Addressing soaring complexity

...Henk van Houten

Microelectronics has become the most pervasive global industry, with products ranging from mobile communications, computing, and automotive electronics, to personal healthcare, security, and identification. Innovation in mainstream Si microelectronics follows the path of Moore's law. In formulating his famous law, Gordon Moore not only made a lucid prediction, he provided a clear direction and timeline for innovation in the semiconductor industry, which has enabled the definition of internationally agreed roadmaps. Because of this, the various actors in the industry, from materials suppliers to toolmakers, integrated circuit (IC) manufacturers, and software houses, can be fairly confident that their expenditures on R&D are timely, well directed, and profitable.

The exploding cost of realizing successive technology generations, however, has become prohibitive and dealing with the s*oaring cost of innovation* is the greatest challenge for Si microelectronics today. On an architectural level, the winning solution is the system-on-a-chip (SoC) approach. Because of their programmability, SoCs can be manufactured in large numbers for a range of applications, offering maximum reuse of costly design and testing efforts. At the technological level, the solution is partnerships, for example in joint R&D programs and facility sharing.

Meanwhile, we are witnessing progress beyond the one-dimensional highway of Moore's law. Further miniaturization needs extensive integration of passive components such as inductors and capacitors, which take up the majority of printed circuit board area in, for example, a mobile phone. This requires new approaches in materials, design, and processing, as the traditional scaling rules for complementary metal oxide semiconductor (CMOS) circuits do not apply here. Another trend is the increasing incorporation of a variety of functions into personal electronic systems, such as miniature cameras, weather stations, accelerometers, as well as global positioning, biometric identification, and health monitoring systems. Apart from nonCMOS process features, such as high-voltage, low-power, analog, and radio-frequency devices, nonsemiconductor technologies are needed to realize functions like integrated passives or mechanical and optical sensors. Nano- and biotechnology are around the corner, and will have a dramatic impact on this new class of sophisticated elements.

The key challenge to be addressed in this new field of 'more than Moore' is managing the *soaring complexity*, caused by the bewildering variety of applications and emerging technical solutions. Roadmaps are virtually nonexistent, and the pursuits of material suppliers, toolmakers, device makers, and designers are not yet well aligned. Added to this are the pitfalls of the innovator's dilemma: how to balance investing in a new application based on unproven technology against the next generation of a predictable technology?

In solving these challenges, the lessons learned in Si microelectronics can provide useful guidance. At an architectural level, the complexity can be addressed, at least partially, by the concept of system-in-a-package (SiP). Whereas a SoC minimizes the cost per switch, a SiP focuses on achieving the highest value for a single packaged microsystem. Added value in a SiP is achieved by integrating several functions into a single module or package, combining electrical as well as nonelectrical elements. For example, Philips is developing a miniature camera SiP called FluidFocus comprising a CMOS image sensor and a tunable lens based on electrowetting.

In our view, the world of 'more than Moore' can only become as successful as Si microelectronics if we also succeed in defining shared roadmaps with modular and platform solutions, common modeling, simulation, and design tools, and shared testing strategies. This will call for intensive technology partnerships. Philips, being a strong believer in open innovation, is pursuing this by sharing our long-range application and technology visions with partners and key customers. We are also actively engaged in a variety of joint R&D programs.

As a concrete step towards open innovation, Philips Research has recently opened its new MiPlaza cleanroom at the High Tech Campus in Eindhoven, the Netherlands. MiPlaza – short for Microsystems Plaza – is a multipurpose facility with a 2650 m^2, class 100-10 000 cleanroom area offering a broad range of process equipment and analytical services. Almost all types of materials can be handled without fear of cross-contamination, and a wide variety of substrate sizes and shapes can be dealt with. Several third-party start-up companies are already using MiPlaza. We are also working with companies such as ASML and FEI, and leading universities. It is our intention that MiPlaza will become a highly interdisciplinary meeting place for researchers working together in a spirit of open innovation in the fields of microsystems and nanotechnology.

Henk van Houten is Senior Vice President of Philips Research. He is based in Eindhoven, the Netherlands and Aachen, Germany.