Prediction of semiconductor lifetime using bayesian linear models with mixed distributions

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Abstract

Modeling and predicting lifetimes of power semiconductor devices has become more and more important during the last years. Since resources, especially time, are restricted, reliable prediction methods for lifetime of Devices under Test (DUT) are required.

For this study 10 datasets containing Cycles to Failure (CTF) of Smart Power ICs, tested with a temperature cycle stress test system, are used. Currently these tests are modeled with a log-normal distribution to predict the required parts per million (ppm) quantiles. Generally, predictions of mean lifetime are done with physical acceleration models, e.g. Arrhenius or Coffin-Manson model, but for the given data these models fail. Further difficulties arise with the given data, because the DUTs show two different failure mechanisms.

First a Bayesian linear model (LM) based on four test parameters is used. Based on previous research, for the data the normal distribution ($N(\mu, \sigma^2)$) is chosen, where the mean is modeled with a LM ($\mu = X\beta + \epsilon$). For the model parameters and σ^2 non-informative prior distributions are applied. This model shows weaknesses because it does not consider the mixed behavior of the data. To adapt the model to the DUTs behavior, a Bayesian LM with a mixture of two normal distributions is investigated. As before, non-informative priors are used, except for the intercepts, where uniform priors based on expert knowledge are applied. Since it can be demonstrated that the mixing proportion depends linearly on the peak temperature of the DUTs, this information is also included into the model. To compare the performance of the two models, leave-one-out cross validation is used. The analysis showed a significant increase in quality for the model with mixed distribution.

Keywords

Bayesian linear models, Semiconductor reliability, Cross validation, Mixed distributions.

References

Bluder, O. (2008). *Statistical analysis of smart power switch life test results*. Diploma thesis, Alpen-Adria-University of Klagenfurt, Austria.

Escobar, L.A. and Meeker, W.Q. (2006). A review of accelerated test models. *Statist. Sci. 21(4)*, 552–577.

Gill, J. (2008). *Bayesian Methods*. Boca Raton(FL): Chapman & Hall/CRC.

Glavanovics, M., Estl, H., and Bachofner, A. (2001). Reliable smart power systems ICs for automotive and industrial application - the infineon smart multichannel switch family. *Proceedings of 43. International Conference Power Electronics, Intelligent Motion, Power Quality (PCIM), Nürnberg, Germany*.

Glavanovics, M., Köck, H., Eder, H., Košel, V., and Smorodin, T. (2007). A new cycle test system emulating inductive switching waveforms. *Proceedings of 12th European Conference on Power Electronics and Applications (EPE), Aalborg, Denmark*, (1–9).

Hamada, M.S., Wilson, A.G., Reese, C.S., Martz, H.F. (2007). *Bayesian Reliability*. New York: Springer Science + Business Media.

Shao, J. (1993). Linear model selection by cross-validation. *J. Amer. Statist. Assoc. 88*, 486–494.