Verifying the Efficiency of AI-based Inspection in Detecting Oxidation in Soldering Leads of Electronic Components during Assembly: A Case Study

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***Abstract*—Corrosion on electronic component leads during assembly can lead to the failure of electronic devices. The leads of electronic components are susceptible to corrosion when exposed to moisture and other corrosive agents during and before the assembly process. This corrosion can cause physical damage to the leads, resulting in poor electrical contact and possible failure of the electronic component. In this paper, we present a case study where an automotive production line utilized Cybord's AI-based inspection system to detect and prevent contamination in the soldering leads of electronic components. The system interfaced with the vision system of pick-and-place machines in real-time and collected bottom-side images of all components placed on printed circuit boards (PCBs). The AI algorithm, based on a 3 billion component database, detected evidence of corrosion, mold, and other contaminants on each component and allowed the removal of poor-quality components from production. The reel was disqualified and sent to a lab for SEM-EDX analysis, which confirmed the findings of the AI algorithm, that the issue was evidence of oxidation contamination. The results of this case study demonstrate the effectiveness of using AI-based inspection in detecting and preventing contamination in electronic assembly, boosting the overall quality and reliability of the final product.**

***Index Terms*—AI algorithm, Assembly process, Corrosion, DPM rate, Electronic component, Inspection, IPC standard, Lead, Oxidation.**

. INTRODUCTION

CORROSION and corrosive contamination on electronic component leads during assembly is a major issue that can result in the failure of electronic devices[1], [2]. The leads of electronic components are typically made of metal and are susceptible to corrosion when exposed to moisture and other corrosive agents during and before the assembly process [3]–[6]. This corrosion can cause physical damage to the leads, resulting in poor electrical contact and possible failure of the electronic component. Additionally, corrosion can also cause electrical failures, resulting in poor performance or complete system failure[7].

Understanding the causes and mechanisms of corrosion on electronic component leads [8]–[10]during assembly is crucial for preventing it from happening in the first place and for mitigating its effects. This can be achieved by using the appropriate materials, inspection, and assembly processes [1], [11].

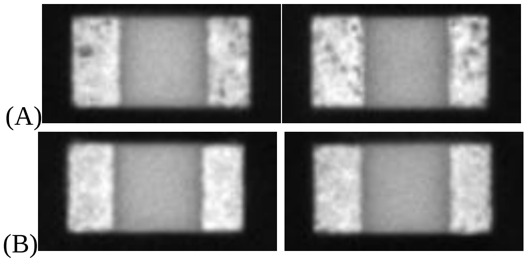

Fig. 1. Images of chip resistors 1K .5% 0402 -55/125 63MW with detected contamination on the soldering leads (A), vs uncontaminated soldering leads (B) within the same reel.

The presented system [12] addresses this issue by interfacing with the vision system of pick-and-place machines in real time and collecting bottom-side images of all components placed on printed circuit boards (see an example in Fig. 1) [13], [14]. An AI algorithm, based on a 3 billion component database, detects evidence of corrosion, mold, and other contaminants on each component and allows the removal of poor-quality components from production [14], [15]. This can be done by disqualifying an entire reel or by signaling the location of the defective component for automatic or manual replacement.

I. CASE STUDY

In this work, we present a case study where an automotive production line utilized the proposed system to flag a reel as suspicious due to evidence of oxidation [16] on terminals that did not comply with IPC standards [1]. Fig. 1 illustrates an example of a chip resistor with contaminated leads, as well as a comparison example of components without contamination, both taken from the same reel. Based on the system's recommendation, the reel was disqualified and torn down. Fig. 2 illustrates the system's detection and recommendation methodology, highlighting the process of identifying contamination and the subsequent actions taken to address it. The reel was then sent to a lab for SEM-EDX analysis, which confirmed the analysis and identified the findings as oxidation contamination.

The uniformity of the level of contamination on the reel was not consistent, similar to what was presented on the homogeneity of apparent age in reels [12]. The system identified and flagged the most severe cases of contamination, and as the defects-per-million (DPM) rate exceeded the acceptable level, the reel was deemed ineligible for further use in the assembly process. This non-uniform distribution of

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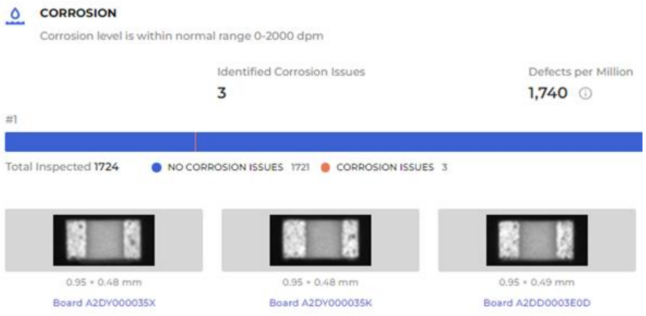


CORROSION

Corrosion level is within normal range 0-2000 dpm

Identified Corrosion Issues: 3

Defects per Million: 1,740

#1

Total Inspected 1724

● NO CORROSION ISSUES 1721

● CORROSION ISSUES 3

0.95 × 0.48 mm
Board A2DY000035X

0.95 × 0.48 mm
Board A2DY000035K

0.95 × 0.49 mm
Board A2DD0003E0D

Fig. 2. VSON-12 Gate Drivers NexFET images captured by an ASM Siplace SX mounting machine and detected by Cybord.ai system with quality issues.

contamination can have significant implications for the performance and reliability of the electronic components, as some areas of the reel may be more affected than others [17].

It is important to note that the DPM rate is a commonly used metric for evaluating the quality of electronic components and assemblies, as it provides a quantitative measure of the number of defective components per million components. The acceptable DPM rate varies depending on the application and industry standards, but it is generally agreed that a lower DPM rate is desirable as it indicates a higher level of quality and reliability. In this case, the DPM rate exceeded the acceptable level, indicating that the reel was not suitable for use in the assembly process and needed to be disqualified.

In order to ensure the quality and reliability of electronic components and assemblies, it is crucial to monitor and control the level of contamination throughout the reel during the assembly process. This can be achieved through the use of advanced inspection and monitoring techniques, such as those employed by the presented system [12], [14], [16], as well as by implementing appropriate materials, assembly processes, and storage conditions to minimize the risk of contamination.

The laboratory received the reel that contained all the components that were not used in the production process. The severe defect rate was determined to be 1740 DPM, which equates to only 0.17% of the total components on the reel. This level of contamination cannot be effectively detected through traditional sampling methods, as it is below the threshold of detection. To circumvent this limitation, the laboratory selected random cases of mild contamination to analyze the composition of the contamination.

It is important to note that even though the contamination level is low, it is still enough to affect the performance of the electronic components and cause a system failure. This highlights the importance of implementing advanced inspection and monitoring techniques, such as those used by the presented system, to detect and prevent contamination at early stages.

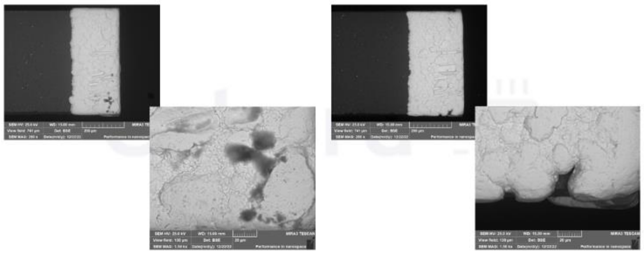


Fig. 3. Microscope images of randomly selected components from a reel that had a corrosion defect rate of 0.17%.

To supplement the analysis, microscope images were also presented in Fig. 3 to provide a visual representation of the contamination found on the reel. These images can aid in the identification of the specific contaminants present and help to inform the development of appropriate mitigation strategies.

The samples collected from the reel were then analyzed using Scanning Electron Microscopy with Energy Dispersive X-ray Spectroscopy (SEM-EDX) to determine the composition of the contamination. SEM-EDX [18] is a powerful analytical technique that allows for the identification of elemental composition of a sample at a high resolution. This technique was selected as it allows for the analysis of the samples in their natural state, without the need for sample preparation, and it can detect a wide range of elements.

I. RESULTS

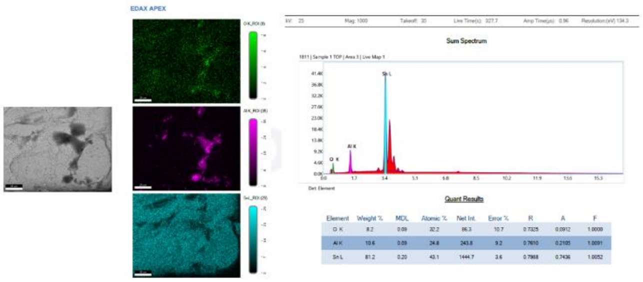
The results of the analysis are presented in Fig. 4. These results provide a detailed characterization of the contaminants present on the reel and can aid in the identification of their origin and potential sources of contamination. Furthermore, this information can be used to inform the development of appropriate mitigation strategies and to prevent future contamination issues.

I. DISCUSSION

This case study demonstrates the effectiveness of the AI algorithm in detecting even small instances of oxidation on the soldering leads based on the images captured by the pick-and-place vision system. The sensitivity of the algorithm can be adjusted to detect different levels of contamination, allowing for a more comprehensive analysis of the components.

It is important to note that the IPC (International Electronics Manufacturing Initiative) standards do not permit corrosion contamination on components during assembly. This is due to the fact that, although the corrosion may not have a significant effect on the solderability of the components, it can have a detrimental impact on the reliability of the electronic product over its lifespan. Corrosion can continue to grow and spread, causing physical damage to the leads and ultimately leading to poor electrical contact and system failure.

Therefore, the results of this case study not only demonstrate the ability of the AI algorithm to detect and prevent contamination, but also highlight the importance of



kV: 25 Mag: 1000 Takeoff: 35 Live Time(s): 327.7 Amp Time(µs): 0.96 Resolution:(eV) 134.3

Element	Weight %	MDL	Atomic %	Net Int.	Error %	R	A	F
O K	8.2	0.09	32.2	86.3	10.7	0.7325	0.0912	1.0000
Al K	10.6	0.09	24.8	243.8	9.2	0.7610	0.2105	1.0091
Sn L	81.2	0.20	43.1	1444.7	3.6	0.7988	0.7436	1.0052

Fig. 4. SEM-EDX analysis of the contamination on the soldering leads. Al oxidation was detected.

adhering to industry standards and implementing appropriate measures to maintain the quality and reliability of electronic products.

This case study demonstrates the effectiveness of using in-situ inspection of components during the assembly process as a tool for removing contaminated reels from production. By identifying and removing contaminated components at an early stage, the overall quality of production is improved, and the failure rate is reduced. Additionally, by implementing this method, the first pass yield is also improved.

It is important to note that by preventing the use of contaminated components in the assembly process, the risk of system failures and poor performance is reduced, ultimately improving the quality and reliability of the final product. This highlights the importance of implementing advanced inspection and monitoring techniques, such as those used by Cybord's system, to detect and prevent contamination at early stages and boost the overall quality of production.

I. CONCLUSION

This case study demonstrates the effectiveness of using AI-based inspection in detecting and preventing contamination in electronic assembly. The system was able to detect even small instances of oxidation on the soldering leads of electronic components based on the images captured by the pick-and-place vision system. By identifying and removing contaminated components at an early stage, the overall quality of production was improved, and the failure rate was reduced. Additionally, by implementing this method, the first pass yield was also improved. The results of this case study highlight the importance of implementing advanced measures to maintain the quality and reliability of electronic products. It also shows that AI-based inspection method can be a powerful tool for detecting and preventing contamination in electronic assembly, and ultimately, improve the overall performance and longevity of the final product.

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