SOC/SIP for energy management

Bernard Courtois

SOC/SIP for energy management

Bernard COURTOIS
CMP
46 avenue Felix Viallet - 38031, Grenoble Cedex, FRANCE
Bernard.Courtois@imag.fr

Abstract - **This paper deals with how ICs and MEMS can address energy issues like the generation, the conversion, the use, the storage, of energy. Energy management is indeed a major issue for the world. Several domains are reviewed like equipment, buildings, lighting, transport, industry. Such a topic complements another important topic addressed for ICs and MEMS themselves, namely the design of low-power devices. A way for future ultra low power devices is also addressed. ICs and MEMS for energy management can be obtained from CMP that is briefly reviewed.**

Keywords: *energy, power, CO_2, photovoltaics*

I - INTRODUCTION

For a long time the IC power issue has been focusing on the design of low-power ICs and MEMS in order to look for the longest possible battery lifetime of mobile devices, like telephones. This is a very useful goal, but the role of ICs and MEMS in energy management is likely to be even more important. This paper has 4 external sources: the IEA to G8 policy recommendations, in terms of total energy, the keynote by R.P. de VRIES at ISSCC 2009 [1], the keynote by Ch. BELADY at ICCD 2008 [2], and course notes by A. SHAKOURI [3].

The recommendation of IEA to G8 is to save 20% of total energy by 2030. This will reduce by 20% per year the global CO_2 emissions by 2030.These savings could come from various domains like Buildings, equipment, Lighting, Transport, Industry, for a total of 92 EJ. Examples of savings are given for several domains in the following.

II - ELECTRONIC EQUIPMENT

The standby modes and the operational modes can be considered. It is considered that the standby mode is responsible for 5% to 10% of the total home power consumption. Great savings may be achieved.

An example of potential savings in the operational mode can be given with TV displays. The figure 1 displays the power as a function of the size of the screen. When 36M decide to move to home cinema, it means that an additional power plant is necessary…. The worst comes from the fact that plasma TV consumes much more than LCD while plasma TV is recommended for very large screens. These power consumption values are much more higher than the power consumption of the old cathodic displays: around 100 W. Huge savings could be obtained here. MEMS are also offering a hope if TMOS could replace LCD, plasma and OLED devices [1].

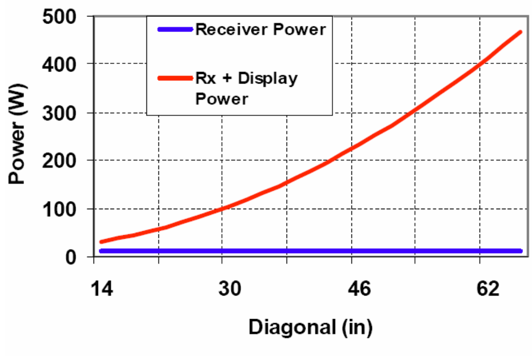

Figure 1: TV power vs. screen size

Data centers were responsible for 1.2% of the total consumption in USA in 2005. Here the design of low-power servers is crucial since every W saved in the die translates into $3 to $4 in support cost. This is important when data centers contain 100.000 or 200.000 servers.

III - AUTOMOTIVE

Automotive is a major source of oil consumption: 60% of the world oil is consumed in transport, road vehicles are responsible for 80% of the total transport energy consumption. Much has already been done since 35% decrease in oil consumption per car has been achieved over the last 30 years. But more is recommended to come: 50% more reduction by 2030 and 50% more for light-duty vehicles. Of course, electronics has been and will even be more responsible for these savings.

Electric cars will help on oil consumption on the roads, but they need an electrical source …. (if all cars in France would go electrical, this would lead to +25% to +50% electrical consumption…). So the total process may be not very efficient. Presently, the $ value of batteries is about 30% in an electrical car.

Various types of hybrid cars can save oil consumption with stop-start, with the use of electrical power for acceleration, with regenerative braking, with electrical transmission…. Many DC-DC converters are needed, DC-AC are needed, etc.

IV - LIGHTING

Lighting is responsible for 20% of total electricity produced. The replacement of incandescent lamps by fluorescent or tube lights can save 80% (EU: by 2012). The move from discrete power components to integrated solutions for the drive electronics will help. Occupancy detection can also help in savings.

V - BUILDINGS

Energy is consumed here for the ventilation, heating, air conditioning, lighting.

Metering allows the shaving of peaks (hence of the total capacity), by powering off some devices. Many sensors are required.

Concrete examples exist like a zero energy building in France (where 1,600 sensors and 550 sqm of PV are used) and a rotating solar building in Germany.

VI - THE DEVELOPMENT OF SOLAR ENERGY

Here is another example of the use of electronics. The power output of a PV cell is maximized when the cell is operated at an optimal voltage, depending on the temperature and on the irradiance. This is illustrated by the figures 2, 3 and 4. Electronics is necessary to optimize the power generation. The installed PV capacity is expected to grow by 20% to 40% per annum, and to increase rapidly when the parity cost will be achieved (between 2012 and 2018 depending on the countries).

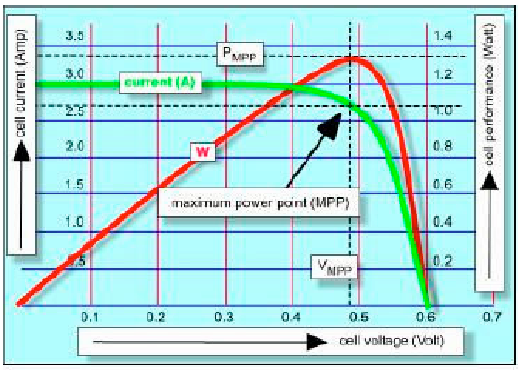

Figure 2: Optimum Load for Single Photovoltaic Cell (National Semiconductor)

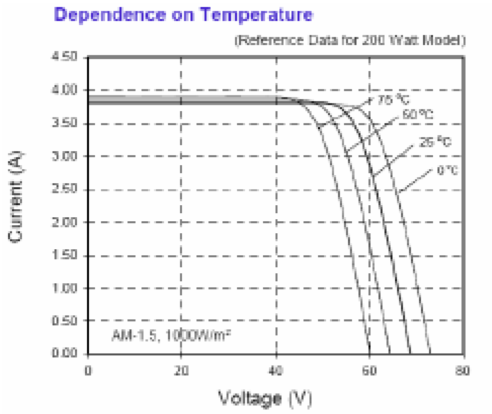

Figure 3: Temperature Dependence of a PV Module (National Semiconductor)

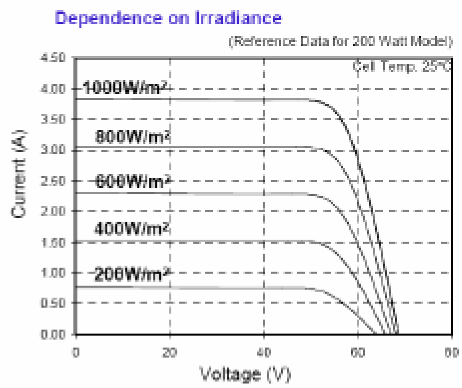

Figure 4: Irradiance Dependence of a PV Module (National Semiconductor)

VII - ICS AND MEMS AVAILABLE FROM CMP

CMP is a non profit Service, reporting to CNRS (the French National Council for Research) and to Universities in Grenoble.

CMP aims to serve Universities, Research Labs and Companies in ICs and MEMS fabrication. CMP give access to a number of technologies, for prototyping and low volume production. Since 1981, CMP has served more than 1,000 institutions from 70 countries in various processes. Support to Industry started in 1990.

Development at CMP

Several periods may be distinguished.

1981–1982	:	launching CMP with NMOS
1983–1984	:	development of NMOS, launching CMOS
1984–1986	:	development of CMOS
1987–1989	:	abandon NMOS, increase the frequency of CMOS runs
1990–1994	:	launching Bipolar, BiCMOS, GaAs MESFET, GaAs HEMT, advanced CMOS (.5 µ TLM)
1995–1997	:	launching CMOS and GaAs compatible MEMS, DOEs, deep-submicron CMOS (.25µ 6LM)
1998	:	launching silicon surface micromachining, abandon MESFET GaAs

1999 : launching SiGe, deep submicron CMOS (.18µ 6LM), SOI/SOS CMOS (.5µ)
2000 : launching SiGe BiCMOS (.35µ 5LM)
2001 : launching very deep submicron CMOS (.12µ 6LM)
2002 : launching Inp HBT process
2003 : launching 0.35µ CMOS-Opto
2004 : launching very deep submicron CMOS (90nm, 7LM), HBT Sige:C BiCMOS 0.25µ
2006 : launching CMOS 65nm (7LM)
2008 : launching CMOS 45nm

Processes available
Presently the processes available for ICs manufacturing are depicted in Table 1.

Austriamicrosystems	0.35µ CMOS C35B4C3
	0.35µ CMOS C35B4M3
	0.35µ CMOS-Opto C35B4O1
	0.35µ CMOS Flash C35B4E3
	0.35µ SiGe BiCMOS S35D4M5
	0.35µ HV-CMOS H35B4D3
STMicroelectronics	45nm CMOS CMOS045
	65nm SOI
	65nm CMOS CMOS065
	90nm CMOS CMOS090
	130nm CMOS HCMOS9GP
	130nm SOI
	0.25µ SiGe:C BiCMOS7RF
OMMIC	0.2µ HEMT GaAs ED02AH

Table 1: IC processes available

ICs design kits and CAD software
Design kits and libraries are distributed by CMP for most of the processes and most commonly used CAD tools. CMP sometimes develop design kits, in cooperation with the manufacturers and the CAD vendors. CMP also offers special CAD software conditions from a few CAD vendors. As a focal point, CMP also distributes information on configuration files, converters, etc. About 40 design kits are available for each process and the main CAD tools.

Test and packaging
Packaging and testing services are also offered. Various types of packages are supported, including DIL, SOIC, CQFP, JLCC, PGA, etc. Test of prototypes is usually done by the final user. On request, especially for low volume production, CMP may take over testing together with manufacturing.

MEMS
CMP offers several processes for MEMS manufacturing based on bulk micromachining, as well as specific MEMS processes.

These are depicted in Table 2.

Integrated micromachining	Base Austriamicrosystems .35µ
	Base STMicroelectronics .25µ BiCMOS post-process ASIMPS from CMU
Specific MEMS	PolyMUMPS from MEMSCAP
	MetalMUMPS from MEMSCAP
	SOIMUMPS from MEMSCAP
	SUMMiT V from SANDIA

Table 2: MEMS processes available

VIII - CONCLUSIONS

Energy management is a formidable challenge to the world. Electronics will greatly help in coping with that challenge. CMP can help by providing an infrastructure for Students, Researchers, SMEs to prototype and obtain small volume production.

Other than energy management key application areas are healthcare, environment and security. CMP provided a help in many BioMed applications [4]. To cope with all these challenges, CMP will develop along several lines.

A. More Moore

It has been recognized that Students, Researchers and SME designers must be provided with the possibility to have their circuits fabricated. From its inception in 1981, CMP has been successfully pursuing this goal and experiencing a very significant growth to reach and to keep its present level. The success is partly due to the basic principles which have been governing the choices of the Service: use of industrial and advanced process lines. Advanced processes are more and more necessary because of the need for very skilled designers and because CAD industrial software is more widely available to Universities (instead of University CAD software). Since new versions of CAD software are targeted to industrial use, there is no choice but to use advanced processes. Industry makes also more and more use of the Service. During the 80s, the CMP processes were not very advanced, but they approached more and more industry state of the art during the 90s, because of CAD software reasons and because of the increasing industry use of CMP. Since then, CMP is always offering state of the art processes.

CMP introduced 130nm CMOS as early as 2001. A total of 250 circuits were fabricated. CMP introduced 90nm CMOS in 2004 and 242 circuits have been fabricated up to now. 65nm CMOS was launched in 2006 and 57 circuits have been fabricated so far. This means a total of more than 500 circuits coming from about 50 Research Laboratories and Industrial Companies. These processes have been very well received.

CMP next introduced 45nm CMOS in 2008. First runs are scheduled in 2009. CMP will proceed with further downsized processes. But it should be clear that the downsizing will…. go down, to get to an end for several reasons, like cost, acceptance, power density, temperature, variability, leakage power, lengthening of money-making time for a generation. And fundamental limits will be reached coming from thermodynamics, quantum mechanisms, electromagnetics, etc.

B.- More than Moore

But the never ending quest for more complex systems may be satisfied by other technology developments, like the move to 3D processes, possibly not including very advanced process dies. 3D processes lead to easier to manage interconnections and to reasonable cost. CMP will introduce soon 3D processes using TSVs (through silicon vias).

It is also recognized that complementary developments must be addressed, in order to address more diversified needs. With this respect, CMP has been a pioneer in being the first service in the world to offer MEMS processes as early as 1995. Going further, more than mechanics-electronics is to be addressed like photonics, optics, fluidics, etc. CMP will be actively promoting these developments in the future.

REFERENCES

[1] Leaner and Greener: Adapting to a Changing Climate of Innovation, R.P. de VRIES, International Solid-State Circuits Conference (ISSCC), San Francisco, 8-12 February 2009

[2] Lean IT: Lead or Die, Ch. BELADY, keynote at International Conference on Computer Design (ICCD), Lake Tahoe, 12-15 October 2008

[3] A. SHAKOURI, course notes, University of California Santa Cruz

[4] Infrastructures for Education, Research and Industry: CMOS and MEMS for BioMed
B. COURTOIS, B. CHARLOT*, G. DI PENDINA, L. RUFER**
Invited paper at the 12th World Multi-Conference or Systemics, Cybernetics and Informatics (WMSCI 2008), Orlando USA, 29 June – 2 July 2008
*IES/MITEA, Montpellier - France,
**TIMA, Grenoble – France