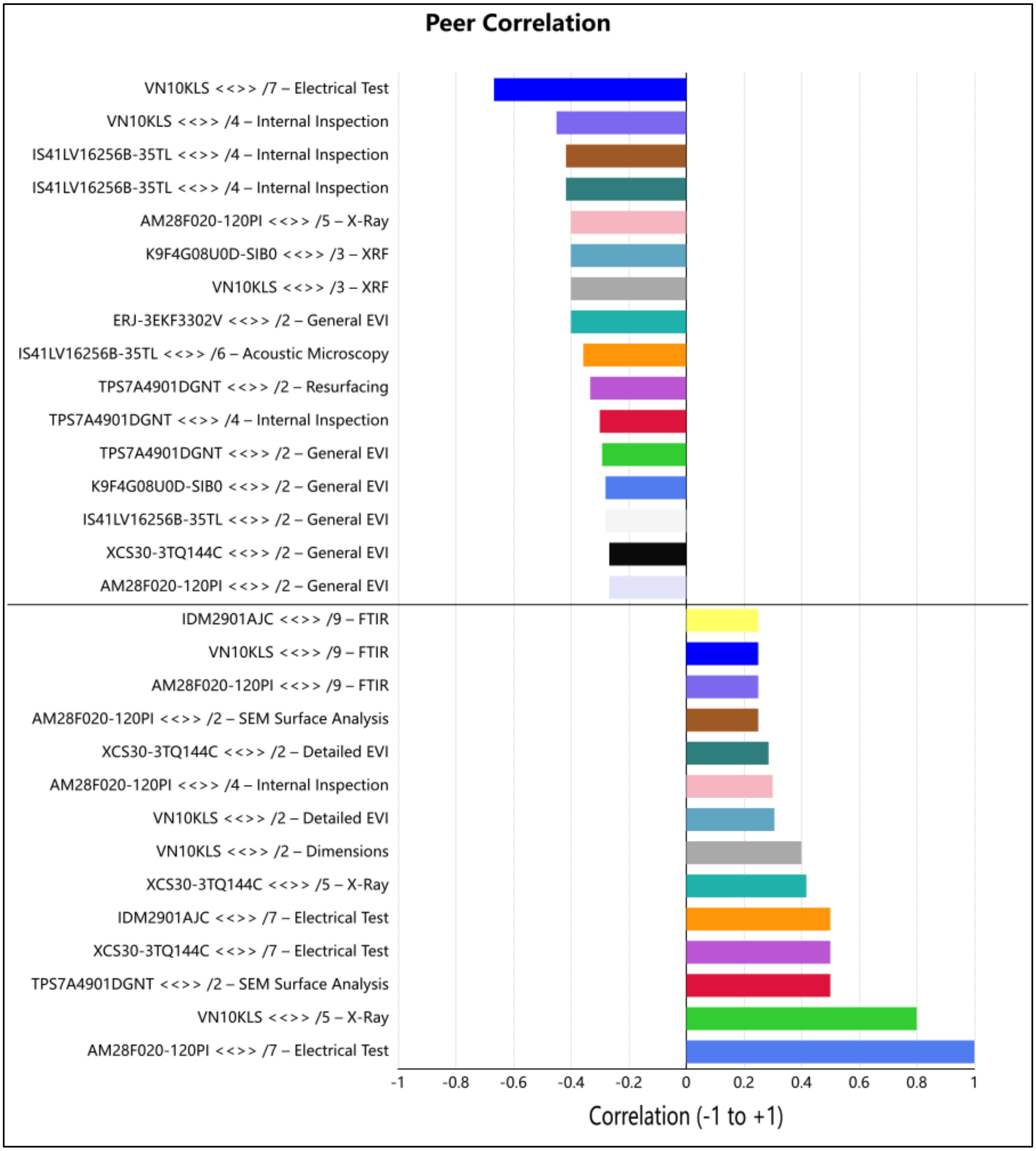


Figure 15 Lab 3 Peer Correlation Data

4.2. Lab 4

Lab 4 was able to perform a broad range of test capabilities supporting test methods /2 (except SEM surface analysis), /3 (XRF), /4 (Internal Visual Inspection), /5 (X-Ray) and /7 (Electrical Test).

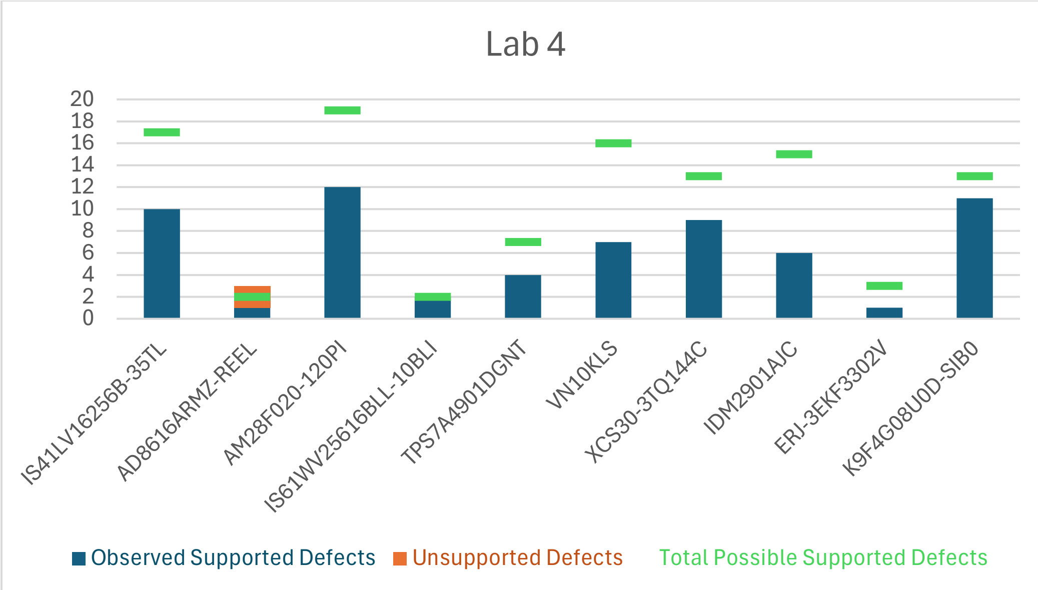


Figure 16 Lab 4 Defect Detection

4.2.1. Unsupported Defects Summary

Unsupported defects reflect observations which could not be substantiated through the data provided by any of the test labs. A lower number reflects well documented supporting evidence for identified defects.

Results:

[AD8616ARMZ-REEL] Improper Package Surface Textures (inconsistent packages) – This defect, along with Evidence of Resurfacing/ Blacktopping are both associated with the appearance of a coating on the top surface of these parts. The defect was identified during the Detailed EVI. Multiple labs noted the top surface had a rougher than typical texture, but no other labs considered the texture to be an improper condition. Lab 9 had a golden sample of this part number for comparison. They noted the surface being rougher on the test sample than on the golden sample, but did not consider it a significant enough difference to warrant identifying it as a defect. Resurfacing tests by all labs including Lab 4 did not reveal any coating. This demonstrates that the Detailed EVI is not a conclusive test for determining the presence of coatings.

[AD8616ARMZ-REEL] Evidence of Resurfacing/ Blacktopping – Identified during the Detailed EVI as a visually apparent coating. See the Improper Package Surface Textures (inconsistent packages) discussion above for additional details.

4.2.2. Supported Defects Summary

Supported defects reflect observations that had supporting evidence. The maximum supported defects are the combined potential defects found by any lab which this test lab has the potential for identifying. This does not mean all of these defects are definitely present in the lab's sublot of parts, but there is a high probability of that defects presence.

IS41LV16256B-35TL

Observations by peer labs but not noted by Lab 4	Key defects identified by Lab 4	Observations with contradictory evidence
Termination defects – refinishing, color variations, lack of tooling marks	Termination damage and oxidation	None
Package color change due to blacktopping	Surface texture alteration, sanding marks, blacktopping	
Tin whiskers	Ghost markings	
	Lead frame and wire bond pattern variations	

AD8616ARMZ-REEL

Observations by peer labs but not noted by Lab 4	Key defects identified by Lab 4	Observations with contradictory evidence
None	Oxidation/corrosion on terminations	Blacktopping noted from visual inspection but not supported by blacktopping tests.

AM28F020-120PI

Observations by peer labs but not noted by Lab 4	Key defects identified by Lab 4	Observations with contradictory evidence
Terminal color variations (caused by oxidation)	Oxidized leads	None
Package color variations, inconsistent surface textures and extraneous marks (sanding striations)	Altered surface texture, blacktopping, pin 1 marker alteration	
Package surface contamination	Wrong die and lead frame	
Package material composition inconsistent due to resurfacing	Electrical test failure	

IS61WV25616BLL-10BLI

Observations by peer labs but not noted by Lab 4	Key defects identified by Lab 4	Observations with contradictory evidence
None	Damaged termination on 1 part	None
	Chip out on one part	

TPS7A4901DGNT

Observations by peer labs but not noted by Lab 4	Key defects identified by Lab 4	Observations with contradictory evidence
Laser burn on markings	Sanded packages, blacktopping	None
Extraneous marks on package	Surface contamination	

VN10KLS

Observations by peer labs but not noted by Lab 4	Key defects identified by Lab 4	Observations with contradictory evidence
Refinished terminations, missing lead trim marks, reattached leads	Damaged terminations	None
Package color variations, extraneous marks	Altered package surface, marking inconsistency, package inconsistency, extraneous markings, blacktopping	
Altered mold marks	Lead frame inconsistency	
Inconsistent wire bond pattern (due to lead frame/die variations), die variations		

XCS30-3TQ144C

Observations by peer labs but not noted by Lab 4	Key defects identified by Lab 4	Observations with contradictory evidence
Surface texture alteration	Terminations damaged, refinished, color variations	None
Ghost markings (uncommon, may not have been present)	Package surface texture, blacktopping, altered mold marks	
Package color shifts, extraneous marks		
Inconsistent lead frames (uncommon, may not have been present)		

IDM2901AJC

Observations by peer labs but not noted by Lab 4	Key defects identified by Lab 4	Observations with contradictory evidence
Terminations damaged, refinished, missing tooling marks	Lead oxidation, color variations	None
Varied surface alterations, remarking, top vs. bottom inconsistency, resurfaced (but not blacktopped)	Package issues – color, extraneous marks, chipouts, contamination	

ERJ-3EKF3302V

Observations by peer labs but not noted by Lab 4	Key defects identified by Lab 4	Observations with contradictory evidence
Incorrect termination dimensions	Package fracture (chipout)	None
Incorrect part markings		

K9F4G08U0D-SIB0

Observations by peer labs but not noted by Lab 4	Key defects identified by Lab 4	Observations with contradictory evidence
Plating thickness variations, missing tooling marks	Package thickness measurements	Inconsistent electrical test results between labs, unclear which lab is correct
	Sanding, surface texture, blacktopping, marking inconsistency, electrical test failure	

Table 26 Lab 4s Part Defect Findings

4.2.3. Correlation Analysis

This assessment shows the correlation of the lab's results with their peers. Correlation score values fall between +1 and -1 where positive values indicate agreement with peers and negative values indicate disagreement with peers. The larger the value, the greater the agreement. Scores reflect test method correlation meaning the lab's findings using the specified test method were in agreement with their peers using that same test method. This does not necessarily imply overall consensus agreement. It is important to note that labs tend to have key analysis strengths which they utilize as primary detection methods. These key analyses vary between labs. This can impact the test method correlation but result in the same overall conclusions. This assessment does not evaluate test results accuracy (see section 3 for accuracy details), only alignment with peers. The chart includes items with correlation >0.25 and <-0.25

Note: Scoring excludes the /8 – Raman test method since Lab 3 was the only participating lab with the ability to perform this test as well as /10 – TGA since Lab 1 was the only lab with the capability to perform this test.

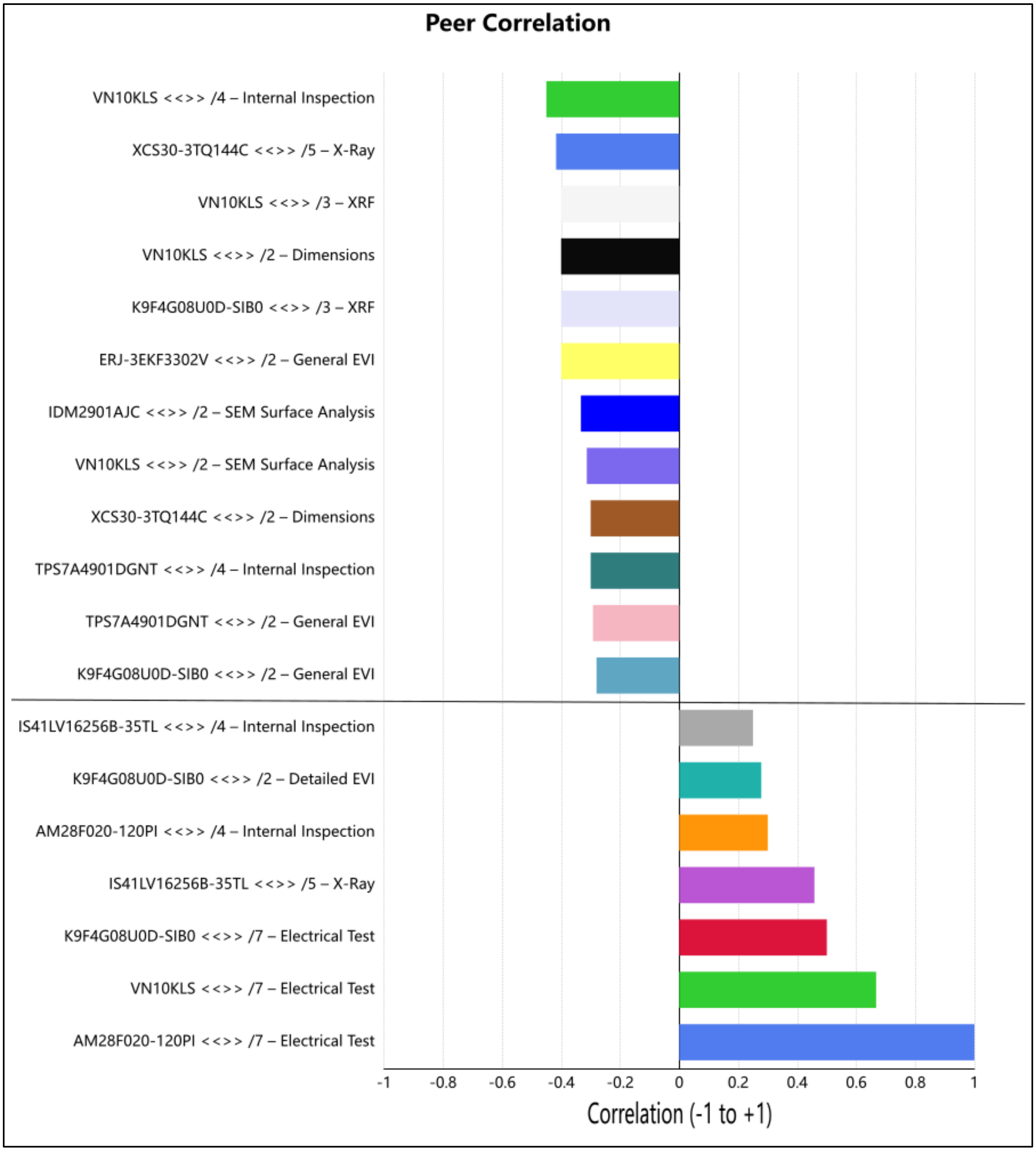


Figure 17 Lab 4 Peer Correlation Data

4.3. Lab 1

Lab 1 was one of the most capable labs participating in the round robin. They were able to support test methods /2 through /10 with the exception of /7 (electrical test). They were the only lab which was able to perform the /10 (TGA) test method.

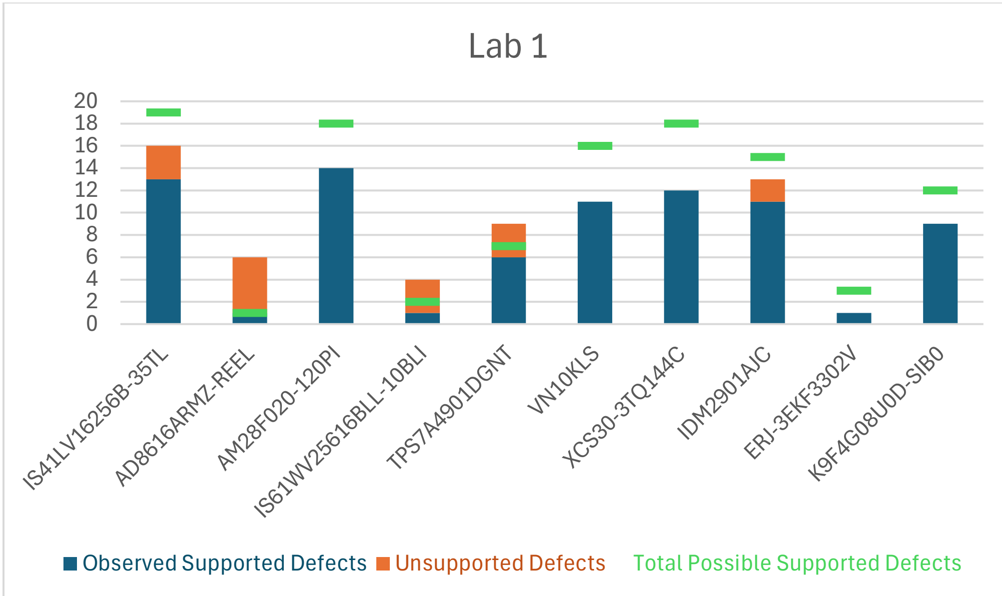


Figure 18 Lab 1 Defect Detection

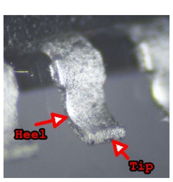
4.3.1. Unsupported Defects Summary

Unsupported defects reflect observations which could not be substantiated through the data provided by any of the test labs. A lower number reflects well documented supporting evidence for identified defects.

Results:

[IS41LV16256B-35TL] Incorrect Part Package Outline Dimensions – All 5 test samples were identified as out of specification for thickness and length. No other test labs identified dimensional irregularities. Package thickness is not a manufacturer controlled parameter. Lab 1 derived this value from the specifications for lead standoff and overall height (lead standoff + package thickness). Derived values should not be identified as out of specification conditions. Package length is a controlled parameter. The dimensional notes from the datasheet state that the measurements do not include any flash. Images of these parts show that flash was present. Lab 1 performed their measurements using a combination of non-contact measurement and a caliper. Caliper based measurement makes it very difficult to exclude flash from the measurement. These type of measurements should be performed exclusively using non-contact methods. It should also be noted that the probability of having received 5 out of specification parts and no other lab receiving any is 0.0007%.

[IS41LV16256B-35TL] Incorrect Termination Dimensions – Contact pad length was identified as too low for all 5 part samples. Additionally, lead pitch was measured as too large for 4 of 5 parts. No other labs measured contact pad length so comparatives cannot be made. No other lab indicated lead pitch as out of specification though many measurements were comparable to the



Lab 1 measurements. Measuring contact pad length is very subjective since it measures from the lead tip (which is well defined) to the heel (which is poorly defined due to the broad bend in the lead).

The specification for lead pitch is 0.80mm BSC (Basic Spacing between Centers). This is not an absolute specification, but should be considered an average value. No maximum or minimum is specified and variations of 0.05-0.10mm are not uncommon. The measured values indicated as out of specification ranged from 0.81mm to 0.87mm which should be considered within normal variance range.

[IS41LV16256B-35TL] Heat Exposure – No other test labs noted this anomaly. This was presented as a possible explanation for unique FTIR spectra from one measurement spot on the top of one part. This hypothesis was not fully supported and was not confirmed by other labs.

[AD8616ARMZ-REEL] Modified or Improper Surface Texture (physical alteration) – The top vs. bottom surface roughness was observed to be different. This was noted by other labs as well, but it does not necessarily imply that the surface had been modified. Additional testing did not confirm alteration of the surface.

[AD8616ARMZ-REEL] Modified or Improper Markings on Package – Part markings were observed to vary in location. This can be an indicator of inconsistent refurbishment. In comparison to devices with full traceability to authorized sources, this condition is also present in those devices so it should be considered a manufacturing variance as opposed to modified markings.

[AD8616ARMZ-REEL] Evidence of Resurfacing/ Blacktopping – Associated with the appearance of a coating on the top surface of these parts. The defect was identified during the Detailed EVI. Resurfacing tests by all labs including Lab 1 did not reveal any coating. This demonstrates that the Detailed EVI is not a conclusive test for determining the presence of coatings.

[AD8616ARMZ-REEL] Altered or Added Pin One Marker – This defect reflects the same issue with part marking placement as addressed for the defect Modified or Improper Markings on Package. Refer to that item above for more details.

[AD8616ARMZ-REEL] Wrong Die or Functional Passive Element – This observation was associated with the 2008 date on the die compared to the package date. Lab 1 interpreted the 1193 marking to be the device date code. This is not the date code. The date code is #141 (2011 or 2021 manufacture). This issue is discussed in detail in section 3.1.4.1 of this report.

[IS61WV25616BLL-10BLI] Incorrect Part Package Outline Dimensions – The package thickness was identified as too thin for all 5 devices tested. The package thickness is not a manufacturer controlled parameter. The requirement was derived from the total device height (package + ball height) and the ball height. The total package height has no minimum requirement (only maximum), allowing for a thin package as long as the ball height remains within acceptable limits.

[IS61WV25616BLL-10BLI] Modified or Improper Markings on Package – Small variations in the markings were noted. These were minor differences and would be attributable to normal process variation. These parts were purchased through authorized distribution to assure authenticity.

[IS61WV25616BLL-10BLI] Evidence of Resurfacing/Blacktopping – Exposure to solvent #2 (Dynasolve) left the surface smoother and some black material was transferred to the swab when rubbed. This solvent will degrade encapsulants when overexposed during testing. This is why

AS6171/2A requires checking the part for damage every 5 minutes and a note is provided explaining that the solvent can break down the encapsulant.

[TPS7A4901DGNT] Incorrect Part Package Outline Dimensions – Thickness (5 of 5), length (5 of 5), and width (2 of 5). Thickness measurements were too thin. Length and width were too large. No other test labs found dimensions to be out of specification. Package thickness is not a controlled parameter. This was derived from the total height minus the lead standoff height. Total height only has a maximum value, no minimum, so deriving a minimum package height specification from the maximum total height results in a constrained requirement for package thickness. Length and width specifications for this part exclude mold flash, protrusions and gate burrs from the measurement. Measurements were performed using a combination of non-contact and caliper methods. It is very difficult to get an accurate measurement which excludes these artifacts if caliper methods are used. Part photos show a significant amount of flash present on the test samples. Statistically, there is a 0.0007% chance that Lab 1 received 5 out of specification parts and no other labs received out of specification parts.

[TPS7A4901DGNT] Wrong Die or Functional Passive Element – This defect was noted during acoustic microscopy inspection and X-Ray. Some variation in die dimensions were observed. This could be the result of die differences or just cleaving differences. Internal visual inspection is necessary to determine which scenario is the cause. Internal visual inspection looked at 2 devices that had shown die size differences during these tests and did not confirm the die size differences or observe layout differences. The internal inspection report indicated that no die markings were observed, which would be beneficial in determining if the correct die was present. However, other test labs did find die markings on die with the same configuration. Labs showing die markings used significantly higher magnification to read the markings (1000X vs. 60X). All die markings imaged were the same and reflected the device part number (TPS7A49C).

[TPS7A4901DGNT] Improper or Missing Die Markings – Refer to the above discussion for Wrong Die or Functional Passive Element for details on die markings. An example of the device's die markings are shown in Figure 19 TPS7A4901DGNT Die Markings below.

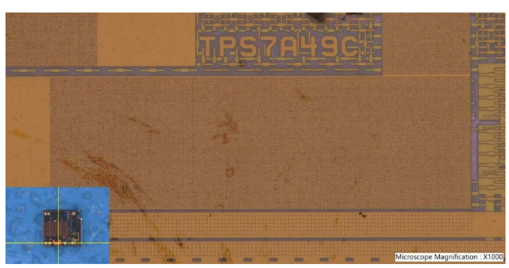


Figure 19 TPS7A4901DGNT Die Markings

[IDM2901AJC] Missing Bond Wires – Missing bond wires were reported from X-Ray and Acoustic Microscopy inspections. This observation was refuted through internal visual inspection. Bond wires were determined to be aluminum. Both X-Ray and Acoustic Microscopy rely on material density differences to image internal physical elements. This device contains fine aluminum bond wires which are not readily observable with these technologies. This is not a potential issue with the part, but is a limitation of the inspection technology. Defects which require capabilities beyond the capability of the inspection equipment in use should not be treated as credible defects.

4.3.2. Supported Defects Summary

Supported defects reflect observations that had supporting evidence. The maximum supported defects are the combined potential defects found by any lab which this test lab has the potential for identifying. This does not mean all of these defects are definitely present in the lab's sublot of parts, but there is a high probability of that defects presence.

Supported defects reflect observations that had supporting evidence. The maximum supported defects are the combined potential defects found by any lab which this test lab has the potential for identifying. This does not mean all of these defects are definitely present in the lab's sublot of parts, but there is a high probability of that defects presence.

Results:

IS41LV16256B-35TL

Observations by peer labs but not noted by Lab 1	Key defects identified by Lab 1	Observations with contradictory evidence
Terminations - Refinished, color variations (due to oxidation), missing tooling marks	Termination damage, oxidation	Package and terminal dimensions
Tin whiskers	Modified surface texture, mold marks	
Wire bond pattern variation (due to lead frame differences)	Ghost markings	
Internal layer delamination	Sanding marks, blacktopping	
	Multiple lead frames	

AD8616ARMZ-REEL

Observations by peer labs but not noted by Lab 1	Key defects identified by Lab 1	Observations with contradictory evidence
None	Contamination of device surface	Modified surface texture, modified markings, blacktopping

AM28F020-120PI

Observations by peer labs but not noted by Lab 1	Key defects identified by Lab 1	Observations with contradictory evidence
Improper material on leads due to severe degradation	Oxidized terminations	None
Package color variations due to coating	Sanding, blacktopping, altered mold marks	
Tin whiskers	Surface material variations and contamination	
	Wrong die and lead frame	

IS61WV25616BLL-10BLI

Observations by peer labs but not noted by Lab 1	Key defects identified by Lab 1	Observations with contradictory evidence
Damaged termination and chipout	Contamination on external surface	Part dimensions
		Part markings
		Blacktopping

TPS7A4901DGNT

Observations by peer labs but not noted by Lab 1	Key defects identified by Lab 1	Observations with contradictory evidence
None	Bent terminations	Part dimensions
	Sanding, blacktopping, altered pin 1 marker	Incorrect die
	Surface contamination	

VN10KLS

Observations by peer labs but not noted by Lab 1	Key defects identified by Lab 1	Observations with contradictory evidence
Terminations – damaged, missing tooling marks, re-attachment	Refinished terminations	None
Package color variations (due to resurfacing)	Sanding, blacktopping, surface texture variations, marking inconsistencies, pin 1 marker variations	
	Wrong die, wire bond variations, lead frame variations	

XCS30-3TQ144C

Observations by peer labs but not noted by Lab 1	Key defects identified by Lab 1	Observations with contradictory evidence
Refinished terminations, missing tooling marks	Termination damage, color variations, oxidation	None
Package color variation due to coating	Sanding, blacktopping, extraneous marks	
Altered mold marks	Ghost markings	
Internal layer delamination	Tin whiskers	
	Inconsistent lead frame	

IDM2901AJC

Observations by peer labs but not noted by Lab 1	Key defects identified by Lab 1	Observations with contradictory evidence
Refinished terminations, missing tooling marks	Lead oxidation, color variations	Missing bond wires
Package color variations, scuffs	Marking variations	
	Surface texture variation, chipouts	
	Resurfaced, contamination	

ERJ-3EKF3302V

Observations by peer labs but not noted by Lab 1	Key defects identified by Lab 1	Observations with contradictory evidence
Incorrect termination dimensions	Poor quality markings	None
Incorrect lead frame	Marking composition elemental variances	

K9F4G08U0D-SIB0

Observations by peer labs but not noted by Lab 1	Key defects identified by Lab 1	Observations with contradictory evidence
Terminations refinished, missing tooling marks	Terminations damaged, dimensions wrong (plating thickness)	None
Pin 1 markers altered (partially filled)	Sanding, resurfacing, remarking, extraneous surface marks	
	Ghost markings	
	Surface contamination	

Table 27 Lab 1 Part Defect Findings

4.3.3. Correlation Analysis

This assessment shows the correlation of the lab's results with their peers. Correlation score values fall between +1 and -1 where positive values indicate agreement with peers and negative values indicate disagreement with peers. The larger the value, the greater the agreement. Scores reflect test method correlation meaning the lab's findings using the specified test method were in agreement with their peers using that same test method. This does not necessarily imply overall consensus agreement. It is important to note that labs tend to have key analysis strengths which they utilize as primary detection methods. These key analyses vary between labs. This can impact the test method correlation but result in the same overall conclusions. This assessment does not evaluate test results accuracy (see section 3 for accuracy details), only alignment with peers. The chart includes items with correlation >0.25 and <-0.25

Note: Scoring excludes the /8 – Raman test method since Lab 3 was the only participating lab with the ability to perform this test as well as /10 – TGA since Lab 1 was the only lab with the capability to perform this test.

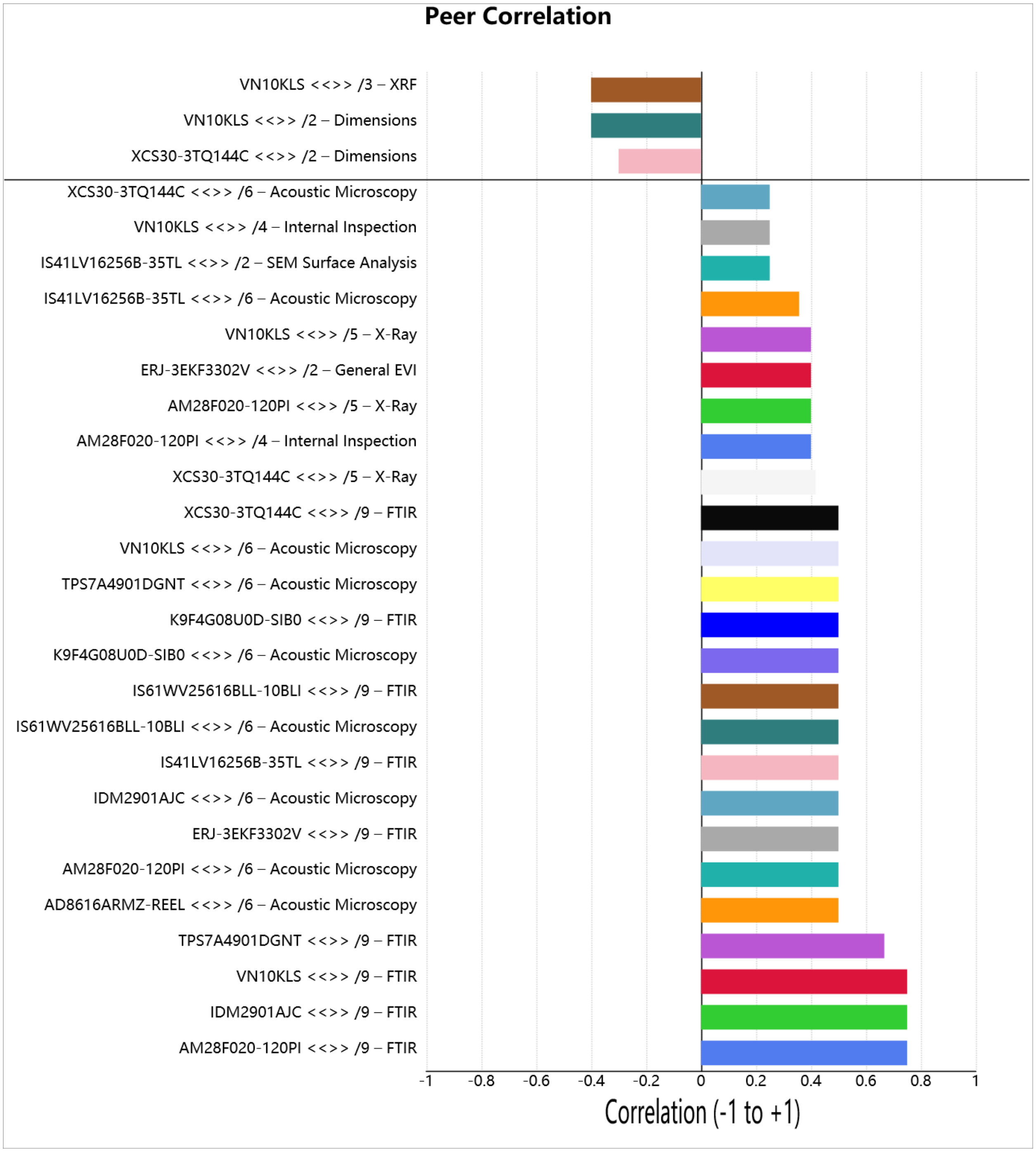


Figure 20 Lab 1 Peer Correlation Data

4.4. Lab 6

Lab 6 was only able to test 3 of the 10 parts included in the round robin due to workload commitments. The part numbers tested were randomly selected from the sample population. The scope of testing included /2 (general EVI, detailed EVI, remarking, resurfacing), /4 (internal visual) and /5 (X-Ray).

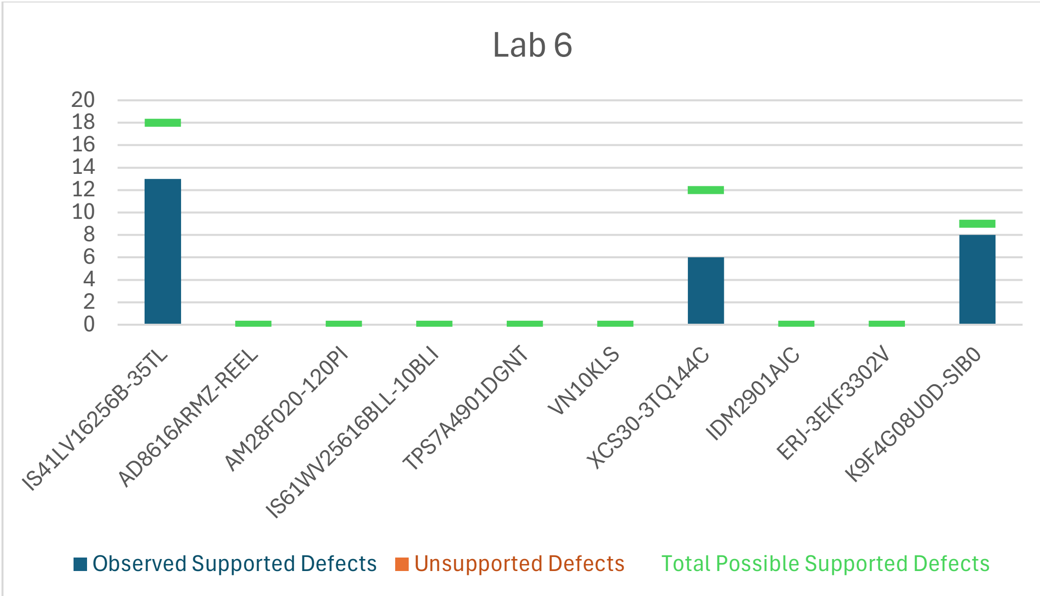


Figure 21 Lab 6 Defect Detection

4.4.1. Unsupported Defects Summary

Unsupported defects reflect observations which could not be substantiated through the data provided by any of the test labs. A lower number reflects well documented supporting evidence for identified defects.

Results: None identified

4.4.2. Supported Defects Summary

Supported defects reflect observations that had supporting evidence. The maximum supported defects are the combined potential defects found by any lab which this test lab has the potential for identifying. This does not mean all of these defects are definitely present in the lab's sublot of parts, but there is a high probability of that defects presence.

Supported defects reflect observations that had supporting evidence. The maximum supported defects are the combined potential defects found by any lab which this test lab has the potential for identifying. This does not mean all of these defects are definitely present in the lab's sublot of parts, but there is a high probability of that defects presence.

Results:

IS41LV16256B-35TL

Observations by peer labs but not noted by Lab 6	Key defects identified by Lab 6	Observations with contradictory evidence
Terminations are refinished, missing tooling marks	Termination color variations, oxidation, contamination	None
Ghost markings (on back)	Surface texture alteration, part-filled mold marks, package variation	
Sanding marks	Blacktopping,	
Tin whiskers	Multiple die revs, multiple lead frames, varied wire bond pattern	

AD8616ARMZ-REEL

Observations by peer labs but not noted by Lab 6	Key defects identified by Lab 6	Observations with contradictory evidence
Not Tested		

AM28F020-120PI

Observations by peer labs but not noted by Lab 6	Key defects identified by Lab 6	Observations with contradictory evidence
Not tested		

IS61WV25616BLL-10BLI

Observations by peer labs but not noted by Lab 6	Key defects identified by Lab 6	Observations with contradictory evidence
Not tested		

TPS7A4901DGNT

Observations by peer labs but not noted by Lab 6	Key defects identified by Lab 6	Observations with contradictory evidence
Not tested		

VN10KLS

Observations by peer labs but not noted by Lab 6	Key defects identified by Lab 6	Observations with contradictory evidence
Not tested		

XCS30-3TQ144C

Observations by peer labs but not noted by Lab 6	Key defects identified by Lab 6	Observations with contradictory evidence
Termination color variation	Terminations damaged, refinished, missing tooling marks	None
Sanding marks	Package color variations, surface texture variation	
Font variations	Blacktopping, altered pin 1 marker	
Ghost markings (some devices)		
Random extraneous marks		

IDM2901AJC

Observations by peer labs but not noted by Lab 6	Key defects identified by Lab 6	Observations with contradictory evidence
Not tested		

ERJ-3EKF3302V

Observations by peer labs but not noted by Lab 6	Key defects identified by Lab 6	Observations with contradictory evidence
Not tested		

K9F4G08U0D-SIB0

Observations by peer labs but not noted by Lab 6	Key defects identified by Lab 6	Observations with contradictory evidence
Inconsistent top vs. bottom texture	Terminations refinished, missing tooling marks	None
	Blacktopped, remarked, altered pin 1 marker	

Table 28 Lab 6 Part Defect Findings

4.4.3. Correlation Analysis

This assessment shows the correlation of the lab's results with their peers. Correlation score values fall between +1 and -1 where positive values indicate agreement with peers and negative values indicate disagreement with peers. The larger the value, the greater the agreement. Scores reflect test method correlation meaning the lab's findings using the specified test method were in agreement with their peers using that same test method. This does not necessarily imply overall consensus agreement. It is important to note that labs tend to have key analysis strengths which they utilize as primary detection methods. These key analyses vary between labs. This can impact the test method correlation but result in the same overall conclusions. This assessment does not evaluate test results accuracy (see section 3 for accuracy details), only alignment with peers. The chart includes items with correlation >0.25 and <-0.25

Note: Scoring excludes the /8 – Raman test method since Lab 3 was the only participating lab with the ability to perform this test as well as /10 – TGA since Lab 1 was the only lab with the capability to perform this test.

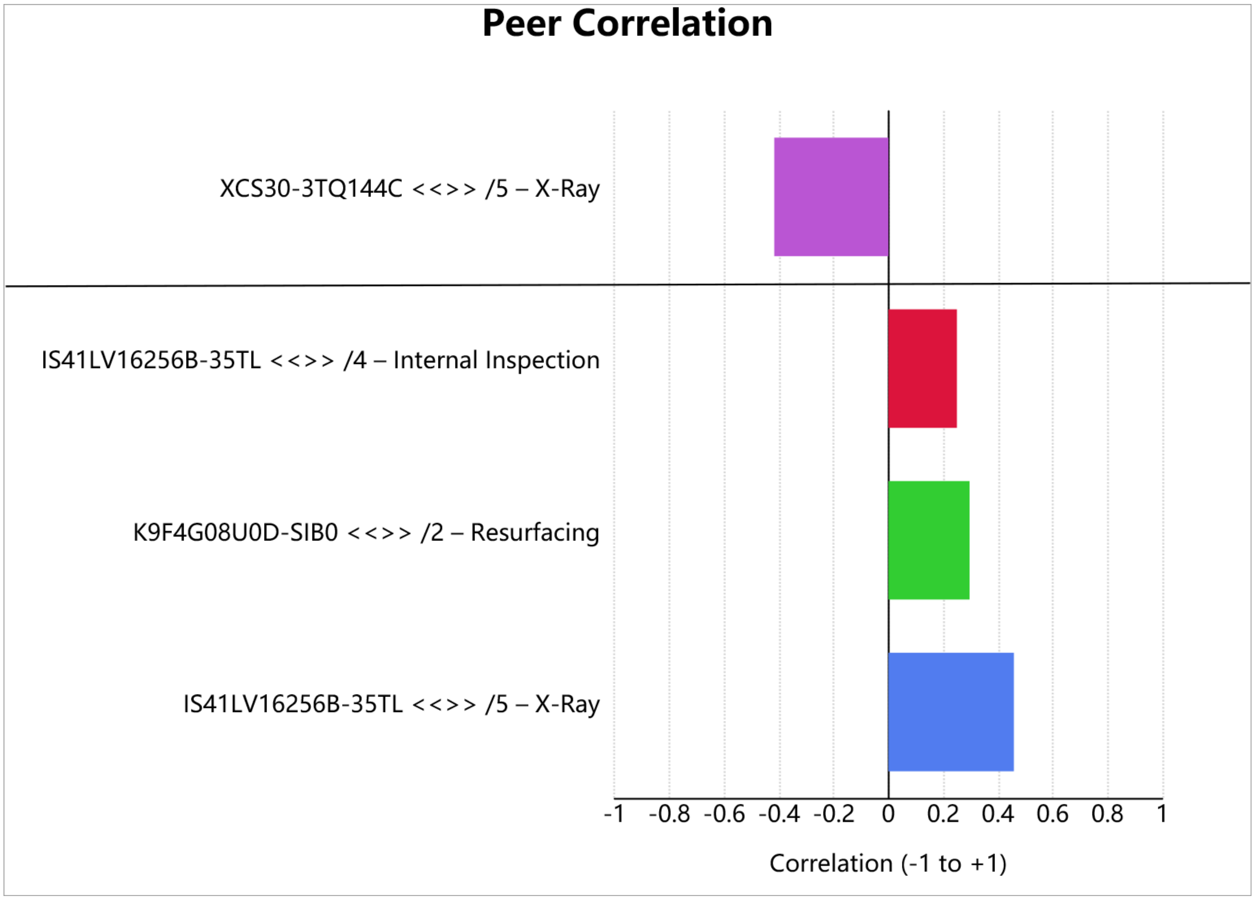


Figure 22 Lab 6 Peer Correlation Data

4.5. Lab 5

Lab 5 was only able to test 1 of the 10 parts included in the round robin due to workload commitments. Testing was limited to the TPS7A4901DGNT. Performed tests included /2 (general EVI, detailed EVI, remarking, resurfacing, dimensions), /3 (XRF), /4 (internal visual) and /5 (X-Ray).

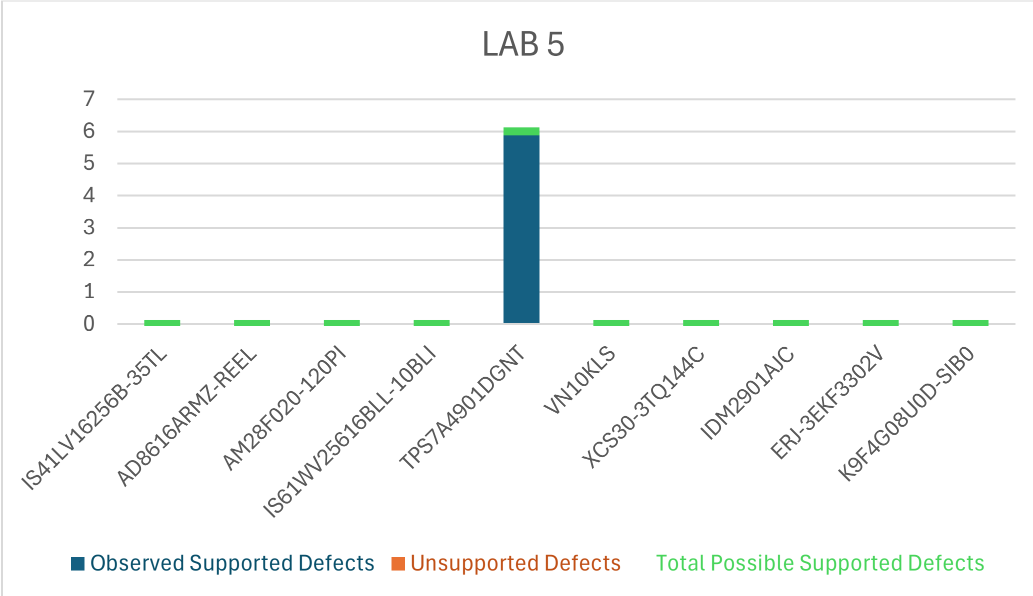


Figure 23 Lab 5 Defect Detection

4.5.1. Unsupported Defects Summary

Unsupported defects reflect observations which could not be substantiated through the data provided by any of the test labs. A lower number reflects well documented supporting evidence for identified defects.

Results: None identified

4.5.2. Supported Defects Summary

Supported defects reflect observations that had supporting evidence. The maximum supported defects are the combined potential defects found by any lab which this test lab has the potential for identifying. This does not mean all of these defects are definitely present in the lab's sublot of parts, but there is a high probability of that defects presence.

Supported defects reflect observations that had supporting evidence. The maximum supported defects are the combined potential defects found by any lab which this test lab has the potential for identifying. This does not mean all of these defects are definitely present in the lab's sublot of parts, but there is a high probability of that defects presence.

Results:

IS41LV16256B-35TL

Observations by peer labs but not noted by Lab 5	Key defects identified by Lab 5	Observations with contradictory evidence
Not tested		

AD8616ARMZ-REEL

Observations by peer labs but not noted by Lab 5	Key defects identified by Lab 5	Observations with contradictory evidence
Not tested		

AM28F020-120PI

Observations by peer labs but not noted by Lab 5	Key defects identified by Lab 5	Observations with contradictory evidence
Not tested		

IS61WV25616BLL-10BLI

Observations by peer labs but not noted by Lab 5	Key defects identified by Lab 5	Observations with contradictory evidence
Not tested		

TPS7A4901DGNT

Observations by peer labs but not noted by Lab 5	Key defects identified by Lab 5	Observations with contradictory evidence
None	Surface texture alterations, uneven sanding, altered pin 1 marker	None
	Blacktopping	

VN10KLS

Observations by peer labs but not noted by Lab 5	Key defects identified by Lab 5	Observations with contradictory evidence
Not tested		

XCS30-3TQ144C

Observations by peer labs but not noted by Lab 5	Key defects identified by Lab 5	Observations with contradictory evidence
Not tested		

IDM2901AJC

Observations by peer labs but not noted by Lab 5	Key defects identified by Lab 5	Observations with contradictory evidence
Not tested		

ERJ-3EKF3302V

Observations by peer labs but not noted by Lab 5	Key defects identified by Lab 5	Observations with contradictory evidence
Not tested		

K9F4G08U0D-SIB0

Observations by peer labs but not noted by Lab 5	Key defects identified by Lab 5	Observations with contradictory evidence
Not tested		

Table 29 Lab 5 Part Defect Findings

4.5.3. Correlation Analysis

This assessment shows the correlation of the lab's results with their peers. Correlation score values fall between +1 and -1 where positive values indicate agreement with peers and negative values indicate disagreement with peers. The larger the value, the greater the agreement. Scores reflect test method correlation meaning the lab's findings using the specified test method were in agreement with their peers using that same test method. This does not necessarily imply overall consensus agreement. It is important to note that labs tend to have key analysis strengths which they utilize as primary detection methods. These key analyses vary between labs. This can impact the test method correlation but result in the same overall conclusions. This assessment does not evaluate test results accuracy (see section 3 for accuracy details), only alignment with peers. The chart includes items with correlation >0.25 and <-0.25

Note: Scoring excludes the /8 – Raman test method since Lab 3 was the only participating lab with the ability to perform this test as well as /10 – TGA since Lab 1 was the only lab with the capability to perform this test.

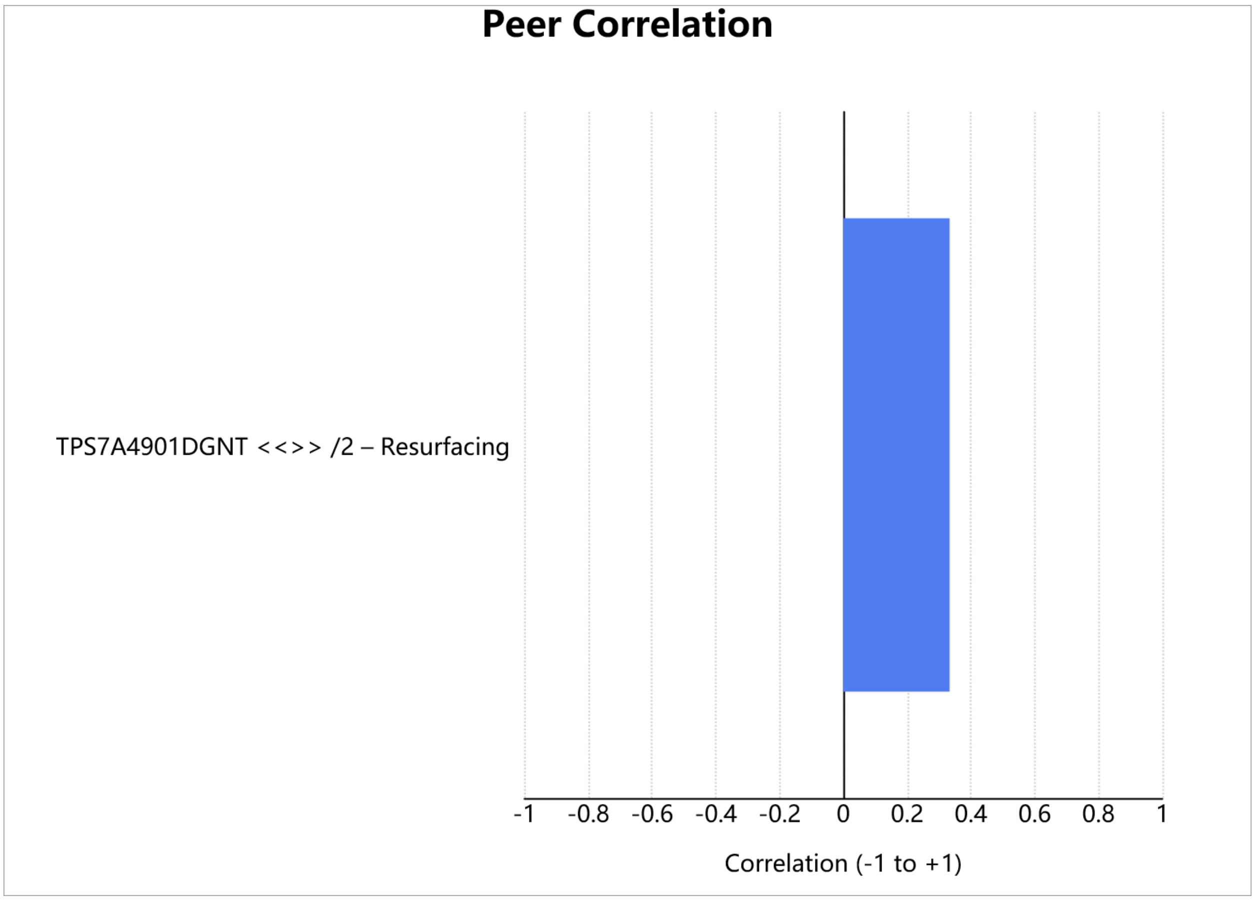


Figure 24 Lab 5 Peer Correlation Data

4.6. Lab 8

Lab 8 was able to support test methods /2 (general EVI, detailed EVI, remarking, resurfacing, dimensions, SEM surface inspection), /3 (XRF), /4 (internal visual) and /5 (X-Ray).

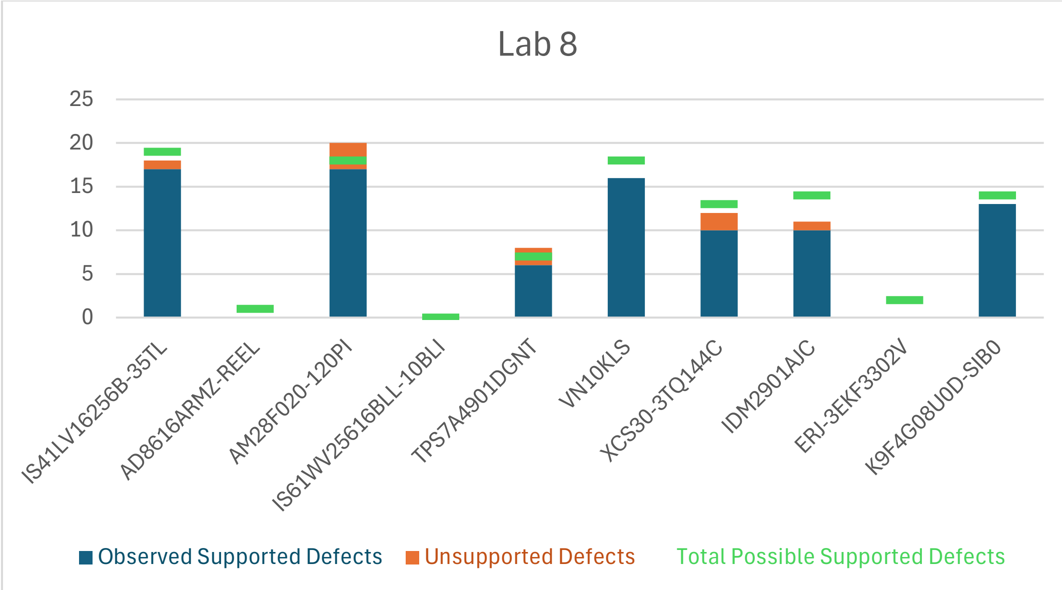


Figure 25 Lab 8 Defect Detection

4.6.1. Unsupported Defects Summary

Unsupported defects reflect observations which could not be substantiated through the data provided by any of the test labs. A lower number reflects well documented supporting evidence for identified defects.

[IS41LV16256B-35TL] When performing XRF, a variation in plating thickness was observed. This was categorized as incorrect termination materials, though the actual material composition was acceptable. The plating thickness variation is a valid observation, but it highlights a weakness in the defect definitions that does not adequately address this condition.

[AM28F020-120PI] The package dimension measurements performed pin spacing measurements on bent pins resulting in out of specification spacing. Dimensions are verification of as-built characteristics which does not include bent pins. This issue should be addressed as damaged terminations and measurements should evaluate nominal measurement values. This issue is applicable to two identified defects: Incorrect Part Package Outline Dimensions, and Incorrect Termination Dimensions.

[AM28F020-120PI] The terminations were identified as having been refinished. They exhibited extensive oxidation, but did not show any indications of replating such as excess solder buildup, solder splashes, or a demarcation line near the package body. All of these attributes are common evidence of refinishing on gull wing leads as are found on this device.

[TPS7A4901DGNT] Defective wire bonds were noted stating “Bond wires and bonding is inconsistent, unusual and malformed. Suspect re-bonded parts.” The provided imagery does not provide insight into what anomalies may have been observed. Similar die imagery from other labs also did not support this observation.

[TPS7A4901DGNT] Improper or missing die markings were noted. No manufacturer identification was found on the die. However, the die family and revision were found on the die which aligns with the device part number (die marking TPS7A49C). Manufacturer name or logo is not required to be on the die, though it is common on dies in this size range.

[XCS30-3TQ144C] Incorrect part package outline dimensions and incorrect termination dimensions were both identified. This is associated with pin spacing measurements. Measurements were taken on bent pins leading to out of specification spacing measurements. Dimensional measurements are intended to reflect the as-manufactured dimensions. Per IEC 60191-1:2018, "Outline drawings shall show terminals separately from the main body where necessary. Dimensions of the device shall be taken from the datum features, not from deformable terminal extremities." This criteria indicates that measurements should not consider lead tip alignment.

[IDM2901AJC] Altered or Added Pin 1 Marker was noted. This device has a notched end to designate pin 1. There were no additional details provided in the report which provided clarity on the alteration noted. No irregularities in the end notch were apparent.

4.6.2. Supported Defects Summary

Supported defects reflect observations that had supporting evidence. The maximum supported defects are the combined potential defects found by any lab which this test lab has the potential for identifying. This does not mean all of these defects are definitely present in the lab's sublot of parts, but there is a high probability of that defects presence.

Supported defects reflect observations that had supporting evidence. The maximum supported defects are the combined potential defects found by any lab which this test lab has the potential for identifying. This does not mean all of these defects are definitely present in the lab's sublot of parts, but there is a high probability of that defects presence.

Results:

IS41LV16256B-35TL

Observations by peer labs but not noted by Lab 8	Key defects identified by Lab 8	Observations with contradictory evidence
Ghost markings (on bottom)	Terminations damaged, refinished, color variations, missing tooling marks, oxidation	Termination material incorrect
Tin whiskers	Modified and inconsistent package surface texture, modified markings, body color variations, sanding, blacktopping, surface contamination	
	Wire bond pattern, die variations,, lead frame variations	

AD8616ARMZ-REEL

Observations by peer labs but not noted by Lab 8	Key defects identified by Lab 8	Observations with contradictory evidence
Package surface contamination (some samples)	None	None

AM28F020-120PI

Observations by peer labs but not noted by Lab 8	Key defects identified by Lab 8	Observations with contradictory evidence
Tin whiskers	Terminations damaged, plating issues, color variations, oxidation	Part/lead spacing dimensions
	Modified surface, color variations, inconsistent textures, unexpected marks on package, contamination	Missing tooling marks
	Blacktopping, altered pin 1 indicator	
	Varied wire bond pattern, wrong die, wrong lead frame, incorrect die markings	

IS61WV25616BLL-10BLI

Observations by peer labs but not noted by Lab 8	Key defects identified by Lab 8	Observations with contradictory evidence
None	None	None

TPS7A4901DGNT

Observations by peer labs but not noted by Lab 8	Key defects identified by Lab 8	Observations with contradictory evidence
Laser burns from marking	Termination oxidation	Defective wire bonds
	Sanding, inconsistent surfaces, surface contamination	Improper die markings
	Blacktopping	

VN10KLS

Observations by peer labs but not noted by Lab 8	Key defects identified by Lab 8	Observations with contradictory evidence
Terminations damaged and reattachments	Terminations refinished, plating inconsistency, missing tooling marks	None
	Sanding, marking inconsistencies, color variation, package variations, surface contamination	
	Blacktopped, altered pin 1 marker,	
	Lead frame variations, die variations, wire bond pattern variations	

XCS30-3TQ144C

Observations by peer labs but not noted by Lab 8	Key defects identified by Lab 8	Observations with contradictory evidence
Color variation on terminations	Terminations damaged, refinished, plating thickness variation, missing tooling marks	Lead spacing measurement
Ghost markings (some devices, top)	Sanding, inconsistent surface textures, extraneous marks	
Package color variations	Blacktopped, altered pin 1 marker	

IDM2901AJC

Observations by peer labs but not noted by Lab 8	Key defects identified by Lab 8	Observations with contradictory evidence
Oxidation related color variation on leads	Termination refinished, missing tooling marks	Altered pin 1 marker (no supporting evidence)
Termination oxidation	Modified surface texture, altered markings, extraneous marks on package, chipouts	
Resurfaced (but not blacktopped)	Top vs. bottom surfaces differ	
Surface contamination		

ERJ-3EKF3302V

Observations by peer labs but not noted by Lab 8	Key defects identified by Lab 8	Observations with contradictory evidence
Incorrect termination dimensions	None	None
Improper markings		

K9F4G08U0D-SIB0

Observations by peer labs but not noted by Lab 8	Key defects identified by Lab 8	Observations with contradictory evidence
Ghost markings	Terminations damaged, refinished, plating thickness, missing tooling marks, oxidation	None
	Surface texture, extraneous marks, contamination	
	Blacktopping, altered pin 1 marker	

Table 30 Lab 8 Part Defect Findings

4.6.3. Correlation Analysis

This assessment shows the correlation of the lab's results with their peers. Correlation score values fall between +1 and -1 where positive values indicate agreement with peers and negative values indicate disagreement with peers. The larger the value, the greater the agreement. Scores reflect test method correlation meaning the lab's findings using the specified test method were in agreement with their peers using that same test method. This does not necessarily imply overall consensus agreement. It is important to note that labs tend to have key analysis strengths which they utilize as primary detection methods. These key analyses vary between labs. This can impact the test method correlation but result in the same overall conclusions. This assessment does not evaluate test results accuracy (see section 3 for accuracy details), only alignment with peers. The chart includes items with correlation >0.25 and <-0.25

Note: Scoring excludes the /8 – Raman test method since Lab 3 was the only participating lab with the ability to perform this test as well as /10 – TGA since Lab 1 was the only lab with the capability to perform this test.

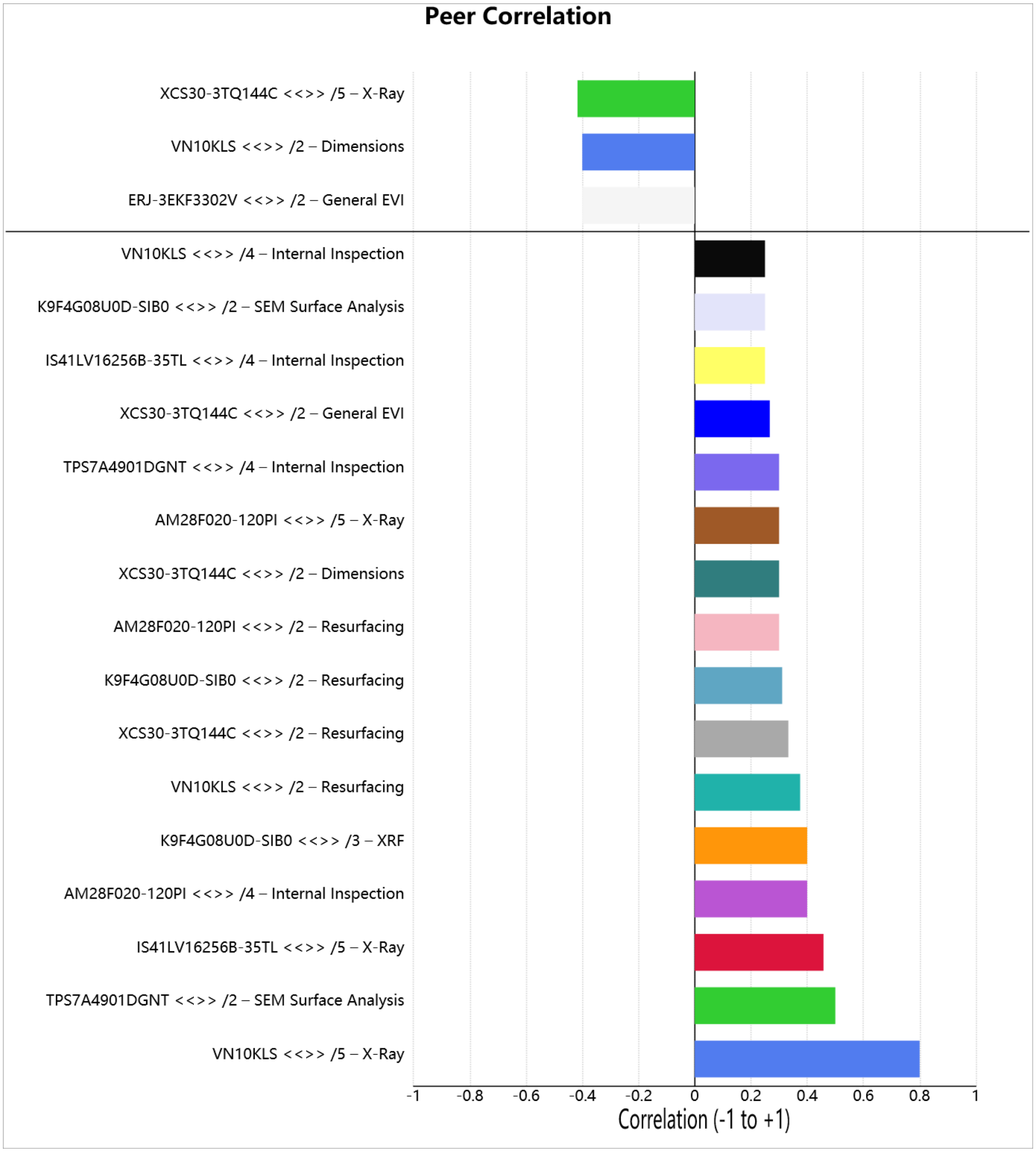


Figure 26 Lab 8 Peer Correlation Data

4.7. Lab 9

Lab 9 was able to support test methods /2 (general EVI, detailed EVI, remarking, resurfacing, dimensions), /3 (XRF), /4 (internal visual), /5 (X-Ray) and /7 (electrical test) on some part types. As noted in section 2.2, Lab 9 performs a hybrid approach to testing which includes both AS6171 test methods and comparison to known authentic devices. Their business model requires the availability of a golden sample, either provided by the test requestor or available through the part database maintained by Lab 9. For the purpose of this project, Lab 9 tested all parts with or without a golden sample. Lab 9 had golden samples available for AD8616ARMZ-REEL, IS61WV25616BLL-10BLI, TPS7A4901DGNT, and ERJ-3EKF3302V. These golden samples were very beneficial in clarifying several observations throughout this project. It should also be noted that when a golden sample was available, the difference between observed supported defects and total possible supported defects tended to be smaller.

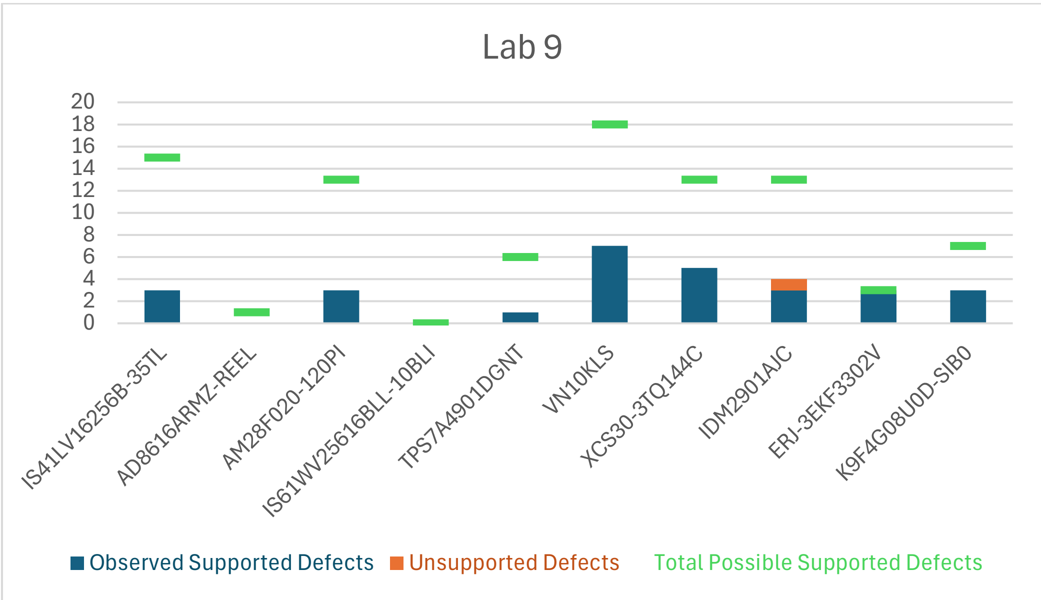


Figure 27 Lab 9 Defect Detection

4.7.1. Unsupported Defects Summary

Unsupported defects reflect observations which could not be substantiated through the data provided by any of the test labs. A lower number reflects well documented supporting evidence for identified defects.

[IDM2901AJC] There is no pin 1 marker on these parts, so this was characterized as an altered pin 1 marker. However, the datasheet notes that there are variants of this device with different features. One variant is the inclusion/exclusion of a pin 1 mark. The device maintains pin orientation through the notch on one end of the device. Given that the pin 1 dot may or may not be present, then only the notch can be considered a pin 1 identifier.

4.7.2. Supported Defects Summary

Supported defects reflect observations that had supporting evidence. The maximum supported defects are the combined potential defects found by any lab which this test lab has the potential for identifying. This does not mean all of these defects are definitely present in the lab's sublot of parts, but there is a high probability of that defects presence.

Supported defects reflect observations that had supporting evidence. The maximum supported defects are the combined potential defects found by any lab which this test lab has the potential for identifying. This does not mean all of these defects are definitely present in the lab's sublot of parts, but there is a high probability of that defects presence.

IS41LV16256B-35TL

Observations by peer labs but not noted by Lab 9	Key defects identified by Lab 9	Observations with contradictory evidence
Terminations damaged, color variations	Terminations refinished, missing tooling marks, oxidation	None
Sanding, blacktopping, partially filled mold marks/pin 1 marker		
Ghost markings, package color variations, extraneous marks on package, surface contamination		
Tin whiskers		

AD8616ARMZ-REEL

Observations by peer labs but not noted by Lab 9	Key defects identified by Lab 9	Observations with contradictory evidence
Surface contamination (some parts)	None	None

AM28F020-120PI

Observations by peer labs but not noted by Lab 9	Key defects identified by Lab 9	Observations with contradictory evidence
Termination materials incorrect (due to excessive plating degradation), color variations (oxidation), tin whiskers	Terminations oxidized,	None
Modified markings (due to resurfacing)	Sanding marks, altered pin 1 marker	
Package color variations (due to resurfacing)		
Extraneous marks due to sanding, blacktopping, surface contamination, irregular surface composition (due to blacktopping)		

IS61WV25616BLL-10BLI

Observations by peer labs but not noted by Lab 9	Key defects identified by Lab 9	Observations with contradictory evidence
Random surface contamination on some parts	None	None

TPS7A4901DGNT

Observations by peer labs but not noted by Lab 9	Key defects identified by Lab 9	Observations with contradictory evidence
Surface alteration (sanding)	Terminations oxidized	None
Burn marks from laser marking		
Top surface uneven due to sanding		
Extraneous marks on the package		
blacktopping		

VN10KLS

Observations by peer labs but not noted by Lab 9	Key defects identified by Lab 9	Observations with contradictory evidence
Terminations damaged, refinished, missing tooling marks	Termination plating issues	Package width measurement
Altered surface texture (sanding)		
Package color variations, part to part inconsistencies, extraneous marks		
Blacktopping, altered pin 1 marker, improper surface composition		

XCS30-3TQ144C

Observations by peer labs but not noted by Lab 9	Key defects identified by Lab 9	Observations with contradictory evidence
Termination color variances	Terminations damaged, refinished, missing tooling marks	None
Modified surface texture (sanding)	Inconsistent package surface	
Improper markings (molded font variance)	Incorrect lead frame	
Ghost markings (top, some devices)		
Package color variations, extraneous marks		
Blacktopping, altered pin 1 marker		

IDM2901AJC

Observations by peer labs but not noted by Lab 9	Key defects identified by Lab 9	Observations with contradictory evidence
Terminations refinished, color variations, missing tooling marks	Terminations damaged, oxidized	Altered pin 1 marker
Surface texture alteration, top vs. bottom differences, extraneous surface marks, contamination	Modified markings	
Chipouts (some devices)		
Resurfaced (not blacktopped)		

ERJ-3EKF3302V

Observations by peer labs but not noted by Lab 9	Key defects identified by Lab 9	Observations with contradictory evidence
None	Termination dimensions incorrect	None
	Incorrect lead frame	
	Incorrect part markings	

K9F4G08U0D-SIB0

Observations by peer labs but not noted by Lab 9	Key defects identified by Lab 9	Observations with contradictory evidence
Terminations refinished, missing tooling marks	Terminations damaged, plating has varied elemental composition	None
Surface texture alteration, inconsistent top vs. bottom	Improper markings	
Ghost markings		
Sanding, blacktopping, altered pin 1 marker		

Table 31 Lab 9 Part Defect Findings

4.7.3. Correlation Analysis

This assessment shows the correlation of the lab's results with their peers. Correlation score values fall between +1 and -1 where positive values indicate agreement with peers and negative values indicate disagreement with peers. The larger the value, the greater the agreement. Scores reflect test method correlation meaning the lab's findings using the specified test method were in agreement with their peers using that same test method. This does not necessarily imply overall consensus agreement. It is important to note that labs tend to have key analysis strengths which they utilize as primary detection methods. These key analyses vary between labs. This can impact the test method correlation but result in the same overall conclusions. This assessment does not evaluate test results accuracy (see section 3 for accuracy details), only alignment with peers. The chart includes items with correlation >0.25 and <-0.25

Note: Scoring excludes the /8 – Raman test method since Lab 3 was the only participating lab with the ability to perform this test as well as /10 – TGA since Lab 1 was the only lab with the capability to perform this test.

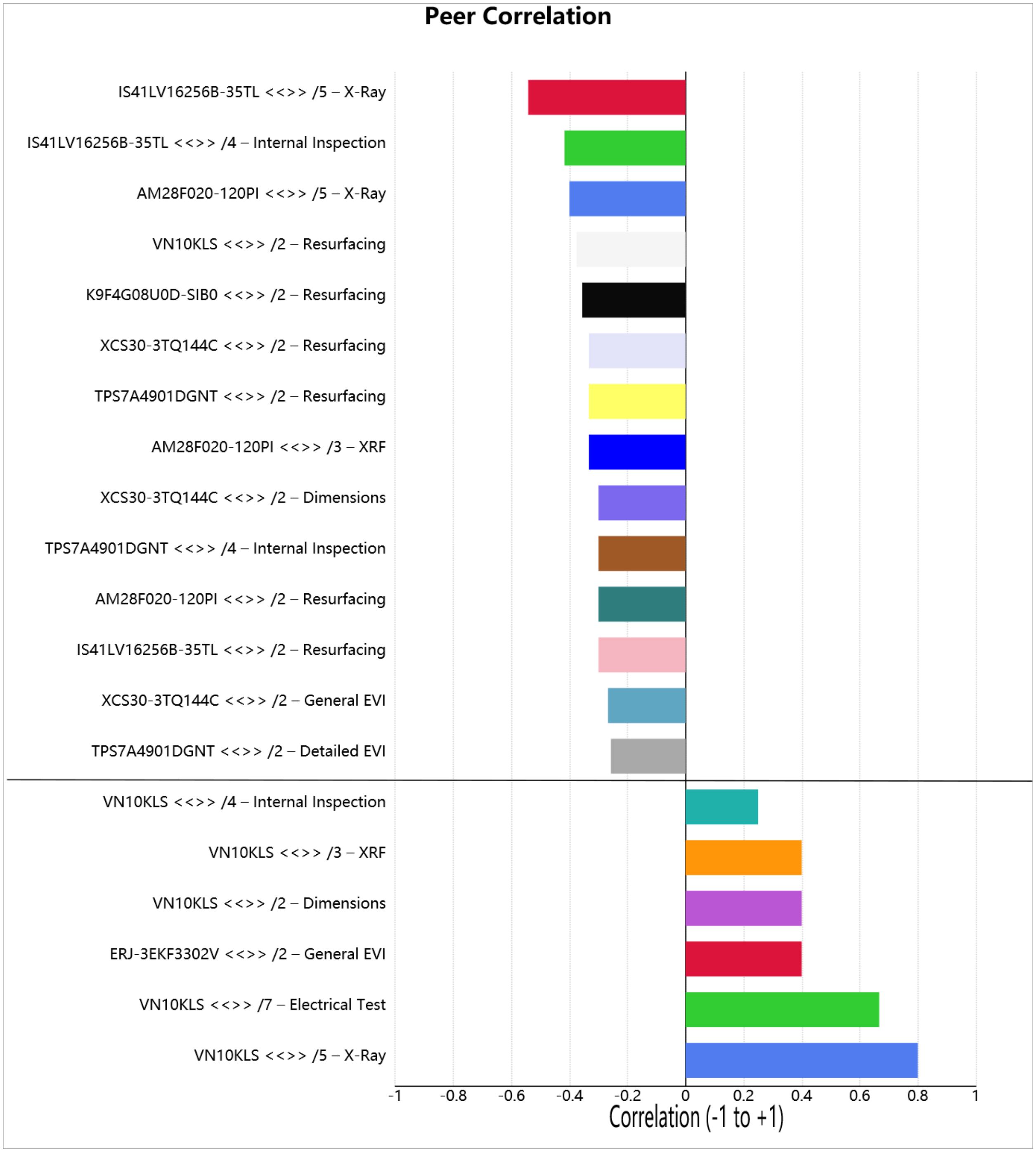


Figure 28 Lab 9 Peer Correlation Data

5. Test Method Details

The test method details section addresses the effectiveness of each test method to detect defects potentially associated with counterfeiting. Each section includes a table of defects which were reported by the participating labs using the specified test method. This list includes only the defects which could be validated for each part. This table contains the number of times (Quantity) an observation was identified by any of the labs using the defined test method. For example, if 5 labs found the same defect in 3 different part numbers, then there were 15 opportunities to identify that defect. The frequency of reporting an observation is attributable to multiple factors, the prevalence of the defect in the overall population of parts and the effectiveness of the test method to identify that defect. The quantity of part numbers which have confirmed occurrences of the defect (# Parts w/ Defect) is provided to show the overall likelihood of the defect being detected with the test method and the average number of times a defect was identified per applicable part number is shown (Freq. per Part). This establishes a relative effectiveness of the test method to identify the defect. High frequency values indicate greater levels of effectiveness. When comparing the effectiveness of two different test methods to identify the same defect, higher frequency values indicate greater effectiveness.

5.1. /2 – General External Visual Inspection (EVI)

The purpose of the general external visual inspection (AS6171/2A) is to identify nonconformities within the overall population. The process looks at the part population as a whole to identify inconsistencies between parts that may not be noticed looking at each part individually. Typical observations are color variations, marking inconsistencies, package texture variations, lead damage, etc. Table 32 lists the defects identified during the round robin testing attributed to General EVI

Property Type	Defect	Quantity	# Parts w/ Defect	Freq. per Part
Physical - Terminations	Damaged Terminations	13	8	1.6
Physical - Surface	Modified or Improper Markings on Package	11	8	1.4
Physical - Terminations	Refinished Terminations	7	5	1.4
Physical - Terminations	Missing or Unexpected Tooling Marks on Terminations	7	5	1.4
Physical - Surface	Modified or Improper Surface Texture (physical alteration)	8	7	1.1
Physical - Surface	Improper Package Surface Textures (inconsistent packages)	7	7	1.0
Physical - Terminations	Oxidation/Corrosion of Terminations	6	7	0.9
Physical - Surface	Altered or Added Pin One Marker	5	6	0.8
Physical - Surface	Evidence of Resurfacing/Blacktopping	4	7	0.6
Physical - Terminations	Incorrect Termination Dimensions	1	2	0.5
Physical - Surface	Contamination or Corrosion on External Surface(s)	3	8	0.4
Physical - Terminations	Color Variations on Terminations	2	5	0.4
Physical - Extensive Properties	Incorrect Part Package Outline Dimensions	1	3	0.3
Physical - Surface	Color Variations	1	5	0.2
Physical - Surface	Unexpected or Extraneous Marks on Package	1	7	0.1

Table 32 General EVI Detected Defects

5.1.1. Test Method Observations

Execution of this test method varied significantly among the participating labs. The labs which adhered strictly to the AS6171 process tended to have the most observations using this test method. Other labs tended to combine the General EVI and Detailed EVI into a common test given their close relationship. As a test practice, this should be discouraged since the emphasis appeared to be focused on detailed defects typically more identifiable through the Detailed EVI. This leaves the common mode defects intended to be identified through the General EVI less likely to be observed.

5.2. /2 – Detailed External Visual Inspection (EVI)

Detailed EVI (AS6171/2A) focuses on the specific external physical details of each part, as opposed to the General EVI which addresses the homogeneity of the overall lot of parts. Parts are inspected individually under magnification to find defects which may be present. Commonly observed defects include surface alterations and lead issues. Detailed EVI detects the broadest range of defects compared to any other test method (AS6171 /2 through /11). Detection frequency is also noticeably higher with Detailed EVI than with General EVI.

Property Type	Defect	Quantity	# Parts w/ Defect	Freq. per Part
Physical - Surface	Modified or Improper Surface Texture (physical alteration)	26	7	3.7
Physical - Surface	Modified or Improper Markings on Package	29	8	3.6
Physical - Terminations	Refinished Terminations	18	5	3.6
Physical - Surface	Evidence of Resurfacing/Blacktopping	24	7	3.4
Physical - Surface	Altered or Added Pin One Marker	19	6	3.2
Physical - Surface	Improper Package Surface Textures (inconsistent packages)	21	7	3.0
Physical - Terminations	Oxidation/Corrosion of Terminations	19	7	2.7
Physical - Terminations	Damaged Terminations	20	8	2.5
Physical - Terminations	Missing or Unexpected Tooling Marks on Terminations	11	5	2.2
Physical - Surface	Color Variations	11	5	2.2
Physical - Surface	Package Fracture Damage	7	4	1.8
Physical - Terminations	Color Variations on Terminations	8	5	1.6
Physical - Surface	Contamination or Corrosion on External Surface(s)	10	8	1.3
Physical - Surface	Unexpected or Extraneous Marks on Package	9	7	1.3
Physical - Surface	Whiskers	4	3	1.3
Physical - Terminations	Incorrect Termination Dimensions	2	2	1.0
Physical - Extensive Properties	Incorrect Part Package Outline Dimensions	2	3	0.7

Table 33 Detailed EVI Detected Defects

5.2.1. Test Method Observations

Detailed EVI is able to effectively identify a wide range of external defects. Most defects can be validated directly through the results of this test. However, Evidence of Resurfacing/Blacktopping should be considered as a preliminary indicator requiring further evaluation as opposed to a definitized finding. This was evident in the round robin testing where the AD8616ARMZ-REEL was identified as having a blacktop coating by several labs during Detailed EVI. Further blacktop specific testing during the Resurfacing Test could not validate the presence of a coating. Additionally, cross section analysis also did not show the presence of a coating.

5.3. /2 – Remarking

The remarking test (AS6171/2A) is designed to detect parts whose markings are not authentic. The test evaluates the marking's resistance to solvents. Degradation of the markings by the solvent is considered to be a sign of possible counterfeiting since part markings are required to be indelible to cleaning solvents commonly used in part/assembly cleaning during the manufacturing process. The test is intended to detect only one defect "Modified or Improper Markings on Package". However, related defects are sometimes also detected with this test.

Property Type	Defect	Quantity	# Parts w/ Defect	Freq. per Part
Physical - Surface	Altered or Added Pin One Marker	1	6	0.2
Physical - Surface	Modified or Improper Surface Texture (physical alteration)	1	7	0.1
Physical - Surface	Modified or Improper Markings on Package	1	8	0.1
Physical - Surface	Improper Package Surface Textures (inconsistent packages)	1	7	0.1
Physical - Surface	Evidence of Resurfacing/Blacktopping	1	7	0.1

Table 34 Remarking Detected Defects

5.3.1. Test Method Observations

The remarking test produced very poor detectability scores for all defects, including "Modified or Improper Markings on Package" which it was designed to identify. The evolution of counterfeiting processes has made this test of minimal value. Counterfeit parts with ink markings are nearly all using inks which are resistant to the solvents. There has also been a substantial increase in the use of laser markings for which this test does not provide any benefit. Alternative test methods such as Detailed EVI are much more effective at identifying marking anomalies since they evaluate the marking characteristics as opposed to just the resistance to solvents. Other defects identified by this test are also more commonly observed through Detailed EVI.

5.4. /2 – Resurfacing

The resurfacing test (AS6171/2A) actually consists of five subtest methods: 1) Nonaggressive acetone, 2) Aggressive acetone, 3) 1-Methyl-2-Pyrrolidinone, 4) Commercial solvent 1 (or 2), 5) Mechanical scrape test. The purpose of the test is to verify if a secondary coating has been applied to the part. Each solvent is intended to address different potential coating methods. Several additional defects may also be detected with this test method which are all related to the surface integrity. Given that the part surface is examined closely during this test, these additional observations are expected.

Property Type	Defect	Quantity	# Parts w/ Defect	Freq. per Part
Physical - Surface	Evidence of Resurfacing/Blacktopping	31	7	4.4
Physical - Surface	Modified or Improper Surface Texture (physical alteration)	18	7	2.6
Physical - Surface	Improper Package Surface Textures (inconsistent packages)	14	7	2.0
Physical - Surface	Modified or Improper Markings on Package	15	8	1.9
Physical - Surface	Altered or Added Pin One Marker	8	6	1.3
Physical - Surface	Unexpected or Extraneous Marks on Package	7	7	1.0
Physical - Surface	Ghost Markings	3	3	1.0
Physical - Surface	Contamination or Corrosion on External Surface(s)	6	8	0.8
Physical - Surface	Improper Material Composition of the External Surface(s)	5	9	0.6
Physical - Surface	Color Variations	1	5	0.2

Table 35 Resurfacing Detected Defects

5.4.1. Test Method Observations

The evolution of blacktopping methods has impacted the relative effectiveness of the resurfacing subtest methods. Data was collected on each of the subtests to determine which test approach(es) were able to identify the presence of coatings. The nonaggressive acetone and aggressive acetone tests were of least value. In no cases were these solvents able to clearly remove a coating. When identified as a positive detection, it was due to slight dark coloring left on the swab when rubbed on the part. The part surface itself did not show clear removal of a coating layer. The 1-Methyl-2-Pyrrolidinone, Commercial solvent 1 (or 2), and scrape tests commonly produced more positive results where a clear change in the surface resulted from the test and the swab would collect substantial material from the surface.

There is significant inconsistency in the methodology used to perform these tests which had an adverse impact on the test outcome. AS6171/2A is vague on the execution of these tests stating that a cotton swab is to be used to wipe the surface to determine if a coating can be removed. The process does not state how aggressive the surface should be wiped or how to distinguish between a positive or negative result (breakdown of encapsulant vs. coating removal). The process just states that "Any removed coating will show on the cotton swab as black in color". This statement led some labs to interpret any discoloration on the swab indicated the presence of a coating without examination of the surface itself to determined if a coating had been present. Further, the process states to avoid part markings when possible. This guidance limits the usefulness of the test methods since it will likely miss the presence of ghost markings on a part. As an example of this, the images in Figure 29 below compare the top surface of the K9F4G08U0D-SIB0 where a larger portion of the surface was processed versus a small area. The ghost markings clearly visible on the large processed area were not detected when only a small area was processed. Only Lab 6 identified these ghost markings through the resurfacing test because of their methodology.

Figure 29 Resurfacing Comparison of Large vs. Small Processed Area

Another issue with the test method is that it does not specify which surfaces should be evaluated. Labs focus on the top surface of the part given that is where markings normally are and where coatings would be applied to mask those markings. However, the IS41LV16256B-35TL also had backside markings which had been obscured with a coating. Only two labs, Lab 4 and Lab 1 found ghost markings on this part. The condition was observed by Lab 1 using acoustic microscopy, not the resurfacing tests. It is unclear what ghost markings Lab 4 observed. They noted observing ghost markings during the resurfacing test using 1-Methyl-2-Pyrrolidinone, but did not indicate where the ghost markings were located or provide imagery of the markings. All of their provided imagery was associated with the top surface, but it is possible they also tested the back side.

5.5. /2 – Dimensional Evaluation

The purpose of the dimensional evaluation (AS6171/2A) is to determine if the parts comply with the datasheet dimensional parameters. Deviations could be an indicator of part substitution or alteration. The test method is very specific to these attributes, so detections were limited to defects specific to dimensional requirements.

Property Type	Defect	Quantity	# Parts w/ Defect	Freq. per Part
Physical - Extensive Properties	Incorrect Part Package Outline Dimensions	9	3	3.0
Physical - Terminations	Incorrect Termination Dimensions	3	2	1.5

Table 36 Dimensional Evaluation Detected Defects

5.5.1. Test Method Observations

AS6171/2A requires the use of optical measurement tools when performing this test. All labs with the exception of Lab 1 performed measurements using these techniques. Lab 1 utilized a combination of non-contact and caliper measurements for this purpose. Comparing these approaches highlighted the rationale behind this requirement. Several instances of out of specification measurements were the result of body and inter-pin flash which may be attributable to caliper measurements. Datasheets typically exclude the flash from their dimensional requirements due to its variability. This is easily done using noncontact measurement methods but very difficult to do with contact methods.

A second issue with dimensional measurements results from the part measurement method as stated in AS6171/2A. The procedure states “Nondestructively measure the overall part dimensions of body length, width, and thickness”. Most labs did not comply with this requirement literally unless these dimensions were specifically listed on the datasheet. They would measure parameters which were most closely related to these values which had specified dimensional limits on the datasheet. The Lab 1 approach was to stay fully compliant with AS6171/2A, which required them to derive values (primarily thickness) from specified values. This resulted in some measurements being outside of their derived parameters and identified as noncompliant even though no datasheet specified parameters were violated. A second issue example of the limitations imposed by identifying length, width, and thickness as the verified parameters is the ERJ-3EKF3302V. This part has termination end metal anomalies which would have likely been detectable defects if measured. Since the defined criteria did not include end metal dimensions, this was not identified.

5.6. /2 – SEM Surface Inspection

SEM surface analysis (AS6171/2A) is intended to provide a higher magnification inspection of the overall surface as compared to that performed during Detailed EVI. The test method allows for the use of optical microscopy as well (200X to 400X). The defects detected with this test are similar to Detailed EVI. The main difference is this inspection focuses much more on the part surface and Detailed EVI addresses the entire part, so lead issues are more commonly observed with Detailed EVI.

Property Type	Defect	Quantity	# Parts w/ Defect	Freq. per Part
Physical - Surface	Evidence of Resurfacing/Blacktopping	9	7	1.3
Physical - Surface	Modified or Improper Surface Texture (physical alteration)	4	7	0.6
Physical - Surface	Improper Package Surface Textures (inconsistent packages)	3	7	0.4
Physical - Surface	Whiskers	1	3	0.3
Physical - Surface	Modified or Improper Markings on Package	1	8	0.1
Physical - Surface	Unexpected or Extraneous Marks on Package	1	7	0.1

Table 37 SEM Surface Inspection Detected Defects

5.6.1. Test Method Observations

Labs used a mix of SEM and optical microscopy for this test method. Both provide a detailed look at the surface conditions and neither method had a statistically significant advantage over the other. SEM offers improved depth of field over optical, so this approach would be more valuable in some situations.

5.7. /3 – XRF Elemental Analysis

XRF (AS6171/3) is used to identify differences in material composition either on one part, when comparing parts, or compared to a specification. The test method has two subtests: material composition and plating thickness. The test method focuses on the analysis of lead plating, though the technique could be used on other surfaces as well.

Property Type	Defect	Quantity	# Parts w/ Defect	Freq. per Part
Physical - Terminations	Incorrect Termination Materials	8	3	2.7
Physical - Terminations	Incorrect Termination Dimensions	6	2	3.0
Physical - Terminations	Oxidation/Corrosion of Terminations	1	7	0.1
Physical - Surface	Evidence of Resurfacing/Blacktopping	1	7	0.1
Physical - Surface	Improper Material Composition of the External Surface(s)	1	9	0.1

Table 38 XRF Detected Defects

5.7.1. Test Method Observations

There were several variations in how this test was performed. All labs performing this test evaluated lead plating composition. A few labs did not perform the plating thickness evaluation. One lab, Lab 4, also evaluated the part body.

5.8. /4 – Internal Visual Inspection

Internal visual inspection (AS6171/4) provides visual confirmation of internal observations identified through previously performed imaging techniques as well as the identification of anomalies which may not be detected through imaging such as die markings, etc.

Property Type	Defect	Quantity	# Parts w/ Defect	Freq. per Part
Physical - Internal	Wrong Die or Functional Passive Element	12	4	3.0
Physical - Internal	Improper or Missing Die Markings	10	2	5.0
Physical - Internal	Inconsistent Wire Bond Pattern	5	3	1.7
Physical - Internal	Inconsistent or Incorrect Lead Frame	5	5	1.0

Table 39 Internal Visual Detected Defects

5.8.1. Test Method Observations

Lab execution of this test method was very consistent in both observations and methodology. Labs focused on the validation of the die itself with minimal attention to bond wires or lead frame. The test method includes optional tests for die shear and bond pull, but no labs performed these tests and this was not requested in the test plan they were provided. Different decapsulation approaches were used as was evident from the extent of bond wire damage. The test document allows for many different approaches, so this is consistent with AS6171/4.

5.9. /5 – X-ray Inspection

X-Ray inspection (AS6171/5) provides detailed inspection of the internal structure of a device. It is the primary method of detection of defects such as lead frame or wire bond pattern irregularities. The AS6171/5 test method allows for significant process variations to meet the performing lab's capabilities and the desired scope of analysis. Both 2D and 3D methods are included. No specific criteria are provided outlining the formal test approach or when each method should be the preferred method.

Property Type	Defect	Quantity	# Parts w/ Defect	Freq. per Part
Physical - Internal	Inconsistent or Incorrect Lead Frame	18	5	3.6
Physical - Internal	Inconsistent Wire Bond Pattern	9	3	3.0
Physical - Internal	Wrong Die or Functional Passive Element	11	4	2.8
Physical - Terminations	Damaged Terminations	4	8	0.5
Physical - Internal	Delamination of Internal Layers	2	4	0.5
Physical - Extensive Properties	Incorrect Part Package Outline Dimensions	1	3	0.3

Table 40 X-Ray Detected Defects

5.9.1. Test Method Observations

All labs performing X-Ray utilized real-time 2D systems. Most labs utilized a single perpendicular view and a few also performed side views. No labs performed 3D radiography. Observations were very consistent from this test method with a high level of detectability for lead frame, wire bond variances and differing die size. Several labs noted limitations of their X-Ray equipment under specific conditions. For example, several labs noted that they were unable to adequately image bond wires on the IDM2901AJC. Most noted that this was likely due to the presence of aluminum wires. Lab 1 identified this as a missing bond wire defect which was later determined to be aluminum wires during the internal visual inspection.

5.10. /6 – Acoustic Microscopy

Acoustic microscopy (AS6171/6) is a methodology for the evaluation of internal construction. It is complementary to X-Ray but uses acoustic energy for imaging and evaluation. Acoustic energy is much more effective at identifying voided areas, making it the preferred method for locating voids, cracks and delaminations. When used in reflective mode, the technique is also useful at identifying device alterations by allowing visualization at user defined depths of penetration.

Only two participating labs (Lab 1 and Lab 3) had the capability to perform Acoustic Microscopy. Because of this, an Adjusted Quantity column was added to the detected defects table to scale the quantity of observations of each defect so that the relative effectiveness of Acoustic Microscopy could be compared directly to other test methods. This is necessary since with fewer labs performing the test, there are less opportunities to observe specific defects.

Property Type	Defect	Quantity	Adjusted Quantity	# Parts w/ Defect	Freq. per Part
Physical - Surface	Ghost Markings	3	8	3	2.7
Physical - Internal	Delamination of Internal Layers	4	10	4	2.5
Physical - Surface	Unexpected or Extraneous Marks on Package	6	15	7	2.1
Physical - Internal	Wrong Die or Functional Passive Element	3	8	4	2.0
Physical - Internal	Inconsistent or Incorrect Lead Frame	4	10	5	2.0
Physical - Surface	Modified or Improper Markings on Package	6	15	8	1.9
Physical - Surface	Modified or Improper Surface Texture (physical alteration)	4	10	7	1.4
Physical - Surface	Package Fracture Damage	1	3	4	0.8
Physical - Terminations	Damaged Terminations	2	5	8	0.6
Physical - Surface	Contamination or Corrosion on External Surface(s)	2	5	8	0.6
Physical - Surface	Altered or Added Pin One Marker	1	3	6	0.5

Table 41 Acoustic Microscopy Detected Defects

5.10.1. Test Method Observations

Lab 1 and Lab 3 are the only two participating labs with the capability to perform Acoustic Microscopy. However, the approaches each lab utilize resulted in significantly differing results. Lab 1 performed reflection scans to image the surface interfaces and thru scans to evaluate internal construction on devices with thicker packages. The surface scans proved to be highly effective at the identification of defects such as ghost markings, top vs bottom surface inconsistencies, and sanding marks. Thru scans provided insight into the internal construction attributes very similar to those obtained through X-Ray providing imagery of attributes such as die size and orientation, and lead frame design.

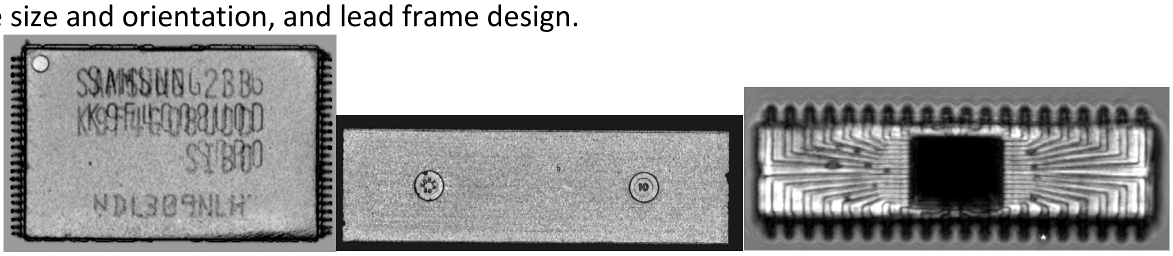


Figure 30 Example Lab 1 Surface Scans Showing Ghost Marking and Sanding, Thru Scan Showing Internal Features

The Lab 3 approach was focused more on the die interfaces which was effective at identifying delaminations on the IS41LV16256B-35TL and XCS30-3TQ144C which were not identified by the Lab 1 approach. However, the use of a single 25MHz transducer for all scans limited the ability to image surface artifacts resulting in not identifying the ghost markings which were observable in 4 of 5 parts in the Lab 1 sublot, sanding marks, or detailed internal structures such as those shown in Figure 30.

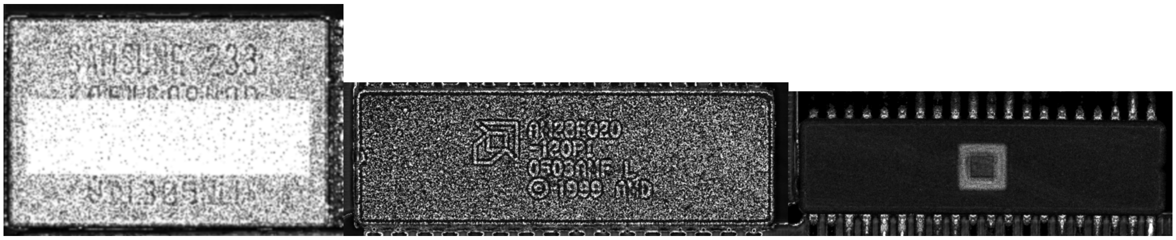


Figure 31 Example Lab 3 Scans of the Same Part views as Shown in Figure 30

5.11. /7 – Electrical Test

The electrical test method (AS6171/7) encompasses a broad range of electrical testing ranging from burn-in to static/active testing to environmental tests. Scope of testing is widely varied and left to the test requestor to define. For this project, electrical testing was limited to basic static tests and value measurements. This was done to align with the level of testing commonly performed in industry and to manage the project cost and schedule. Four labs performed some level of electrical testing. Different labs tested a subset of the parts with only Lab 3 testing all 10 of the part types. For this reason, adjustment factors are applied to the Quantity listed in the Detected Defects table to normalize the frequency scores allowing for test method to test method comparisons.

Property Type	Defect	Quantity	Adjusted Quantity	# Parts w/ Defect	Freq. per Part
Electrical	Out of Specification Static Electrical Characteristic(s)	6	15	4	3.8
Electrical	Out of Specification Electrical Functional Characteristic(s)	1	2.5	1	2.5

Table 42 Electrical Detected Defects

5.11.1. Test Method Observations

Specific guidance on the scope of testing to be performed on each part was not provided to the participating test labs. Each lab determined an appropriate level of basic testing to be performed. The actual scope of testing for each part was similar in most cases. However, significant discrepancies were noted in the test results which may have resulted from differing test procedures or test setup issues. Because of these differences, electrical test results were inconclusive for two parts. Table 43 summarizes test results where substantially differing results were obtained.

Lab	XCS30-3TQ144C	IDM2901AJC
Lab 3	Failed 5 of 5 (data pattern write & verify using JTAG)	Failed 5 of 5 (verified A+B ALU logic)
Lab 4	Passed 5 of 5 (write & verify using custom script)	Passed 5 of 5 (curve trace)

Table 43 Electrical Test Results with Differing Outcomes

5.12. /8 – Raman

Raman spectroscopy (AS6171/8) is a surface analysis method suitable for the determination of material composition. The methodology is very similar to FTIR, but the two methods complement each other in their areas of detectability. Raman is particularly effective at the identification of C-C bonds such as alkenes, hydrocarbons, polymers, sulfur and disulfides, benzene, etc. All of these provide a weak response using FTIR. In counterfeit detection applications, it primarily serves to identify surface contaminants and changes in surface materials. It would be the preferred method to use if biological contamination is suspected. Lab 3 was the only participating lab with the capability to perform Raman. For this reason, Quantity values shown in the detected defects table have been normalized to allow for direct comparison of test method effectiveness.

Property Type	Defect	Quantity	Adjusted Quantity	# Parts w/ Defect	Freq. per Part
Physical - Surface	Improper Material Composition of the External Surface(s)	7	35	9	3.9
Physical - Surface	Contamination or Corrosion on External Surface(s)	1	7	8	0.9

Table 44 Raman Detected Defects

5.12.1. Test Method Observations

None

5.13. /9 – FTIR

FTIR (AS6171/9) is similar to Ramen spectroscopy in principle. FTIR utilizes the absorption of IR light to create a spectral fingerprint which can be compared to known material signatures. FTIR is most effective with organics, polymers, etc. Lab 1 and Lab 3 were the only two labs capable of performing FTIR. For this reason, Quantity values shown in the detected defects table have been normalized to allow for direct comparison of test method effectiveness.

Property Type	Defect	Quantity	Adjusted Quantity	# Parts w/ Defect	Freq. per Part
Physical - Surface	Improper Material Composition of the External Surface(s)	12	30	9	3.3
Physical - Surface	Evidence of Resurfacing/Blacktopping	6	15	7	2.1
Physical - Surface	Contamination or Corrosion on External Surface(s)	3	8	8	1.0
Physical - Surface	Modified or Improper Surface Texture (physical alteration)	1	2	7	0.3

Table 45 FTIR Detected Defects

5.13.1. Test Method Observations

FTIR is an effective method of identifying surface material changes as well as surface contamination. Both labs used it primarily as a comparative tool to look for outliers from the population which would support non-homogeneity as opposed to material identification. Within a homogeneous lot, material variations are not expected. FTIR results must consider the part origins before any determinations can be made from the results. For example, the IS61WV25616BLL-10BLI is an authentic device with OCM traceability. One part tested by Lab 1 showed some variation from the remainder of the population. Given the handling this part experienced and the isolated area showing this abnormality, Lab 1 concluded this to be a contaminant. Without applying this rationale, they could have been led to other conclusions.

5.14. /10 – TGA

Thermogravimetric Analysis (AS6171/10) evaluates material weight change over a controlled temperature environment. As material decomposes over temperature, it creates a unique profile which can be compared to other parts within a population or to known material profiles to identify material variances. Counterfeit parts often have varying origins (differing sources, multiple lots, etc.) which lead to subtle material differences within the lot. TGA provides a method of identifying these inconsistencies which may not be apparent visually. Lab 1 was the only participating lab which had the capability to perform this test. For this reason, Quantity values shown in the detected defects table have been normalized to allow for direct comparison of test method effectiveness.

Property Type	Defect	Quantity	Adjusted Quantity	# Parts w/ Defect	Freq. per Part
Physical - Surface	Improper Material Composition of the External Surface(s)	4	20	9	2.2

Table 46 TGA Detected Defects

5.14.1. Test Method Observations

TGA provides an alternative means of identifying surface composition irregularities. The technique has the potential to identify subtle variations which may not be detectable through alternative test methods. However, in no cases during the round robin testing did this test method identify anything unique or with greater frequency than alternative test methods. Both FTIR and Raman which also evaluate surface composition exhibited higher defect detection rates for this defect.

5.15. /11 – Design Recovery

No participating labs performed the Design Recovery test method (AS6171/11). Analysis of this test method is being performed by the University of Michigan but is not included in this report.

6. Alternative Test Methods

6.1. Lab 2

The Lab 2 analysis process evaluates attributes of the device top and bottom surfaces. The process considers both the main surface area and the mold mark/pin 1 mark areas (referred to collectively as pinholes in the analysis). Font irregularities are also evaluated. The analysis method is currently in the development stage, so it is not used to accept/reject components. It does provide guidance for attributes that should get additional review from the analyst. Since the tool only evaluates surfaces (no termination defects at this time, but this is on their development roadmap), it limits the number of possible observable defects significantly, but it is addressing some of the most commonly occurring defects. Table 48 compares the defects potentially identifiable with this tool to those detected during Detailed EVI, which is the most similar test method to Lab 2. Output from Lab 2 is different than traditional test methods. The tool shows degrees of variability which are different than identifying a directly observed condition. In order to compare the two processes, the Lab 2 output has been mapped to the AS6171 defects. The mapping is based on content within the two report types, so there could be some interpretive differences between test results and defect alignment.

Part	Consensus Conclusion	Lab 2 Conclusion	Comments
IS41LV16256B-35TL	Suspect	Concern	Multiple surface inconsistencies, requires further analysis to verify.
AD8616ARMZ-REEL	Acceptable	Concern	Possible font and surface texture issues. Needs additional review.
AM28F020-120PI	Suspect	Concern	Multiple surface texture issues. Needs additional review.
IS61WV25616BLL-10BLI	Acceptable	Concern	Concerns of the top surface and markings which require additional review.
TPS7A4901DGNT	Suspect	Concern	Top vs. bottom inconsistency requires additional review.
VN10KLS	Suspect	N/A	Package style not supported by Lab 2
XCS30-3TQ144C	Suspect	Concern	Surface texture variability, font irregularities
IDM2901AJC	Suspect	Concern	Surface texture inconsistency
ERJ-3EKF3302V	Suspect	N/A	Package style not supported by Lab 2
K9F4G08U0D-SIB0	Suspect	Suspect	Surface and mold mark inconsistencies, require further analysis to confirm

Table 47 Lab 2 Summary

IS41LV16256B-35TL

Defect	Detailed EVI	Lab 2	Notes
Modified or Improper Surface Texture (physical alteration)	X	X	EVI: Surface inconsistencies, possibly blacktopped Lab 2: Significant surface texture variation, possible blacktopping
Modified or Improper Markings on Package		X	EVI: Not noted Lab 2: Failed font analysis for character consistency
Evidence of Resurfacing/Blacktopping	X	X	EVI: Visual appearance of secondary coating Lab 2: Surface texture inconsistency potentially indicating resurfacing
Altered or Added Pin One Marker	X	X	EVI: Inconsistent markers when comparing devices Lab 2: Pinhole vs. surrounding area too similar, suggesting potential alteration

AD8616ARMZ-REEL

Defect	Detailed EVI	Lab 2	Notes
Altered or Added Pin One Marker		X	EVI: Not identified as a concern Lab 2: Surface variation in marker identified as high risk

AM28F020-120PI

Defect	Detailed EVI	Lab 2	Notes
Modified or Improper Surface Texture (physical alteration)	X	X	EVI: Sanding marks, blacktopping Lab 2: Significant surface texture issues, particularly on bottom
Modified or Improper Markings on Package	X		EVI: Visual identification of remarking Lab 2: Passed font tests
Improper Package Surface Textures (inconsistent packages)	X	X	EVI: Inconsistency from sanding Lab 2: Top vs. bottom texture inconsistent
Evidence of Resurfacing/Blacktopping	X		EVI: Top surface coloration, filled mold marks Lab 2: Not noted, but surface issues could imply a coating is present.
Altered or Added Pin One Marker	X	X	EVI: Filled mold marks Lab 2: Irregular texture in mold marks

IS61WV25616BLL-10BLI

Defect	Detailed EVI	Lab 2	Notes
Modified or Improper Surface Texture (physical alteration)		X	EVI: No issues noted Lab 2: Top surface texture irregularity. Further review is warranted.
Modified or Improper Markings on Package		X	EVI: No issues noted Lab 2: Possible marking issue noting variability in the letter S. Possibly not recognizing 2 fonts are used on the part?

TPS7A4901DGNT

Defect	Detailed EVI	Lab 2	Notes
Modified or Improper Surface Texture (physical alteration)	X	X	EVI: Secondary coating, uneven top surface Lab 2: Top vs. bottom inconsistencies

Defect	Detailed EVI	Lab 2	Notes
Improper Package Surface Textures (inconsistent packages)	X		EVI: Uneven top surface Lab 2: Not noted
Evidence of Resurfacing/Blacktopping	X		EVI: Coating demarcation visible Lab 2: Not noted
Altered or Added Pin One Marker		X	EVI: Not noted Lab 2: Laser mark interpreted as mold mark. Possibly a false indication?

VN10KLS

Defect	Detailed EVI	Lab 2	Notes
Package type not supported by Lab 2			

XCS30-3TQ144C

Defect	Detailed EVI	Lab 2	Notes
Modified or Improper Surface Texture (physical alteration)	X	X	EVI: Sanding, recoated Lab 2: Potential surface alterations due to texture variability.
Modified or Improper Markings on Package	X	X	EVI: Different COO in mold marks Lab 2: Inconsistent letter A. Two fonts are used, so is it comparing the two different fonts?
Improper Package Surface Textures (inconsistent packages)	X		EVI: Different COO in mold marks Lab 2: Not noted
Unexpected or Extraneous Marks on Package	X		EVI: marking irregularities, random reconditioning artifacts Lab 2: Not noted
Evidence of Resurfacing/Blacktopping	X	X	EVI: Coating visually observed Lab 2: Surface inconsistencies and pinhole issues
Altered or Added Pin One Marker	X	X	EVI: Inconsistent pin 1 markers due to resurfacing Lab 2: Texture issues in mold marks

IDM2901AJC

Defect	Detailed EVI	Lab 2	Notes
Modified or Improper Surface Texture (physical alteration)	X	X	EVI: Secondary coating Lab 2: Top vs. bottom inconsistency
Modified or Improper Markings on Package	X	X	EVI: Varied markings part to part, remarked, previous marking visible Lab 2: Marking style variability
Improper Package Surface Textures (inconsistent packages)		X	EVI: Random scratches, package damage Lab 2: Possible surface inconsistency or material change
Unexpected or Extraneous Marks on Package	X		EVI: Solder residue on body, scratches Lab 2: Not observed
Evidence of Resurfacing/Blacktopping	X		EVI: Coating on some devices Lab 2: Not specifically noted though surface texture inconsistency may be due to resurfacing

ERJ-3EKF3302V

Defect	Detailed EVI	Lab 2	Notes
Package type not supported by Lab 2			

K9F4G08U0D-SIB0

Defect	Detailed EVI	Lab 2	Notes
Modified or Improper Surface Texture (physical alteration)	X	X	EVI: Visual evidence of coating Lab 2: Surface texture inconsistencies
Modified or Improper Markings on Package	X	X	EVI: Multiple lots, coated mold markings Lab 2: Mold mark texture has insufficient differentiation from surrounding area. Font variances, but could be different fonts used on markings vs. lot number.
Improper Package Surface Textures (inconsistent packages)	X	X	EVI: Mold marks partially filled Lab 2: Mold mark texture variances
Evidence of Resurfacing/Blacktopping	X		EVI: Visual coating demarcation line Lab 2: Not noted, but surface texture inconsistencies indicate the potential of a coating

Table 48 Lab 2 vs. Detailed EVI Comparison

6.2. Lab 9

The Lab 9 process is focused on comparative analysis between golden samples and the part under analysis. Per the Lab 9 process description, the availability of a golden sample is a requirement for Lab 9 to evaluate parts (either provided by the client, or available through the Lab 9 database). Per the Lab 9 test report Requirements section: "To ensure accurate and high-level confident comparisons, it is mandatory for all customers to provide a gold sample reference for inspection purposes. If a gold sample is already available in Lab 9's database or has been previously provided, it will be utilized for comparison." For the purposes of the round robin, Lab 9 provided analysis of parts regardless of the availability of a golden sample. This provides an opportunity to compare processes with and without the availability of a golden sample. Golden samples were available for the following parts: AD8616ARMZ-REEL, IS61WV25616BLL-10BLI, TPS7A4901DGNT, and ERJ-3EKF3302V.

AD8616ARMZ-REEL: Lab 9 had multiple instances of this part type available in their database covering multiple versions of this same part including the round robin part. This part was challenging to characterize for all of the test labs. The part had a unique surface texture that raised concerns with several labs. Additionally, questions regarding the die validity were raised due to package versus die date stamps. The availability of a golden sample was key to resolving these questions in general, beyond just the analysis performed by Lab 9. The overall consensus conclusion for this part was that the part is acceptable for use, though two labs considered it to be suspect counterfeit. Lab 9 identified it as acceptable for use.

IS61WV25616BLL-10BLI: This part was procured directly through an authorized distributor for inclusion in the round robin, so traceability had been maintained. The part received some handling in preparation for the round robin, so parts did have some indications of that which was noted by a few labs. Lab 9 found no handling related issues in their part samples which was supported by their imagery and the pre-screening imagery. The comparative imagery from the Lab 9 database provided a clear reference of both package and die attributes.

TPS7A4901DGNT: This part exhibited several issues which would not be detected through direct comparison to a golden sample. Internal characteristics and the basic body and marking characteristics aligned with the golden sample. Externally, several issues were present which resulted in a suspect counterfeit consensus disposition. Lab 9 was the only lab which did not reach a suspect counterfeit disposition. Detection of these issues would have likely changed the disposition to suspect counterfeit.

- The parts failed resurfacing tests using both 1-Methyl 2-Pyrrolidinone and solvent 1 for 4 of 6 participating labs. Lab 9 and Lab 3 passed the resurfacing test. It is possible that underprocessing allowed the parts to pass this testing.
- The parts had a tapered top surface resulting from uneven sanding.

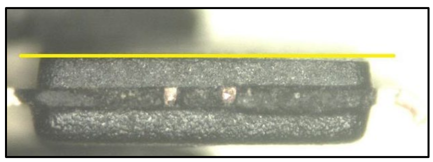


Figure 32 Uneven Top Surface Resulting From Sanding

ERJ-3EKF3302V: This part exemplifies the benefits of having a golden sample. Lab 9 and Lab 1 were the only two labs which identified this part as suspect counterfeit. Lab 1 had concerns over the marking quality and inconsistent FTIR results. However, through comparison to their golden sample, Lab 9 noted their golden sample had no markings at all, unlike the test samples. As follow-up on this, they contacted the manufacturer who confirmed that this part number should not have markings. Lab 9 also noted a lead frame difference in the parts. Because all parts were consistent, no other lab noted this as being anomalous. Neither of these important anomalies would have been detected without the golden sample.

7. Observations and Conclusions

This multi-laboratory round robin evaluation yielded several important insights into the current state of counterfeit detection using SAE AS6171 test methods.

7.1. Effectiveness of AS6171 Methods

The study confirmed that certain AS6171 test methods, particularly internal visual inspection, and X-ray evaluation were consistently effective in identifying counterfeit-related attributes. Other methods demonstrated greater variability in sensitivity, process or interpretation, suggesting the need for refinement of selected slash sheets to improve repeatability and reliability.

- Distinction between General EVI and Detailed EVI tests (AS6171/2A, Method A versus Method B) is not maintained by all labs.
    - Several labs did not clearly differentiate between General EVI testing versus Detailed EVI testing. All was reported as EVI testing. The lack of differentiation made it unclear if both types of testing were performed. In all cases, evidence of Detailed EVI testing was provided. General EVI serves the purpose of assessing the lot in its entirety to look for inconsistencies within the population. These part to part comparisons may not be perceptible when evaluating parts individually.
- Actual execution of the resurfacing test method (AS6171/2A, Method D) varied significantly between labs resulting in inconsistent results. Recurring issues were:
    - Detailed inspection of the surface after solvent use to verify if a coating was present. A 30X (minimum) inspection is required per section 5.3.4.1. This includes top, sides and bottom. Multiple labs did not do the inspection under magnification and instead relied on any coloring that may have been deposited on the swab. This led to false positive results since some residue on the swab is common with the use of aggressive solvents but it is often encapsulant residue, not coating.
    - The procedure details (section 5.3.4.4.1) says to wipe the surface with a swab but does not define the aggressiveness of the wiping. Is it a light single wipe, or a more aggressive rubbing? The procedure isn't clear on this. There should be definition of what is considered appropriate since it affects the solvent performance.
    - The procedure (section 5.3.4.4.1) allows a range of exposure time when using 1-Methyl 2-Pyrrolidinone and commercial solvents 1 and 2. There is minimal guidance on how to know how much time is appropriate. For example, the procedure states "the time and temperature may be adjusted to accommodate your sample". The lack of procedural understanding has led to both under and over processing resulting in erroneous results.
    - The procedure (section 5.3.4.4.1) includes the statement "Any removed coating will show on the cotton swab as black in color." Labs often interpret this statement to mean that they should just look at the swab for black to determine pass/fail. Surface inspection under magnification is necessary as well since a coating needs confirmation and black residue is not sufficient to confirm that. The 30X inspection step was not followed by all labs. This process flow should be better clarified to explain what is expected.
    - The procedure (section 5.3.4) states that the purpose is "to determine if a part has been coated, and if so, evaluate the surface under any removed coating for sanding marks, ghost markings, etc.". Section 5.3.4.4.1 gives the guidance to "avoid markings if possible". This guidance conflicts with the purpose statement since inspecting for ghost markings usually requires coating removal around the part markings.

- The procedure does not specify which surfaces should be tested for resurfacing. For example, the K9F4G08U0D-SIB0 was resurfaced on the back of the part to hide manufacturer markings. Lab 6 was the only lab which tested the back of the part and revealed the ghost markings. Both top and bottom surfaces should be tested, and an area large enough to reveal ghost markings (if present) should be exposed.

- The dimensions test (AS6171/2A, section 5.3.5) states "nondestructively measure the overall part dimensions of body length, width, and thickness." This requirement leads to interpretive issues.
  - Part dimensional specifications nearly always include body length and width specifications with a specified acceptable range. Thickness requirements vary substantially. Within the part types included in the round robin, there were requirements for part body thickness, part total height (body thickness + lead/ball standoff), and maximum limits only, depending on the part type. Labs took varied approaches to comply with the test requirements. In one case, a derived requirement was established based on part total height. This resulted in out of specification results which did not actually violate any datasheet parameters. Other interpretations evaluated part total height instead of thickness. Others ignored thickness entirely, often substituting other measurements they considered significant. Better clarity on appropriate measurements should be provided, particularly regarding thickness measurements and/or appropriate substitution measurements. It is suggested that AS6171/2A be revised to state that length, width, and thickness be measured if explicitly quantified on the part dimensional drawing. If dimension requirements are not explicitly provided, then the closest "similar to" value should be used as an alternative measurement. As an example, referring to Figure 33, a common specified dimension is the part total height which in this drawing is 1.20mm maximum (no minimum requirement). Actual package thickness is not explicitly stated. The total height measurement would be used in place of measuring the part body thickness. For a second example, refer to Figure 4.

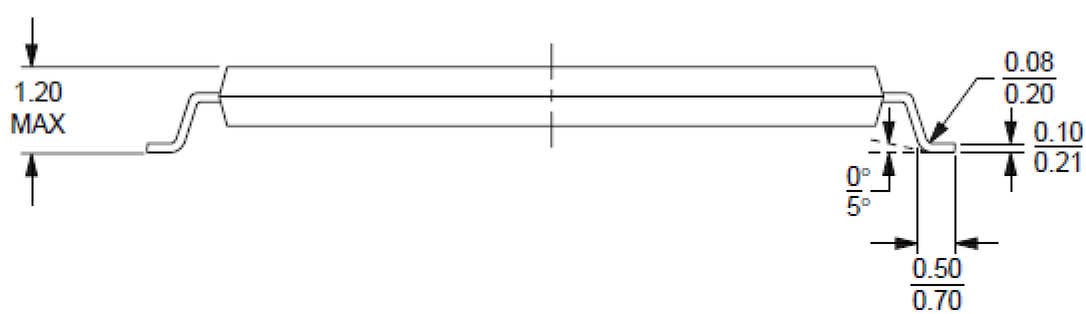


Figure 33 Typical Dimensional Drawing (AM28F020-120PI example)

  - Measurement resolution is not explicitly stated in AS6171. The general standard practice for measurement accuracy is to round measurements to the accuracy of the specification. For example, if a specification is 1.50mm, then a measurement of 1.501mm would be rounded to 1.50mm. This should be explicitly stated in AS6171 to assure measurements are performed consistently and parts are not rejected erroneously.

7.2. Variability in Laboratory Reporting

Differences in how laboratories categorized and reported defects was a recurring theme. For example, irregularities in mold markings were variably classified as “Altered or Added Pin One Marker” by some labs and “Modified or Improper Markings on Package” by others. These discrepancies underscore the importance of clearer definitions and standardized classification guidance within AS6171 to promote consistent outcomes across organizations.

Several defect definitions lead to this ambiguity indicating the need to reconsider the defect classifications. Both expansion and consolidation may be warranted to better align the defect classifications with real world observations.

- Variances in mold markings is not directly addressed in the existing defect definitions. Commonly observed issues are varied content within the marks, variation in content format (such as fonts), and missing marks. This could be covered under the existing “Modified or Improper Surface Texture” defect if the definition is expanded to include this family of defects.
- Test labs were unclear on how to categorize package molding variations per the current defect definitions. An example might be different edge profiles within the same lot. Currently, this defect would be categorized as “Improper Package Surface Textures”. However, this definition is similar to the defect “Modified or Improper Surface Texture” which addresses surface alterations. Since both defects address surface conditions which are not as expected, AS6171 should consider combining both defects into a single defect such as “Altered or inconsistent Package Surface or Molding” to better address these defects.
- Contamination on terminations is not currently included in the defect definitions but is a commonly seen condition. Expanding the definition of “Oxidation/Corrosion of Terminations” to include this defect would be a simple resolution. A suggested name would be “Oxidation/Corrosion/Contamination of Terminations”.
- The current defect definitions do not include plating quality on terminations. The closest match is “Incorrect Termination Materials” but this really addresses incorrect composition, not substandard plating. This defect should be expanded to include plating quality. A suggested name would be “Incorrect Termination Materials or material quality”.
- The presence of “Whiskers” was widely unreported. Multiple examples occurred where labs did not report the presence of whiskers, yet the whiskers were visible in their photos. It is unclear why this defect was often overlooked. The defect is currently categorized as “Physical – Surface”, but it is most commonly observed on the leads, which may be a

contributor to the underreporting. It is suggested that this defect be recategorized as “Physical-Terminations” to align with the most common category. The definition should emphasize that part body related whiskers should be included in this defect definition. Revision of the defect name to “Whiskers – Terminations or Part Body” would also be beneficial.

7.3. Value of Comparative “Golden Sample” Approaches

The Lab 9 database of authenticated golden samples proved highly effective where available, enabling stronger verification of part markings, die topography, and subtle anomalies not easily discerned by standard methods alone. This underscores the potential value of incorporating reference-based comparative techniques into standard counterfeit detection practices. At the same time, reliance on traceable, high-confidence golden samples remains a limiting factor for widespread implementation, particularly for legacy parts.

7.4. Establishing Ground Truth for This Study

While individual laboratories conducted testing independently, this project established a “ground truth consensus” retrospectively, using aggregated results and quality of supporting evidence to benchmark performance. Importantly, counterfeit detection in practice is not performed by consensus across labs. In some cases, strong evidence provided by a single laboratory, though not widely observed, was sufficient to support the final part disposition. This approach ensured that conclusions were driven by the strength of data rather than majority interpretation.

7.5. Insights from the Authentic Control Sample

The inclusion of a known authentic part sourced from an authorized distributor demonstrated that even genuine devices may exhibit anomalies attributable to handling or manufacturing variation. Several labs interpreted these as potential counterfeit indicators, illustrating the importance of contextual interpretation and careful distinction between true counterfeit signatures and benign artifacts. Many defects potentially attributable to counterfeiting can also have alternative reasons for their presence. For example, retinned leads may be an indicator of masking previous use of a part. It could also be done as a preservation action to assure older parts in storage will meet solderability requirements when needed in the future. Blacktopping is commonly done to mask previous part markings and give parts a “like new” appearance by counterfeiters. Manufacturers may also blacktop parts to enable remarking without having to attempt to remove previous markings. These are just a few examples highlighting that the presence of a defect does not confirm counterfeiting. It provides one element of a larger part history that must be considered in context with all other observations to determine the intent behind the observed condition.

7.6. Common Counterfeit Indicators Observed

Commonly occurring counterfeit signatures were observed during the round robin testing. Table 49 provides a list of the most commonly reported defects from the labs participating in this project.

Core Issue	Defect	Frequency Rank / Reporting Count	Comments
Resurfacing	Evidence of Resurfacing/Blacktopping	1/72	Detected frequently with resurfacing and Detailed EVI tests
Resurfacing	Modified or Improper Surface Texture (physical alteration)	2/55	Often reported along with resurfacing due to alterations during the resurfacing
Resurfacing	Modified or Improper Markings on Package	3/52	Often reported along with resurfacing since resurfaced parts also get remarked
Resurfacing	Improper Package Surface Textures (inconsistent packages)	4/40	Commonly caused by sanding prior to resurfacing
Resurfacing	Altered or Added Pin One Marker	5/30	Commonly caused by sanding prior to resurfacing
Handling or reuse	Damaged Terminations	6/29	Poor packaging, handling during salvage of used parts
Resurfacing	Improper Material Composition of the External Surface(s)	7/29	Blacktopping has a different chemical makeup than the epoxy molding compound
Mixed lot	Inconsistent or Incorrect Lead Frame	8/27	Parts were acquired from multiple lots and made to appear as a homogeneous lot
Mixed lot	Wrong Die or Functional Passive Element	9/26	Parts were acquired from multiple lots and made to appear as a homogeneous lot
Handling or reconditioning	Unexpected or Extraneous Marks on Package	10/24	Multiple sources - Poor handling, part salvage, part reconditioning
Handling or reuse	Contamination or Corrosion on External Surface(s)	11/22	Part handling or processing during salvage operations
Handling or reuse	Oxidation/Corrosion of Terminations	12/21	Poor handling/storage, improper lead finish

Table 49 Most Frequently Reported Defects

7.7. Further Part Analysis

The round robin testing documented in this report addresses the scope of testing commonly performed by test labs for counterfeit mitigation purposes. Additional testing can be performed if needed to further reduce risk of counterfeit material. Electrical testing encompasses a wide array of test options which can be very complex and expensive to execute. To gain perspective on the value of more robust electrical testing, Auburn University is performing more extensive testing of the same round robin parts. These test results will help establish which tests may be of greatest value for risk mitigation. Results of this testing are not complete as of the drafting of this report. Complete details of the testing will be included in future project reporting. It is possible this testing could impact conclusions derived from the round robin testing. This will also be addressed in future reports.

None of the round robin test labs support performing the Design Recovery test method (AS6171/11). This is a relatively new test method as of this writing, so it has had little or no application in the field at this time. To evaluate the overall design recovery process and methods, the University of Michigan is applying the test techniques outlined in AS6171 using the same population of sample parts as the round robin. This testing is currently underway and will be reported on in later project reports.

7.8. Overall Conclusion

The round robin exercise demonstrates both the strengths and limitations of standardized counterfeit detection under AS6171. While several methods proved robust, variability in classification and interpretation highlights the need for clearer definitions, improved guidance, and potential integration of reference-based comparative techniques. The project’s use of aggregated ground truth provides a valuable lens for benchmarking laboratory performance, but counterfeit determinations in practice remain the responsibility of individual labs based on the strength of their test evidence.

APPENDIX 1 SURFACE EVALUATION OF AD8616ARMZ-REEL

AD8616ARMZ-REEL

07/20/2025

Summary

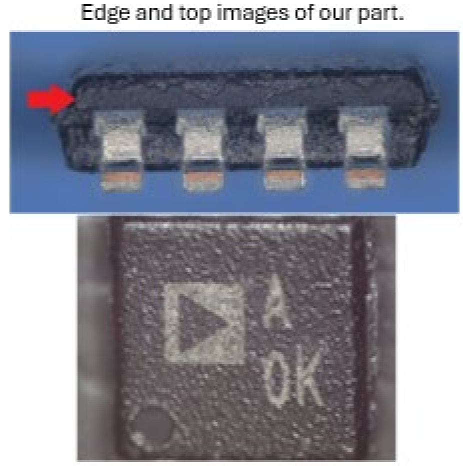
3 chips (11,12,13)

Background info from Steve W.

AD8616ARMZ-REEL in question due to etch inertness and surface morphology

Comparison of the top surface of our parts with a known authentic part. Note the rougher texture on our part.

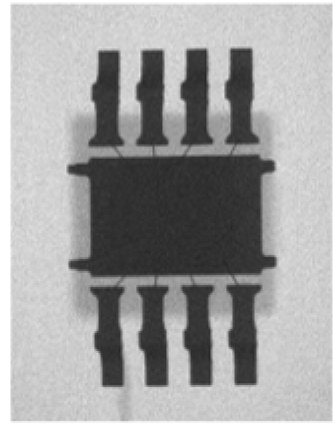
Edge and top images of our part.

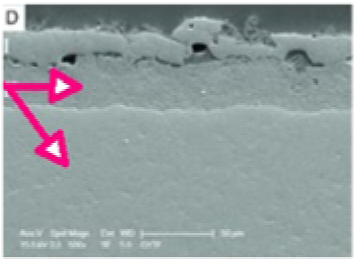


Objective

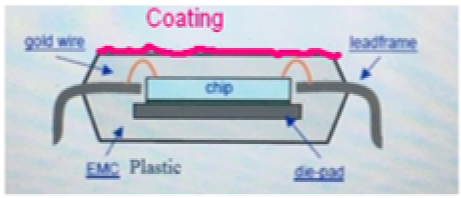
Do a cross sectional analysis of the part
- Surface and encapsulation
- Other part components

Part layout





Schematic of Part layout with suspected coating



Presented hypothesis was that a surface coating was applied

Summary of thoughts and conclusions

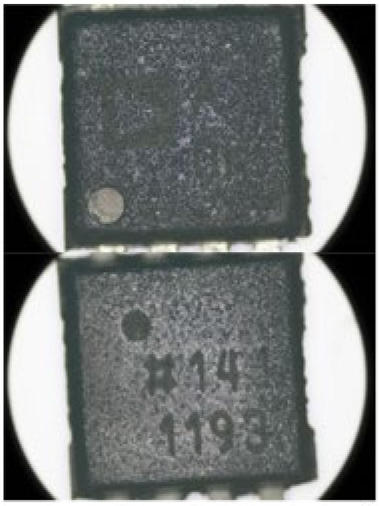
No evidence of a surface coating
seems like surface is pitted, perhaps from an attempted etch

The part layout seems to match the expected layout that I was given.

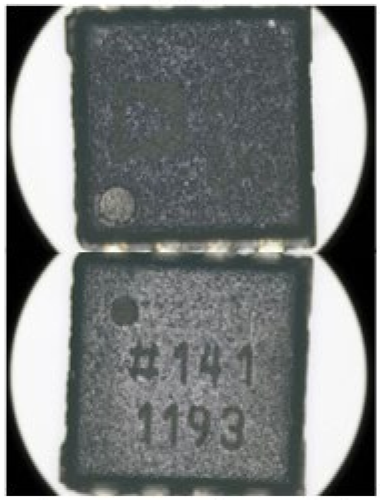
A re-encapsulated part is plausible – would need a reference sample.

Pre-process images

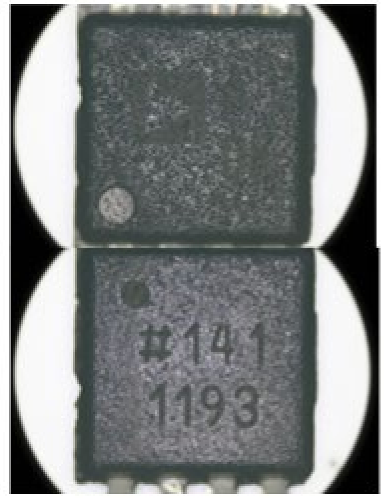
Chip 11



Chip 12



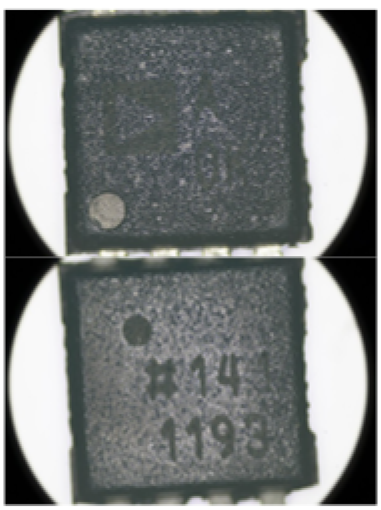
Chip 13



All samples appear qualitatively the same

Features

Chip 11



From our images and those sent by Steve W., the sample appears pitted to me.

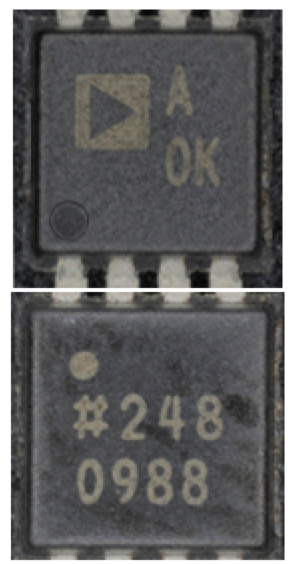
Top surface is more pitted/textured than the bottom surface.

The print/stamp is much less pronounced on both sides. Little color.

Markings also have different registration wrt reference image.

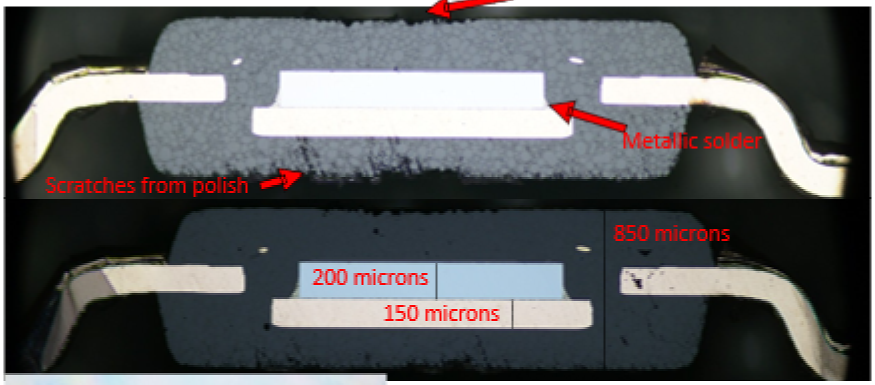
Liquid etchant applied to top with some spill over to the bottom?

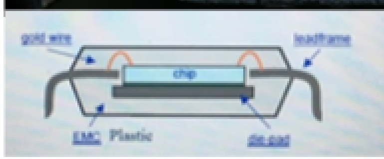
Reference part images



Chip 11

Results here are representative of all samples.



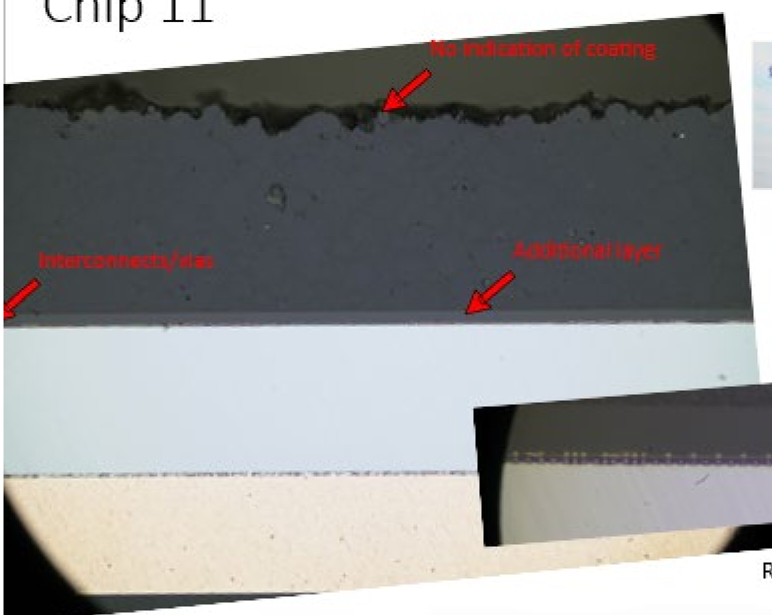


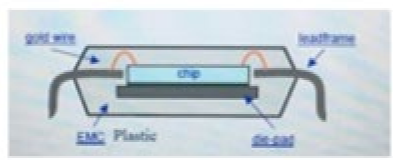
The composite that makes the encapsulant is homogeneous.

Eyeball average particle size ~ 50 microns

Layout matches the schematic.. almost

Chip 11





Additional layer present

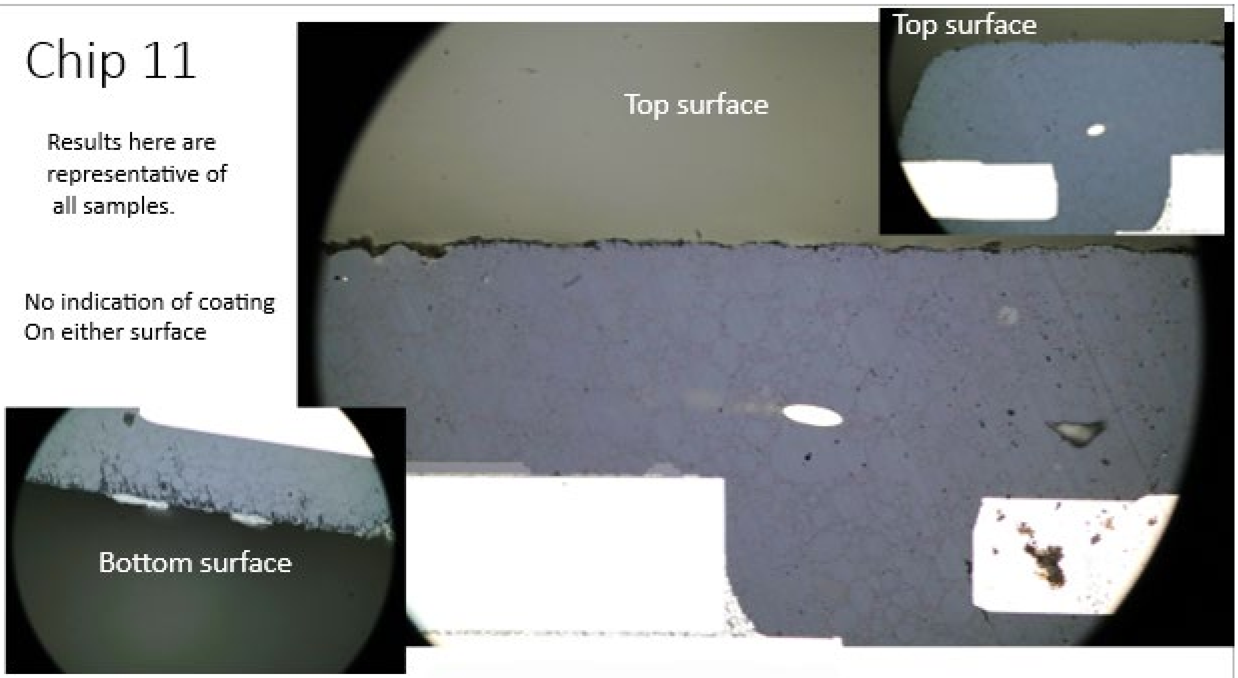
Some vias or interconnects

Results here are representative of all samples.

Chip 11

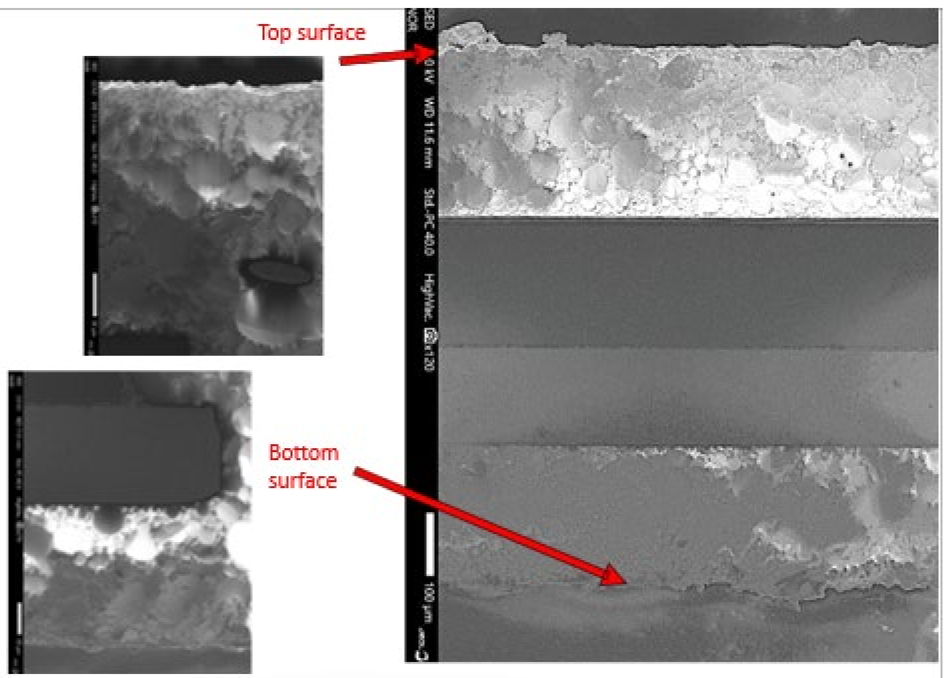
Results here are representative of all samples.

No indication of coating On either surface



Chip 11

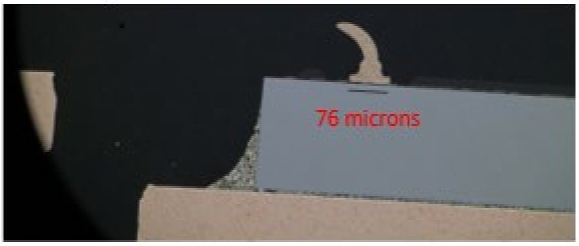
No indication of coating On either surface

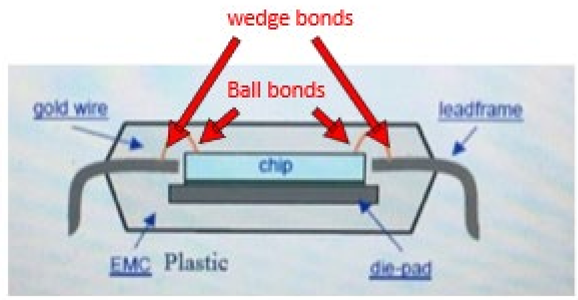


Other features

Was able to resolve the type of wire bonds.
And approx. dimension of the ball bond

Chip 13



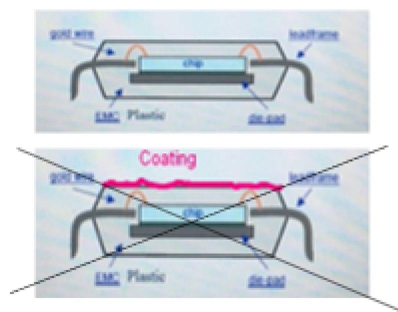


Concluding remarks

No evidence of a surface coating
seems like surface is pitted, perhaps from an attempted etch

The part layout seems to match the expected layout that I was given.

A re-encapsulated part is plausible – would need a reference sample.



Thoughts? Questions?