Ansys

CASE STUDY

Failure Analysis Control Board Project
Early Failures Detected

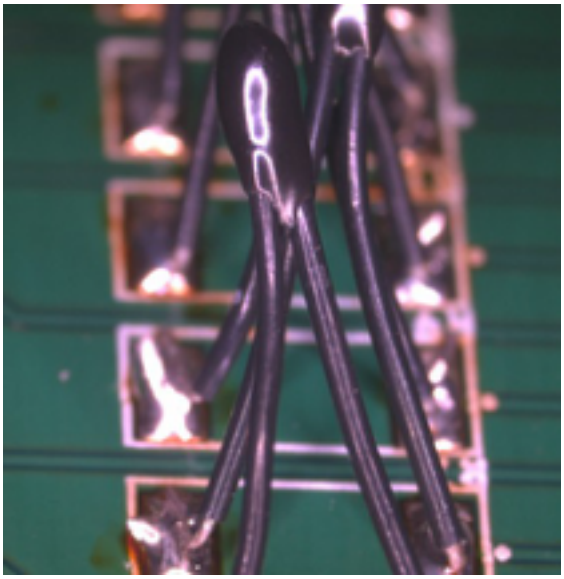
A manufacturer of control boards was experiencing elevated leakage currents and failures of a thermistor component and sought to identify the root cause of the failures. If it was determined that the failures of the thermistor could not be mitigated, the client was also considering a second thermistor supplier. Ansys Reliability Engineering Services (RES) was contracted to determine the failure mode, the root cause of the failure and any potential ways to mitigate the failure going forward.

Approach: Temperature Humidity Bias Test Setup

Based on an initial review of the thermistor manufacturing process and some preliminary failure analysis data from the customer, the experts at Ansys RES recommended performing a mixture of testing and destructive failure analysis.

This led our experts to perform temperature humidity bias (THB) testing to attempt to recreate the failure modes suspected to have occurred in the field. We were looking to determine if electrochemical migration (ECM) was the root cause of failure in the thermistors. Test coupons were soldered with 20 thermistors per coupon: 36 thermistors manufactured by the current manufacturer and four thermistors from a potential secondary manufacturer. THB testing showed failures of the current thermistors after as little as 22 hours; comparatively, there were no issues with the opposing brand thermistors over the same test period.

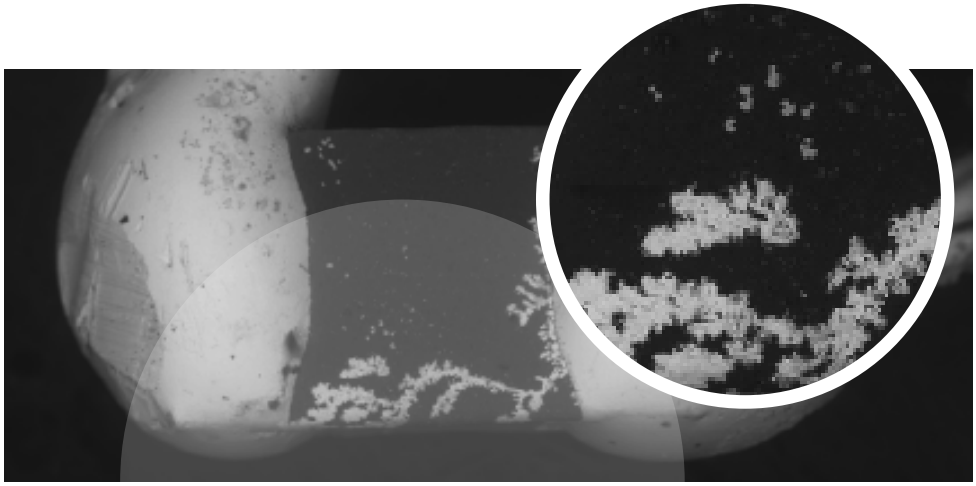
The thermistors resulting in failure were decapsulated through an iterative process of using an epoxy-specific solvent on a hot plate. Our engineers immediately noticed signs of an unknown material between the terminations while looking at the samples under the optical microscope.



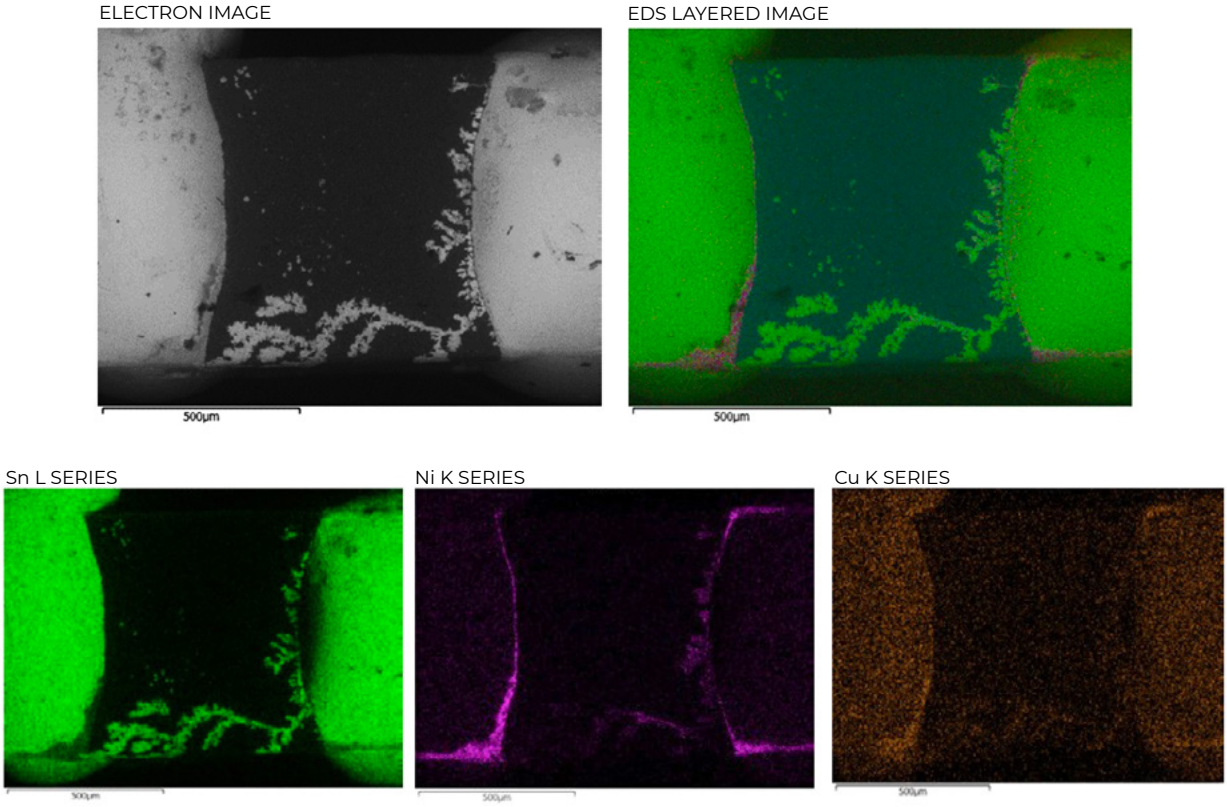
Thermistor prior to decapsulation

Thermistor post-decapsulation under optical microscope

In the scanning electron microscope (SEM), the images collected show signs of migration — dendritic growth shorting the two terminations.



Furthermore, energy dispersive X-ray spectroscopy (EDS) analysis helped confirm the presence of the dendritic growth that was seen in the SEM images. Areas of high nickel and copper corresponded with regions of terminals that had depleted tin. This combination of SEM and EDS analysis highlighted evidence of migration of tin, which lead to shorting between the two terminals of the thermistor.



THB testing was conducted against units from multiple lots to determine if this failure mode was isolated to one particular production batch. Hard shorts and/or intermittent signal losses were recreated in thermistors across multiple lots, which indicated that this defect was not isolated to a specific lot. This helped confirm that this failure was related to the general manufacturing and construction of this thermistor.

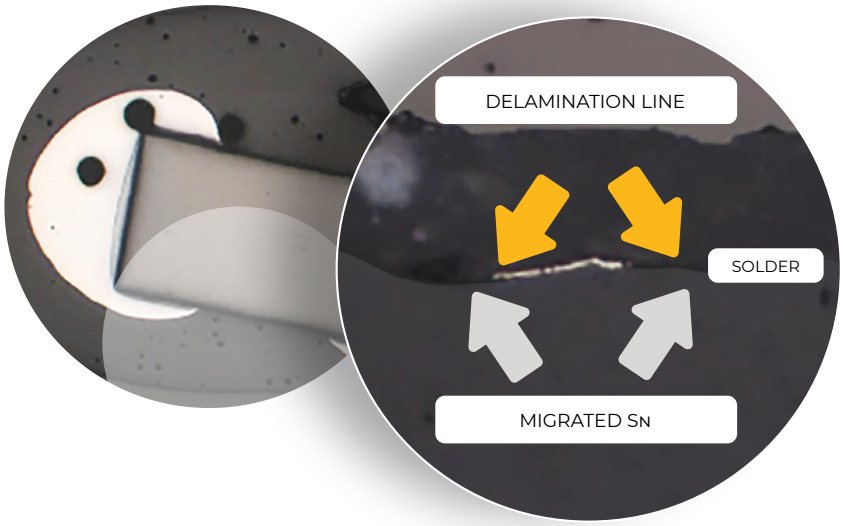
/ Cross-sectioning

One unit that failed after 38 hours was potted for cross-sectioning. The purpose was to verify the presence of the following:

- Delamination between the epoxy and the component body
- Thermal shock cracks from the manual soldering process

Cross-sectioning revealed scattered voiding in the epoxy encapsulant, including a void close to the interface of the epoxy and thermistor body. Voiding along the epoxy/thermistor interface makes the device susceptible to delamination and moisture ingress, creating the environment needed for dendritic growth under bias.

The images below reveal an apparent demarcated line on the bottom side of the component, confirming signs of tin migration.



/ Results

Both decapsulation and cross-sectioning showed signs of electrochemical migration of tin in multiple components that failed temperature humidity bias testing. Additionally, cross-sections showed signs of a thin delamination line at the epoxy/thermistor interface caused by tin migration, further indicating the presence of moisture ingress and delamination to allow dendritic growth.

Multiple failures in THB testing were very early (<48 hours), indicating the possibility of initial moisture ingress/entrapment in the thermistors.

/ Recommendation

Ansys RES' primary recommendation was to switch to the second thermistor supplier. As an alternative, we recommended verifying whether baking the current thermistors for 24 hours at 105 C would improve THB performance (by removing suspected initial moisture). However, a follow-on project showed that even baking did not eliminate failures.

There were several issues found with the current supplier's manufacturing process, mainly related to manual fluxing, manual soldering and washing processes. As happens in many of our failure analysis cases, the failure lies in the parts obtained in the supply chain and poor manufacturing practices down the line.

We frequently recommend our clients perform a thorough supplier assessment, not only to evaluate the quality of a manufacturer's products but also to understand their process as it compares to the industry's best practices. A well-executed supplier assessment enables organizations to avoid unexpected field failures by designing for reliability.

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