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A Framework for Incorporating Non-Linear Degradation of Conductive Adhesive in Environmental Testing

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Abstract : Conductive adhesives have found wide-ranging applications in electronics industry ranging from fixing a defective conductor on printed circuit board (PCB) attaching an electronic component in an assembly to protecting electronics components by the formation of “Faraday Cage.” The reliability requirements for the conductive adhesive vary widely depending on the application and expected product lifetime. While the conductive adhesive is required to maintain the structural integrity, the electrical performance of the associated sub-assembly can be affected by the degradation of conductive adhesive. The degradation of the adhesive is dependent upon the highly varied use case. The conventional approach to assess the reliability of the sub-assembly involves subjecting it to the standard environmental test conditions such as high-temperature high humidity, thermal cycling, high-temperature exposure to name a few. In order to enable projection of test data and observed failures to predict field performance, systematic development of an acceleration factor between the test conditions and field conditions is crucial. Common acceleration factor models such as Arrhenius model are based on rate kinetics and typically rely on an assumption of linear degradation in time for a given condition and test duration. The application of interest in this work involves conductive adhesive used in an electronic circuit of a capacitive sensor. The degradation of conductive adhesive in high temperature and humidity environment is quantified by the capacitance values. Under such conditions, the use of established models such as Hallberg-Peck model or Eyring Model to predict time to failure in the field typically relies on linear degradation rate. In this particular case, it is seen that the degradation is nonlinear in time and exhibits a square root t dependence. It is also shown that for the mechanism of interest, the presence of moisture is essential, and the dominant mechanism driving the degradation is the diffusion of moisture. In this work, a framework is developed to incorporate nonlinear degradation of the conductive adhesive for the development of an acceleration factor. This method can be extended to applications where nonlinearity in degradation rate can be adequately characterized in tests. It is shown that depending on the expected product lifetime, the use of conventional linear degradation approach can overestimate or underestimate the field performance. This work provides guidelines for suitability of linear degradation approximation for such varied applications

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