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Short Communication

Electronic Packaging Reliability Physics, and the Role of Failure-oriented-accelerated-testing

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"The only real voyage of discovery consists not in seeing new landscapes, but in having new eyes"

Marcel Proust, French writer

The bottleneck of an electronic, photonic, MEMS or MOEMS (optical MEMS) system's reliability is, as is known, the mechanical ("physical") performance of its materials and structural elements [1,2] and not its functional (electrical or optical) performance, as long as the latter is not affected by the mechanical behavior of the design. It is well known also that it is the packaging technology that is the most critical undertaking, when making a viable, properly protected and effectively-interconnected electrical or optical device and package into a reliable product. Accelerated life testing (ALT) [3-5] conducted at different stages of an IC package design and manufacturing is the major means for achieving that. Burn-in-testing (BIT) [6-8], the chronologically final ALT, aimed at eliminating the infant mortality portion (IMP) of the bathtub curve (BTC) prior to shipping to the customer(s) the "healthy" products, i.e. those that survived BIT, is particularly important: BIT is therefore an accepted practice for detecting and eliminating possible early failures in the just fabricated products and is conducted at the manufacturing stage of the product fabrication. Original BITs used continuously powering the manufactured products by applying elevated temperature to accelerate their aging, but today various stressors, other-than-elevated-temperature, are employed in this capacity. BIT, as far as "freaks" are concerned, is and always has been, of course, a FOAT type of testing. But there is also another, so far less well-known and not always conducted today, FOAT [9-12] that has been recently suggested in connection with the probabilistic design for reliability (PDfR) concept [13-18]. Such a design stage FOAT, if decided upon, should be conducted as a highly focused and highly cost effective undertaking. FOAT is the experimental foundation of the PDfR concept and, unlike BIT, which is always a must, should be considered, when developing a new technology or a new design, and when there is an intent to better understand the physics of failure and, for many demanding applications, such as, e.g., aerospace, military, or long-haul communications, to quantify the lifetime and the corresponding, in effect, never-zero, probability of failure of the product. Such a design-stage FOAT could be viewed as a quantified and reliability-physics-oriented forty years old highly-accelerated-life-testing (HALT) [19-22], and should be particularly recommended for new technologies and new designs, whose reliability is yet unclear and when neither a suitable HALT, nor more or less established "best practices" exist. When FOAT at the design stage and BIT at the manufacturing stage are conducted, a suitable and physically meaningful constitutive equation, such as, e.g., the multi-parametric Boltzmann-Arrhenius-Zhurkov (BAZ) model [23-25] should be employed to predict, from the test data, the probability of failure and the corresponding useful lifetime of the product in the field. Both types of FOAT and the use of the BAZ equation were addressed in the referenced publications using analytical ("mathematical") predictive modeling [26-32]. In the author's opinion and experience, such modeling should always complement computer simulations: these two major modeling tools are based on different assumptions and use different computation techniques, and if the calculated data obtained using these tools are in agreement, then there is a good reason to believe that the obtained data are accurate and trustworthy.

Bibliography

1. E Suhir. "Microelectronics and Photonics – the Future". *Microelectronics Journal* 31.11-12 (2000): 839-851.
2. E Suhir and R Mahajan. "Are Current Qualification Practices Adequate?". *Circuit Assembly* (2011).
3. E Suhir. "Accelerated Life Testing (ALT) in Microelectronics and Photonics: Its Role, Attributes, Challenges, Pitfalls, and Interaction With Qualification Tests". *ASME Journal of Electronic Packaging (JEP)* 124.3 (2002).
4. E Suhir. "Reliability and Accelerated Life Testing". *Semiconductor International*, Feb.1, (2005).
5. E Suhir. "Making a Viable Electron Device into a Reliable Product". Brief Note, *Journal of Electronics and Communications* 1.5 (2020).
6. Burn-In.MIL-STD-883F: Test Method Standard, Microchips. Method 1015.9; US DoD: Washington, DC, USA, (2004).
7. E Suhir. "To Burn-in, or not to Burn-in: That's the Question". *Aerospace* 6.3 (2019).
8. E Suhir. "Burn-in Testing (BIT): Is It Always Needed?". IEEE ECTC, Orlando, Fl., (2020).
9. E. Suhir. "Failure-Oriented-Accelerated-Testing (FOAT) and Its Role in Making a Viable IC Package into a Reliable Product". *Circuits Assembly*, July (2013).
10. E Suhir. "Could Electronics Reliability Be Predicted, Quantified and Assured?" *Microelectronics Reliability,* No. 53, April 15, (2013).
11. E Suhir., *et al*. "Highly Accelerated Life Testing (HALT), Failure Oriented Accelerated Testing (FOAT), and Their Role in Making a Viable Device into a Reliable Product". 2014 IEEE Aerospace Conference, Big Sky, Montana, March (2014).
12. E Suhir. "Failure-Oriented-Accelerated-Testing (FOAT), Boltzmann-Arrhenius-Zhurkov Equation (BAZ) and Their Application in Microelectronics and Photonics Reliability Engineering". *International Journal of Aeronautical Science and Aerospace Research* 6.3 (2019).
13. E Suhir. "Probabilistic Design for Reliability". *ChipScale Reviews* 14.6 (2010).
14. E Suhir., *et al*. "Probabilistic Design for Reliability (PDfR) and a Novel Approach to Qualification Testing (QT)". 2012 IEEE/AIAA Aerospace Conf., Big Sky, Montana, (2012).
15. E Suhir. "Probabilistic Design for Reliability of Electronic Materials, Assemblies, Packages and Systems: Attributes, Challenges, Pitfalls". Plenary Lecture, MMCTSE 2017, Cambridge, UK, Feb. 24-26, (2017).
16. E Suhir. "Probabilistic Design for Reliability (PDfR) of Aerospace Instrumentation: Role, Significance, Attributes, Challenges". 5th IEEE Int. Workshop on Metrology for Aerospace (MetroAeroSpace), Rome, Italy, Plenary Lecture, June 20-22, (2018).
17. E Suhir. "Physics of Failure of an Electronics Product Must Be Quantified to Assure the Product's Reliability". Editorial, *Acta Scientific Applied Physics* 2.1 (2021).
18. E Suhir. "Could Electronics Reliability Be Predicted, Quantified and Assured?". *Microelectronics Reliability*, No. 53, April 15, (2013)
19. M Silverman. "Forty Years of HALT: What Have We Learned?". IEEE EPS ASTR 2012 Oct 17-19, Toronto, CA (2012).
20. "Fundamentals of HALT/HASS Testing". Keithley Instruments, Inc. Cleveland, Ohio. (2000).
21. "What is HALT HASS: Performing HALT". Qualmark Corporation (2012).
22. N Doertenbach. "The Application of Accelerated Testing Methods and Theory (HALT and HASS)". QualMark Corporation (2012).
23. E Suhir and S Kang. "Boltzmann-Arrhenius-Zhurkov (BAZ) Model in Physics-of-Materials Problems". *Modern Physics Letters B (MPLB)* 27 (2013).
24. E Suhir., *et al.* "Technical Diagnostics in Electronics: Application of Bayes Formula and Boltzmann-Arrhenius-Zhurkov Model". *Circuit Assembly*, Dec. 3, (2012).

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25. E Suhir and A Bensoussan. "Application of Multi-Parametric BAZ Model in Aerospace Optoelectronics". 2014 IEEE Aerospace Conference, Big Sky, Montana, March (2014).

26. E Suhir. "Predictive Modeling is a Powerful Means to Prevent Thermal Stress Failures in Electronics and Photonics". *Chip-Scale Reviews* 15.4 (2011).

27. E Suhir. "Analytical Modeling in Electronic Packaging Structures: Its Merits, Shortcomings and Interaction with Experimental and Numerical Techniques". *ASME Journal of Electronic Packaging* 111 (1989).

28. E Suhir. "Analytical Thermal Stress Modeling in Electronic and Photonic Systems". *ASME Applied Mechanics Reviews* 62.4 (2009).

29. E Suhir. "Thermal Stress Failures: Predictive Modeling Explains the Reliability Physics Behind Them". *IMAPS Advanced Microelectronics* 38.4 (2011).

30. E Suhir. "Could Electronics Reliability Be Predicted, Quantified and Assured?" *Microelectronics Reliability* 53.7 (2013).

31. E Suhir. "Analytical Modeling Enables Explanation of Paradoxical Situations in the Behavior and Performance of Electronic Materials and Products: Review". *Journal of Physical Mathematics* 7.1 (2015).

32. E Suhir. "Analytical Modeling Occupies a Special Place in the Modeling Effort". *Journal of Physical Mathematics* 7.1 (2016).