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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.

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