STEEPER

Steep Subthreshold Slope Switches for Energy Efficient Electronics

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Authors: **:** W. Grabinski, A Ionescu, P. Dainesi, K. Leufgen, P. Ulrich

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[1] R = Report, P = Prototype, D = Demonstrator, O = Other

[2] PU = Public, PP = Restricted to other programme participants (including the Commission Services, RE = Restricted to a group specified by the consortium (including the Commission Services), CO = Confidential, only for the members of the consortium (including the Commission Services)

Revision history

Version	Date	Author	Comment
0.1	13.05.11	W. Grabinski	First version
0.2	15.05.11	P. Dainesi	Updated version
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1.0	21.07.11	A. Ionescu	Final approval

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Executive summary

This deliverable presents the so called “Project synopsis”, which consists in a popular scientific summary of the STEEPER project intended to be used as promotional material in different events and accessible to a wide public. It has been prepared by EPFL, STEEPER project coordinator and dissemination manager, together with SCIPROM, the operational manager who is also responsible for the project website.

STEEPER Synopsis

The text below is provided in its integrity without the usual deliverable formatting, in order to fully represent the final visual result of the project synopsis itself.

The project synopsis is also available as a separate pdf document which can be used by all partners for project promotional events and presentations and which will also be available on the STEEPER project website.

Steep Subthreshold Slope Switches for Energy Efficient Electronics

Synopsis

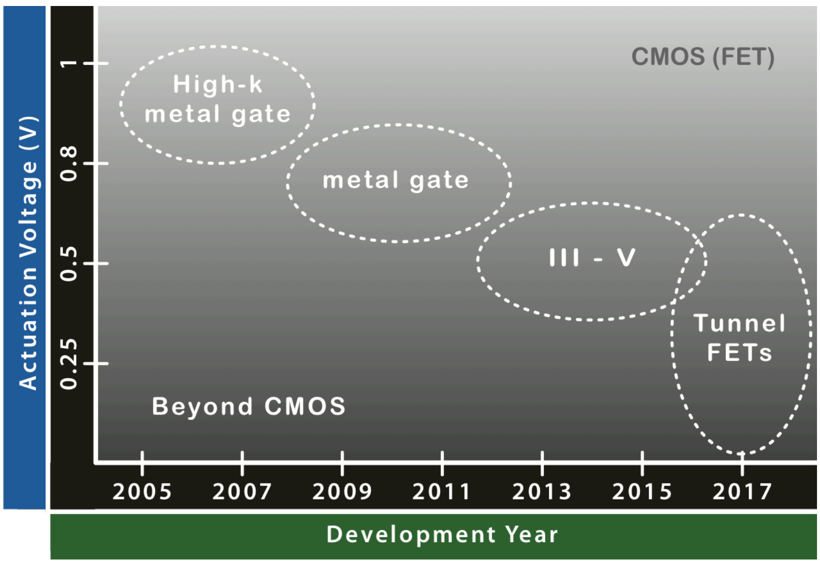
Scientists collaborating in the STEEPER project are applying their expertise for a more efficient use of energy in electronics devices. The project's vision is to touch the basic physics of electronics enabling manufacturers to build future electronic devices such as computers that use negligible energy in particular when they are in standby mode, creating the so-called "zero-power" PC.

Main Objectives

Power dissipation has become one of the major challenges for today's electronics, particularly as the number of devices used by businesses and consumers multiplies globally. To explain the challenge, let's consider a leaky water faucet - even after closing the valve as far as possible water continues to drip. This is similar to today's transistor, the basic electronic functional element, in that energy is constantly "leaking" or being lost or wasted in the off-state. According to the International Energy Agency (IEA), electronic devices currently account for 15 percent of household electricity consumption, and energy consumed by information and communications technologies as well as consumer electronics will double by 2022 and triple by 2030 to 1,700 terawatt hours (TWh). This is equal to the entire residential electricity consumption of the United States and Japan in 2009. Particularly wasteful is the enormous amount of standby consumption. In the European Union it is estimated that standby power already accounts for about 10 percent of the electricity use in homes and offices of all the member States. By 2020, it is expected that electricity consumption in standby/off-mode will rise to 49 TWh per year (e.g. nearly equivalent to the annual electricity consumption of Austria, Czech Republic and Portugal combined). In STEEPER, scientists not only hope to restrain the leak by using a new method to close the valve or gate of the transistor more tightly, but also open and close the gate for maximum current flow with less turns, i.e. less voltage for maximum efficiency.

Technical Approach

The technical approach of the project is based on the development of novel semiconductor devices, that can offer a much more abrupt transition between the off and on states when compared with the physical limit of today's transistor (called MOSFET) at room temperature. This allows for simultaneously reducing the leakage and lowering the operation consumption. These novel devices are called steep slope transistors and the development of energy-efficient transistors of this type operating at low voltage will be a decisive factor in the success of STEEPER.



Roadmap for energy efficient devices highlighting the highest potential offered by tunnel FETs compared to existing solutions to work below 0.5V and even further below 0.25V.

To achieve this, the scientists in the project will study two types of steep-slope transistors. One is the so-called tunnel transistor (TFET) based on silicon or silicon-germanium and the other is based on nanowires composed by a combination of different semiconductors called III-V which belong to group III and group V of the periodic table of elements. Nanowires are cylindrical structures measuring only a few nanometers (nm) in diameter. The STEEPER project will assess the physical and practical limits to boost the performances of TFET and nanowires and technological advantages that will result for future energy efficient devices, circuits and systems (see Figure).

Key Issues

In this type of project the costs of industrialization generally are the greatest financial barrier. Modern transistors are among the cheapest electronic components in the world. It will therefore be difficult to convince industry to replace the present technology with a more expensive and complex one immediately. Both IBM's and INTEL's involvement in STEEPER show an indisputable industrial interest, particularly because the TFETs can be produced without semiconductor manufacturers having to invest in new equipment. In order to offer the lowest possible manufacturing costs, we propose to replace only the essential components of semiconductor circuits with TFETs. In other words, this is a hybrid solution providing the best possible improvement in energy efficiency on a large scale.

Expected Impact

We are estimating that, in less then half a decade, the TFETs will allow to reduce by ten the energy consumption of electronic appliances as well as to minimize it almost to zero in standby mode. This brings a substantial saving in energy, given that the European Union estimates that standby currently counts for about 10 percent of electrical household consumption. This technology will allow mobile telephones to function for a few weeks or even months without having to have their batteries recharged. This technology may further allow to create totally autonomous electronic systems. In other words, appliances could power themselves using solar energy, or other alternative energy sources such as vibrations or electromagnetic waves, thereby replacing batteries.

The interdisciplinary approach of the STEEPER project along with the existing strong links between the project partners ensures synergy and the ability to achieve fast progress to accomplish the scientific objectives and to gain leadership position in the ultra low-power electronics in Europe as well as worldwide. The experience gained when working together in European projects such as STEEPER, will form the basis for future collaborations and enhance the mobility of researchers within Europe. Furthermore, STEEPER will allow incorporating different expertise and fabrication platforms. Overall, this will improve efficiency by fostering knowledge exchange, stimulate innovative ideas on circuit applications, improve the relevance of the conclusions by using the industrial tools available at research institutes, and make it possible to obtain all the parameters for a full benchmarking to other options. The STEEPER initiative is a first step to speed up the development of true custom-made devices.

Apart from the application of the tunnel FETs, the technologies developed in STEEPER, such as strained nanowires and the growth of the III-V structures on silicon are also expected to open new opportunities in other domains including sensors and photonics, eventually leading to completely new applications not considered today.

Coordinated by Swiss Federal Institute of Technology in Lausanne (EPFL), the STEEPER project includes leading corporate R&D organizations (IBM Research Zurich and Intel Mobile Communications), large European research institutes (CEA-LETI and Forschungszentrum Jülich), academic partners (University of Bologna, Technical University of Dortmund, University of Udine and University of Pisa) and the management company SCIPROM.

Project Coordinator:
Prof. Adrian M. Ionescu

Swiss Federal Institute of Technology (EPFL)

SEVENTH FRAMEWORK PROGRAMME

Partners:
CEA-LETI (FR), INTEL (DE), IUNET (IT), GlobalFoundries (DE), IBM (CH), FZ Jülich (DE), SCIPROM (CH), TU Dortmund (DE)

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Website: www.STEEPER-project.eu