Probabilistic Lifetime Prediction of Electronic Packages Using Advanced Uncertainty Propagation Analysis and Model Calibration

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Sponsor: SAMSUNG

Background and Motivation

- The actual lifetime of an electronic product varies due to inherent variability in materials, geometries, and operation conditions.
- The probabilistic aspect should be incorporated in prediction based on the uncertainty propagation analysis to identify the potential safety risks, to predict the yield, and to calculate the warranty and the maintenance costs.
- The conventional uncertainty propagation methods for model calibration suffered from the computational burden and censored data handling.

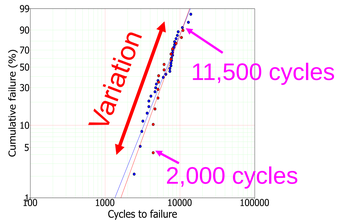


Fig. 1 Variation of life testing data

Objective

- To develop a novel methodology for calibrating physics-based lifetime models using the advanced uncertainty propagation method and a censored data analysis.

Approximate Integration Scheme

- The approximate integration scheme estimates the complete statistical distribution of a system response based on statistical moments.

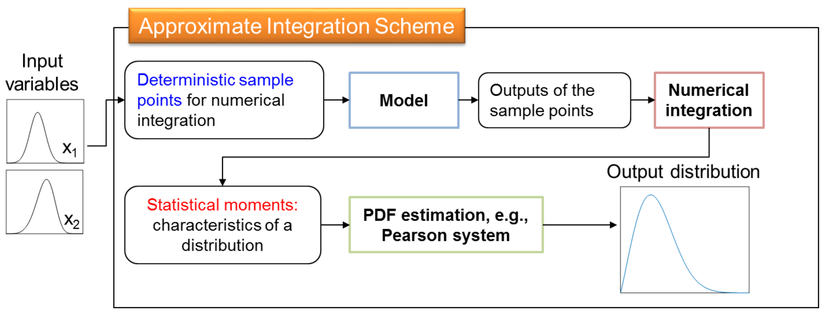


Fig. 2 Uncertainty propagation by approximate integration scheme

Eigenvector Dimension Reduction (EDR) Method

An advanced approximate integration scheme to estimate the statistical moments efficiently and accurately by eigenvector sampling and stepwise moving least square method.

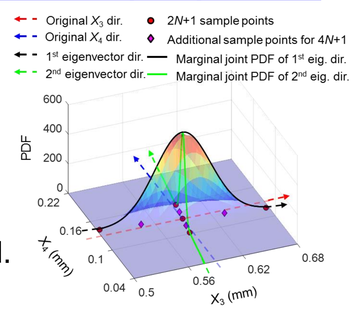


Fig. 3 Eigenvector sampling

Statistical Model Calibration

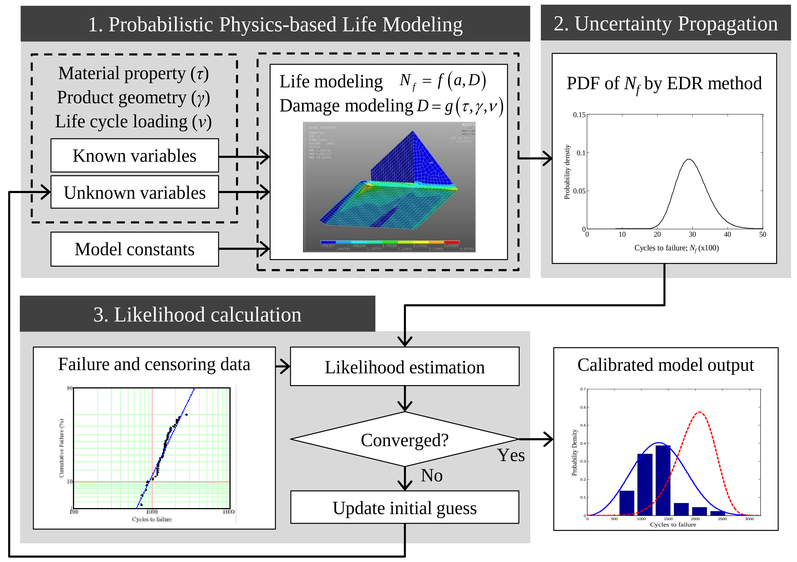


Fig. 4 Statistical model calibration procedure

Censored Data Handling

- The likelihood function is used to express the correlation between the predicted and experimental results. In a life testing, interval- and right-censored data are typically observed, and thus, the likelihood function for censored data handling is adopted.

$$L(p;t_1,\ldots,t_k) \propto \prod_{i=1}^{k} \left[f(t_i) \right]^{d_i} \left[1 - F(t_i) \right]^{r_i}$$

where $f(\cdot)$ and $F(\cdot)$ are the PDF and CDF of t_i, respectively.

Fig. 5 Statistical model calibration procedure

Implementation: Broad Level Reliability

- **Specimen description**

Board level solder joint reliability of 2512-type chip resistors was studied.

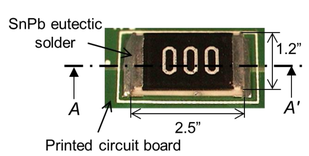


Fig. 6 2512 chip resistors

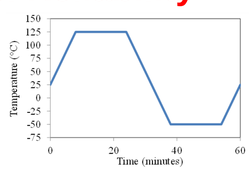


Fig. 7 Thermal cycling loading

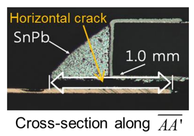
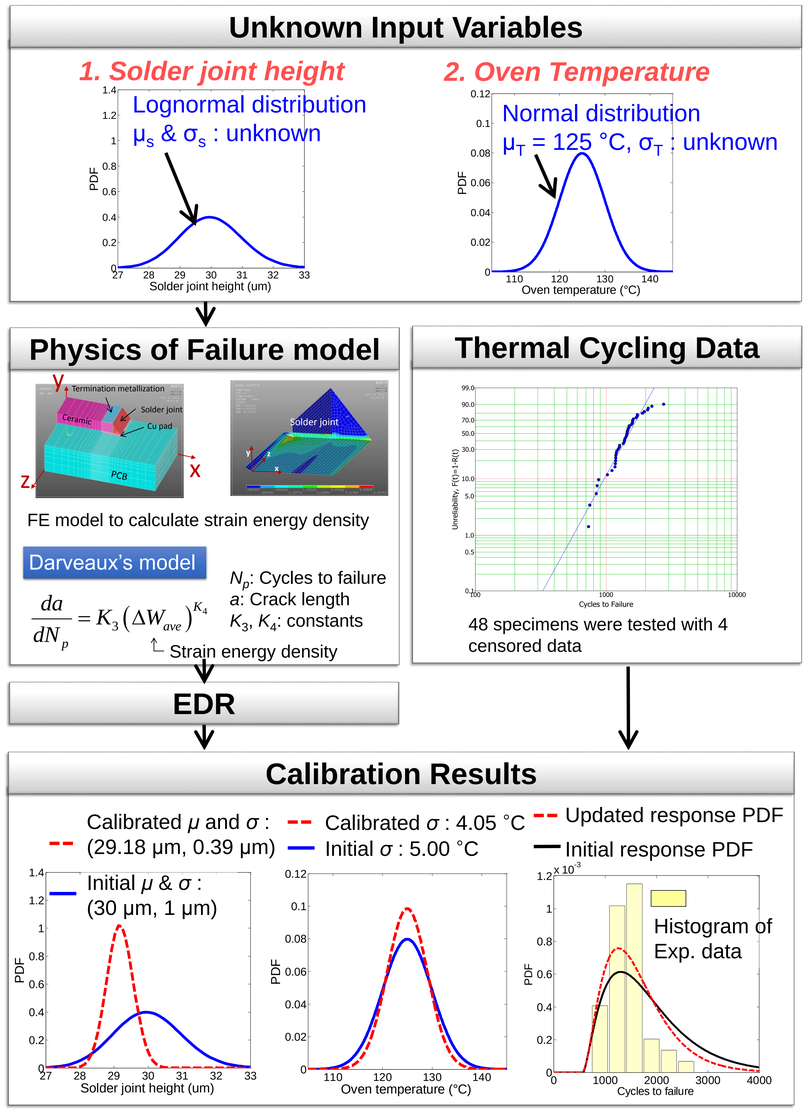


Fig. 8 Bulk solder failure along the copper pad

- **Statistical Calibration Using EDR Method**



Impact

A novel probabilistic lifetime prediction using the combined advanced uncertainty propagation analysis and model calibration was proposed. It can enable more probabilistic reliability assessments of electronic packaging that have not been feasible due to excessive computational cost.

Related Publication

Oh, Hyunseok, et al. "Probabilistic Lifetime Prediction of Electronic Packages Using Advanced Uncertainty Propagation Analysis and Model Calibration." IEEE Transactions on Components, Packaging and Manufacturing Technology 6.2 (2016): 238-248.