ADVANCED RESEARCH IN INFORMATION PROCESSING COMPONENTS INITIATIVES AT EUROPEAN LEVEL

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Excellence in components is at the root of advances in all areas of ICT. Europe has a strong industrial base in micro/nano-electronics, and the ENIAC European Technology Platform on nanoelectronics[1] has identified in its 2020 Vision document, a key role for long-term research in universities and research centres to offer a range of novel approaches to the realisation of future devices.

During Framework Programme 5, FP5 (1998-2002), the **Nanotechnology Information Devices** (NID) initiative of IST FET promoted alternative approaches for the realisation of information processing components. The initiative is now mostly complete. A total of about 50 projects with an EC financing of 70 M€ was supported, many of the projects showing a high degree of novelty. The projects covered areas of devices, architectures and fabrication methods, and gathered a strongly multidisciplinary community.

In FP6 (2002-2006), the IST priority supports advanced research in components through a number of focused initiatives. As part of the strategic objective on "pushing the limits of CMOS", the SiNANO network of excellence launched early 2004 integrates teams active in ultimate CMOS research. Other initiatives covering **Emerging Nanoelectronics**, **Quantum Information Processing** and **Advanced Computing Architectures** are also being implemented with integrated projects and networks of excellence. The first projects for these actions are expected to start in September 2005.

In preparation to FP7 (2007-2013), the IST Future and Emerging Technologies unit organised a number of events to help shape up an eventual programme in advanced ICT research. At a consultation meeting on 16 December 2004[2], driving factors for advanced research on components were highlighted, and lessons taken from the recent developments in the ITRS roadmap chapter on "Emerging Research Devices". Participants of the ENIAC Technology Platform were present at the discussion.

A substantial motivation of research on components is to continue progress according to Moores'law, integrating logic and memory devices that are **increasingly small, fast, cheap and consume less power**. This is the **"More Moore"** agenda.

A second motivation for components research is to pursue the creation of interfaces between the "brains" of the chips of the future, made of logic and memory, and the outside world so that chips acquire a higher added value by interacting with their environment. This line of research is referred to as the "**More than Moore"** agenda.

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[1] European Nanoelectronics Initiative Advisory Council http://www.cordis.lu/ist/eniac/

[2] Emerging Nanoelectronics: Preparing for upstream Non-CMOS R&D in FP7 Brussels, 16 December 2004, ftp://ftp.cordis.lu/pub/ist/docs/fet/enano-2.pdf

The ITRS roadmap provides guidelines on how conventional and unconventional CMOS logic devices could reach the “22nm node” in the year 2016. Further progress will require breakthrough technologies, with a first set of candidates based on new binary logic devices using charge transport such as nanotube- or nanowire-transistors and ballistic devices. More exotic candidates include technologies that are not based on charge transfer, such as quantum computing, spintronics or molecular electronics.

For memories, several competitive technologies are already well developed, such as ferro-electric (FRAM), magnetoresistive (MRAM) or phase-change memories (PCRAM). Beyond these, novel concepts need to be researched to reach ultimate limits of storage.

At an earlier workshop on 21-22 April 2004 in Brussels[3], the following “Grand Challenges” and visionary ideas for future components were identified:

- **Adding functionality to Silicon-based devices and systems**, through the use of nanometre-size material structures for the realisation of new types of functions in sensing, actuating, interfaces, optoelectronics, links with living systems, etc.

- **Combining and interfacing different materials, functions, devices and information carriers**, researching functions that would not represent information by electron charges, but may rely on photons, spins, ions, phonons, or quantum objects.

- **Fabrication of complex nano-scale systems in a cost-effective way**. A challenge is to combine elements of self-organisation with those of top-down manufacturing.

- **Miniaturisation down to the 1 nm limit**, looking at radical ways to represent and process information e.g. in molecular electronics.

- **Master the complexity of gigascale systems**, with new methods allowing fault tolerance, and simplifying the design tasks.

These lines of research are already supported in part by the FP6 targeted initiatives composed of integrated projects including “Emerging Nanoelectronics”, “Advanced Computing architectures”, including operating systems and compilers, “Quantum Computing and Communications”. These could be further pursued, and complemented by initiatives such as:

- Proof of concept of radically new devices
- Nano-Electro-Mechanical Systems (NEMS)
- Electronic Devices exploiting materials found in biological systems
- Fault-tolerant circuit and system architectures
- Atomic-scale technology

In such initiatives, the development of proven concepts up to a level where the promises for industrial R&D can be fully assessed could be undertaken in large collaborative

[3] New Directions for ICTs in FP7: Grand challenges for basic research, 21-22 April 2004, Brussels, http://www.cordis.lu/ist/fet/7fp.htm

projects assembling partners from university, research institutes and industrial partners. More upstream projects could be smaller and have a heavier academic participation.