CATRENE Scientific Committee

Executive Summary: "More-than-Moore" roadmap

Report from the CATRENE Scientific Committee

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Executive summary

The ITRS roadmap is very successful in setting technological challenges and in driving the progress in the digital technologies supporting the microelectronics industry. It helps providing guidance to the research community and to the associated funding agencies worldwide. It synchronizes the technology development and the timely availability of manufacturing tools and methods. And more generally speaking it increases the resource efficiency through focus and it fuels the growth of the microelectronic market in giving confidence in the capability of the microelectronic community to fulfill "*Moore's Law*" for the decade to come.

"*More-than-Moore*" (or MtM) is the other facet of the microelectronic products complementing the digital part of the integrated systems. More specifically the "*More-than-Moore*" approach allows for the *non-digital* functionalities of a product – which do not necessarily scale according to "*Moore's Law*", but provide additional value in different ways – to migrate from the system board-level into the package (SiP) or onto the chip (SoC). This report issued by a Working Group of the CATRENE Scientific Committee is aimed to stimulate a broad roadmapping effort in the "*More-than-Moore*" domain as successfully as it is done in the ITRS for its digital counterpart.

In a first chapter, following the ITRS White Paper on "*More-than-Moore*" in which the Working Group participated, we try to understand why the ITRS was so successful in the digital domain. Through this analysis we are able to outline what are the prerequisites for a potentially successful technology roadmap and what are the specificities of the "*More-than-Moore*" domain. The resulting methodology stresses the importance of defining generic functionalities needed by many "*More-than-Moore*" applications as well as of the underlying devices and technologies which are able to fulfill such functions.

The rest of the document selects few applications and devices which outline the potential and issues of such a methodology.

The selected application domains – energy, automotive, healthcare, security and safety – require advanced "*More-than-Moore*" functionalities. Further segmentation is needed to identify generic functions prone to roadmapping: this was partially achieved in this report along with the identification of some underlying technologies which are central to these applications.

In a second part of this report a tentative taxonomy of potential MtM devices is first established. Then specific MtM devices are selected owing to their perceived potential for technological roadmapping, namely integrated power devices, lighting, image sensors, biochips and MEMS. Finally we consider some emerging research devices having a potential for future use in the "*More-than-Moore*" domain.

Some general conclusions can be drawn from this report:

1. There will not be a single roadmap of the "*More-than-Moore*" domain, but many dedicated roadmaps for those applications or technologies which fits the prerequisites (as defined by the ITRS White Paper) for a successful roadmapping effort.

2. The identification of generic / basic "*More-than-Moore*" functionalities and of the applications which will drive the progress of these functionalities is a central part of any "*More-than-Moore*" roadmap. It requires a huge effort to reach meaningful conclusions which could be only partially achieved owing to the limited resources of the Working Group.

More specific conclusions and recommendations can be drawn for each selected application domain and "*More-than-Moore*" devices and technologies:

3. The **automotive** sector is driven by safety, energy efficiency and/or impact on the environment, which translate into the need of better

transducers and integrated power. It is suggested to focus on the requirements of the **electrical car** which will be addressed by the newly launched European project ICT4FEV. Further activity in this domain could also be pursued within the EPoSS frame.

4. **Energy** as such is a too broad field but few associated device roadmaps are meaningful:

    a. The field of **integrated power** is clearly worth further investigation, more specifically in the medium power domain. This activity will take place within the CATRENE Scientific Committee, through the roadmapping activity of the ECPE organization and/or within the EPoSS frame.

    b. In **lighting** some international and European roadmaps exist for devices. A system-level roadmap could benefit from the update of the section of the ENIAC Strategic Research Agenda dedicated to lighting.

5. A MtM roadmap on **healthcare** should focus on diagnostics rather than therapeutics. However owing to the breadth and diversity of this field it is suggested to postpone a major roadmapping effort covering the entirety of this application domain. On the other hand focused roadmapping effort can be envisaged in fields like **wearable healthcare** or **biosensors** (focusing on molecular / cellular diagnostics and *in-vivo* devices).

6. Some devices and technologies are driven by the **security and safety** application domain, especially infrared image sensors, THz spectroscopy and imaging, and secure hardware. Further work in this direction is recommended.

7. The field of **image sensors** – in the visible range – is very competitive and it is thus unlikely that a roadmap in that domain will emerge. In any case the ITRS frame is best suited to address this field.

8. **MEMS** is a very limited market and a fragmented field which addresses many critical applications, but without showing clear common long-term trends and drivers. As an international effort was started within iNEMI

and will be also pursued from 2011 in the ITRS: it is suggested that Europe play a significant role in these international initiatives.

9. The **analog front end** is one of the main building blocks that any transducer system shares and which would be worthy addressing as a stand-alone section. This could take place within the ITRS frame, *e.g.*, in its "*System Drivers*" chapter.

10. The long-term opportunities of **emerging research devices** in the "*More-than-Moore*" domain are mostly in the fields of photonics, energy and (bio) chemical sensors. From 2011 on, the ITRS will add a section on "*More-than-Moore*" initially focused on wireless applications and it is suggested joining this international effort.