short version

Automotive Electronics heading toward a Crisis?

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The rapidly increasing amount of ICs (integrated circuits) in cars has become a dominant cost factor. Within 5 years the mask cost and other NRE cost have increased by more than a factor of 10. Moore's Law is becoming increasingly misleading. From generation to generation the continuing IC technology progress rapidly creates more and more problems, like increasing IC design cost and time to market, and increasing IC fabrication cost, and decreasing IC robustness and life time expectation. In automotive electronics as well as in industrial equipment, military, aerospace, etc., this may affect long term microelectronic spare part supply logistics and product quality.

Decreasing robustness of ICs. Within the last 12 years the gate oxide thickness has decreased from 20 nm (nano meters) to 2 nm. Figure 1 tries to illustrate, how thin the oxide of a transistor gate has become. Parasitic effects have dramatically increased, like the leakage current growing exponentially with the decreasing dielectric thickness, threshold voltage changes by dopant fluctuation, power noise, and other effects. ICs of newest technology may fade away even when just stored for long time at room temperature. ICs fabricated on a the newest IC fabrication line could have a life time lower than that of the car. Within a couple of years this might cause a major spare part crisis. For unavailable spare parts needed, their fab lines maybe no more existing due to high innovation speed.

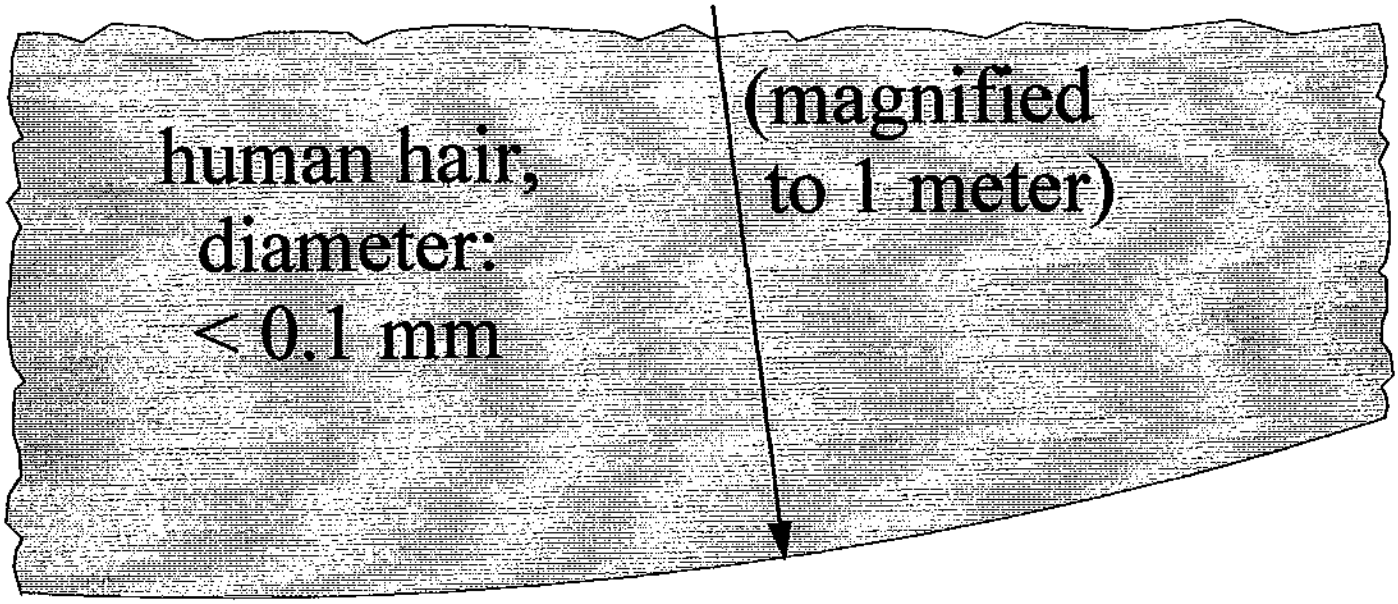
Proposing a Technology Assessment Study. Currently we do not have sufficient experience on the extent of such problems, because cars highly equipped with microelectronics are on the market only for a short time. It is impossible to get quotable publications on strategically relevant data. A non-quotable source from the internet talks about roughly 7 years average lifetime expectation of a newest microprocessor having been announced. IC manufacturers strictly refuse to reveal IC life expectance data or field return statistics. A technology assessment project (TAP) within DaimlerChrysler should study these strategic problem areas and collect more information needed to be sure to avoid an automotive electronics logistics disaster in the far or mid term future.

Morphware. Fortunately now with FPGAs (field-programmable gate arrays) a new kind of IC platform is available, so that we can switch from hardware to morphware, which can be "re-wired" at run time. Because of their general purpose properties FPGAs are a suitable platform not only for reverse engineering of unavailable spare parts required. Morphware is the fastest growing segment of the IC market and has reached a market volume of 7 billion US-dollars worldwide [Dataquest]. Also for DaimlerChrysler such a common morphware platform would be a promising route to avoid the very high mask cost, to reduce the number of IC types needed, to accelerate time to market, and for retro emulation to solve long term spare part supply problems.

A new business model. Not only microcontrollers or simple logic circuits are easy to migrate onto FPGA platforms. Practically everything may be migrated onto morphware. A single FPGA type may replace a variety of hardwired IC types. Design and debugging turn-around times can be reduced from several months to weeks or days. Patches or upgrades may take only days, hours, or even minutes, and, may be even carried out at the customer's site, even remotely over the internet or wireless communication. This means a change of the business model - an important benefit for innovative efforts in remote diagnosis and other customer services - an important benefit for world-wide services and all other after sales consequences.

Innovative spare part logistics. Retro emulation on FPGAs is an efficient way of re-engineering unavailable electronics parts for replacement solutions. But reverse engineering can be avoided in the future, when the implementation of all automotive IC architectures is FPGA-based from the beginning.

Reliability by fault-tolerance. In case, TAP comes to the conclusion of a high risk, countermeasures should be considered for reliability improvement. FPGAs are the most effective way and almost the only viable way to obtain reliable ICs by automatic repair after automatic error detection, what is achieved by partial reconfiguration at run time. But no resources are available commercially, so that a cooperation with a FPGA vendor would be advisable.



transistor gate oxide thickness: 2 nm (0.000 002 mm),
which relatively is very much smaller than this thin line

Fig. 1: The 0.13 µ technology transistor gate oxide thickness compared to a human hair (magnification factor: 10 000 - the human hair is shown here with a diameter of 1 meter).

Reconfigurable Computing. For important compute-intensive applications in areas like telemetry, multimedia and communication, (coarse grain) *Reconfigurable Computing* (RC) arrays may be used instead of (fine grain reconfigurable) FPGAs, to overcome the limited performance of "general purpose" von-Neumann-type controllers or microprocessors. RC is by orders of magnitude more area-efficient than FPGAs. Commercial RC platforms are available from PACT AG, Munich[1], and from Quicksilver Tech, San Jose,[2].

Conclusions. This memo has introduced morphware and its capabilities to avoid the very high cost coming along with specialized silicon at the low production volume being typical to automotive microelectronics (only 6% share of the IC market worldwide [DataQuest]). This memo also has issued a warning about possible threats by future microelectronics technology reliability problems and spare part supply problems. The conclusion is the recommendation to set up a task force for extensive studies of the chances and risks of automotive morphware application, as well as of the risk affecting long term IC reliability and spare parts supply.