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Editorial

Making a Viable Electron Device into a Reliable Product: Brief Review

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Editorial

To assure high operational reliability of an electronic or a photonic product [1-5] one has to understand the underlying reliability physics and, to an extent possible, predict and quantify its performance in the field. In the areas of commercial or agricultural electronics, as long as the customer comes back, not the product, cost-effectiveness and time-to-market are much more important than reliability. The situation is different in aerospace, military, long-haul communication and, in many cases, also in medical electronics engineering, where understanding the physics of possible failures and ability to assure reliability is paramount. Because of the inevitable uncertainties, such an assurance should be done on the probabilistic basis. In effect, the difference between a highly reliable and insufficiently reliable products is "merely" the difference between the levels of their never-zero probabilities of failure. The desirable reliability level cannot be low, of course, but it does not have to be higher than necessary either: it has to be adequate for a particular product and application. Too high level of reliability, when the products "never fail", might be an indication that these products are "over-engineered" and are more expensive than they could and should be. Thus, the ability to predict/quantify reliability of an electronic or photonic product intended for an application, where high level reliability is required, is a must.

The recently suggested, mostly in application to avionics and automotive electronics and photonics, probabilistic design for reliability (PDfR) concept [6-11] is based on the highly focused and highly cost-effective failure-oriented-accelerated-testing (FOAT) [12-17] aimed, first of all, at understanding and confirming the anticipated physics of failure. This type of testing should be conducted, when developing a new technology, in addition to the widely used today, in different modifications, highly-accelerated-life-testing (HALT). In many cases, especially for new products, when suitable HALT have not been developed yet, and "best practices" do not yet exist, FOAT could be designed and conducted, for the most vulnerable material(s) and structural element(s) of the product, even instead of HALT. FOAT should be geared to a flexible, easy-to-use and physically meaningful predictive model that would be able to assess the probability of failure and the corresponding lifetime of the product from the FOAT data. It is shown that the multi-parametric Boltzmann-Arrhenius-Zhurkov (BAZ) equation [18-25] can be employed in this capacity. FOAT, being a "transparent box" that is able, using BAZ equation, to predict the probability of operational failure and the corresponding lifetime of the product, could be viewed as an extension of HALT, a "black box" that has a number of merits, but is unable to quantify reliability.

FOAT could be designed and conducted within the framework of HALT, when "fine tuning" of the design of importance is necessary, while HALT, if exists, could be employed for "rough tuning". No matter how good the design and the manufacturing efforts are, the manufactured products always contain, in addition to robust and healthy products, also weak products, s.c. "freaks" that should be eliminated using burn-in-testing (BIT), before the healthy population of the manufactured product is shipped to the customer(s). Useful guidelines on weather "to BIT or not to BIT" and if "to BIT", how to conduct and interpret the BIT process could be found in [26-29]. All the above predictions were made using analytical modeling [30-35].

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