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AUTOMOTIVE ELECTRONICS – MATERIALS AND RELIABILITY

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The amount of electronic devices in vehicles increases continually. Several causes exist for this phenomenon: On the one hand, the application of most modern electronics drastically increases the functionality and operability and, on the other hand, the efficiency is also significantly improved (combustion control, gearshift, etc.). In addition, automotive networking plays an increasing role. Next to an increasing range of infotainment, autonomous driving becomes more important, which in turn requires higher standards in performance, information density and transfer rates of micro- and nanoelectronics. While only "older" technology nodes were used until approx. 2010 because of their higher and better reliability (completed maturation cycle), latest technologies, such as 20/22 nm CMOS processes, are applied in the automotive industry. In order to ensure operating stability of these new technology nodes, Fraunhofer IKTS together with Volkswagen AG and Fraunhofer II-EAS cooperate in the field of reliability of micro- and nanoelectronic devices. The most important differences in requirements for "consumer electronics" and "automotive" are shown in Table 1. While most of the semiconductor manufacturers cover the less rigorous requirements for "consumer electronics", it is definitely not the case for "automotive". Particularly the targeted lifetime (15 years as compared to merely 3) and the failure rate (0 % "zero defects" as compared to < 10 %) show significant differences.

Based on today's state of the art microelectronics, which are qualified with respect to automotive applications, properties, potentials and challenges will be realized for future microelectronics in this scope. Essential construction and process components of microelectronic products will be evaluated in terms of reliability assessment, including electromigration (EM), stressmigration (SM), time-dependent dielectric breakdown (TDDB), temperature cycling (TC), gate oxide integrity (GOI), etc. Standard models for extrapolations under application-specific operating conditions are critically analyzed and tested for validity.

On the basis of a multiscale materials database, developed at IKTS and describing the characteristic thermomechanical properties of applied materials in semiconductor processes, the reliability-limiting mechanisms, which determine the lifetime of a component deployed in the automotive field, will be further analyzed. This lifetime is characterized as a function of the automotive application area. The entire construction process of new electronic systems (e.g. an electronic control unit) is considered.

Different requirements for microelectronics

Property	Consumer	Automotive
Temperature range	0 °C to +40 °C	- 40 °C to +155 °C
Operating time	1–3 years	10–15 years
Vibration	Negligible	0–2000 Hz
Acceleration	Negligible	500 m/s^2
ESD safety	Up to 3 kV	Up to 15 kV
Tolerated failure rate	< 10 %	Goal: zero defect
Documentation of failure behavior	No	Yes
Long-term supply	No	Up to 30 years

Important applications of micro- and nanoelectronics:
1 *Consumer electronics (Source: commons.wikimedia.org).*
2 *Automotive (Source: Volkswagen AG).*

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