Forum *Romanians in Micro- and Nanoelectronics*, *6 November 2018, Romanian Academy, Bucharest, Romania*

MRAM concepts for extended scalability and ultrafast switching

Lucian PREJBEANU, SPINTEC Grenoble, FRANCE

spintec
SPIN IN ELECTRONICS

About me

1998 Master

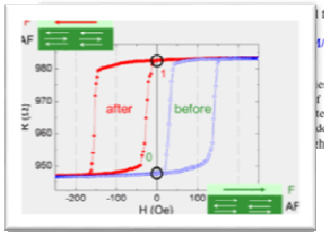
2001 PhD

2015 HDR

2002 spintec SPIN IN ELECTRONICS 2007 — Postdoc → Scientist staff

CROCUS TECHNOLOGY Intelligence in Sensing™ — R&D director

2013 spintec SPIN IN ELECTRONICS — Deputy → Executive director



IOP PUBLISHING JOURNAL OF PHYSICS: CONDENSED MATTER

J. Phys.: Condens. Matter 19 (2007) 165218 (23pp) doi:10.1088/0953-8984/19/16/165218

Thermally assisted MRAM

I L Prejbeanu[1,2], M Kerekes[1], R C Sousa[1], H Sibuet[3], O Redon[3], B Dieny[1] and J P Nozières[2]

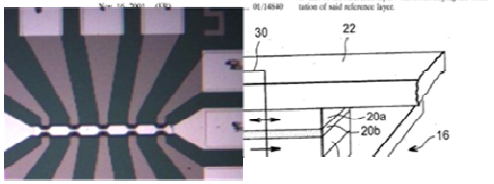
[1] Spintec, URA 2512 CEA/CNRS, CEA-Grenoble, 17 r. des Martyrs, 38054 Grenoble Cedex 9, France
[2] Crocus Technology, 5 Place Robert Schumann, BP 1510, 38025 Grenoble Cedex 1, France
[3] LIMN, DRT/LETI/DIHS, CEA-Grenoble, 17 r. des Martyrs, 38054 Grenoble Cedex 9, France

E-mail: rsousa@cea.fr

form 17 November 2006

/19/165218

es (MRAMs) are a new non-volatile memory
as a mainstream technology. MRAM cell
ted writing scheme (TA-MRAM) is described
design challenges. This approach is compared
ghting the improvements in write selectivity.



US 20050002228A1

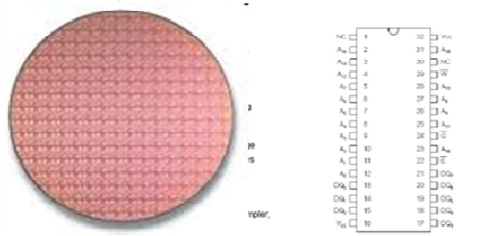
(19) United States
(12) Patent Application Publication
Dieny et al.
(10) Pub. No.: US 2005/0002228 A1
(43) Pub. Date: Jan. 6, 2005

(54) MAGNETIC DEVICE WITH MAGNETIC TUNNEL JUNCTION, MEMORY ARRAY AND READ/WRITE METHODS USING SAME

Publication Classification

(51) Int. Cl.[7] G11C 11/14
(52) U.S. Cl. 365/171

(57) ABSTRACT



CROCUS TECHNOLOGY
Intelligence in Sensing™

PRELIMINARY

CTMR01A08
128K x 8 MRAM Memory

General Description

The Crocus Technology CTMR01A08 is a 1Mbit Magnetic Random Access Memory (MRAM) device organized as 131,072 words by 8 bits. The CTMR01A08 offers SRAM compatible 35ns read/write timing with unlimited endurance. Data is always nonvolatile, with data retention greater than 20-years. Data is automatically protected on power loss by low-voltage inhibit circuitry to prevent writes with voltages out of specification. The CTMR01A08 is the ideal low power solution for data logging, program store, data buffering and data cache applications.

The CTMR01A08 is available in 32-pin SOIC plastic packages and 48-pin SSOP packages. These packages are compatible with similar low-power SRAM products and other non-volatile RAM products.

Crocus Technology memory devices provide highly reliable data storage over a wide range of operating temperatures. The product is offered for commercial temperature (0 to +70°C) operation. Please consult the factory for industrial temperature operation.

see IEEE

Prix SEE-IEEE
Leon-Nicolas Brillouin
2012

NEXT EU FP6 project (2002-2006) finalist Descartes Prize in 2006 → **ANVAR Grand prize for innovation (2005) 13.5 Million Euros raised from VCs (2006)**

About SPINTEC

Created in 2002, now - about 95-100 staff

40 permanent staff & 50-60 PhDs , post-docs & visitors

Summary

Basics of spintronics

Succes story: data storage

MRAM in microelectronics

Need for a non-volatile memory

MRAM roadmap

What's next?

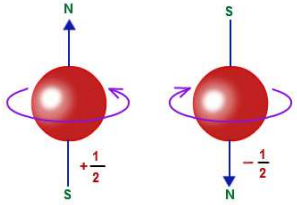
Basics of spintronics

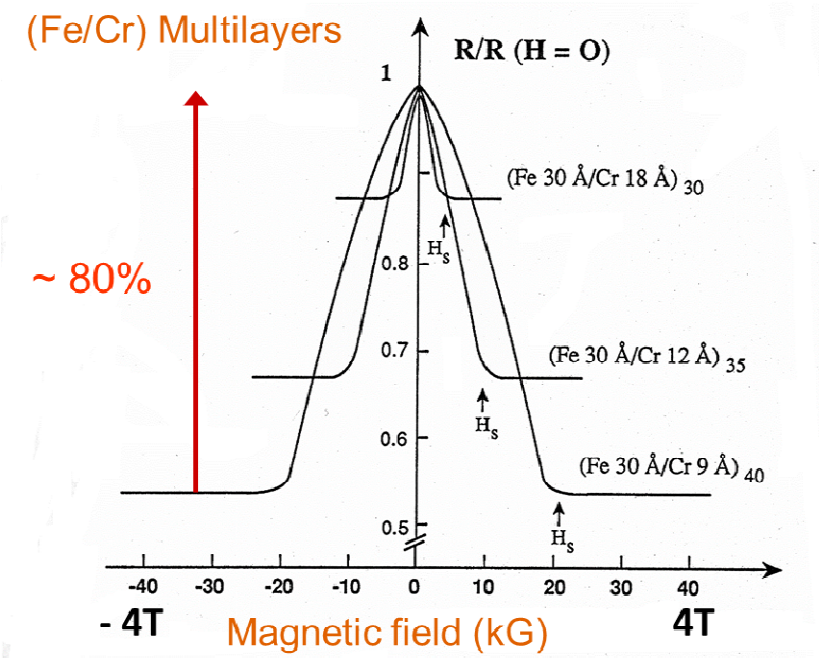
2007
Nobel Prize

Peter Grunberg & Albert Fert

Electronics
Electron Charge

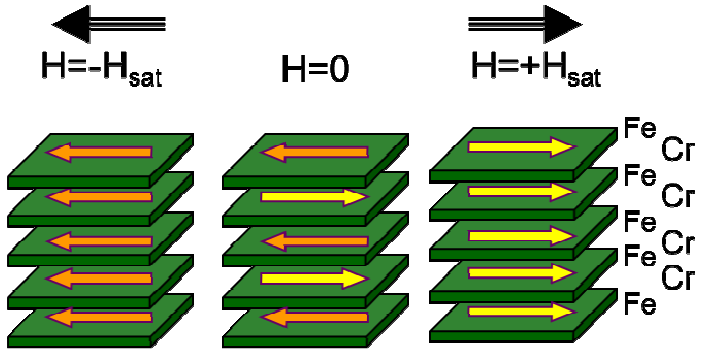
Magnetism
Electron Spin





Main goal of this hybrid technology:

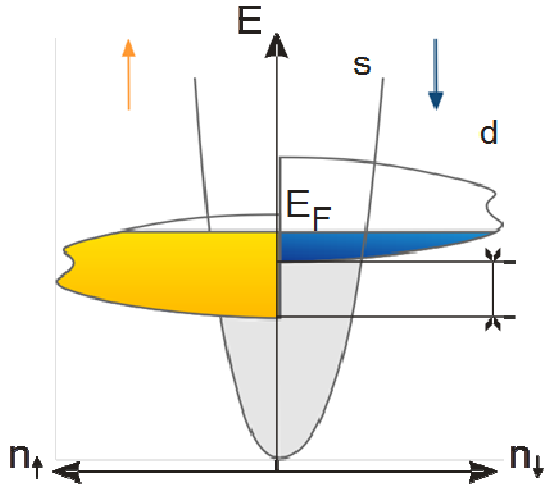
Get the best of the two worlds to obtain new functionalities or improve performances of electronics circuits



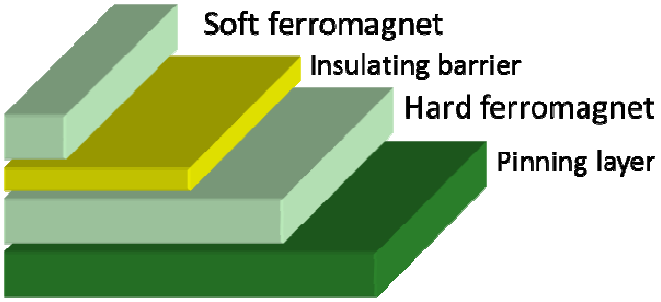
A.Fert et al, PRL (1988)
P.Grunberg et al, patent (1988) + PRB (1989)

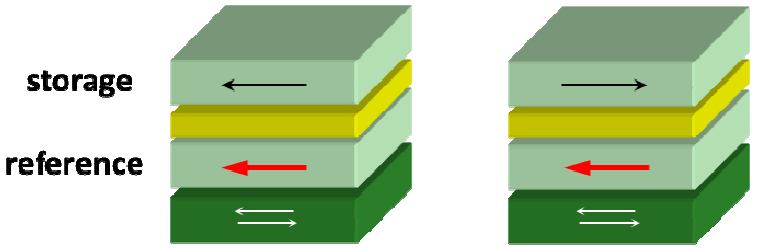
Basics of spintronics

Spin dependent diffusion



Magnetic tunnel junction, Spin valve





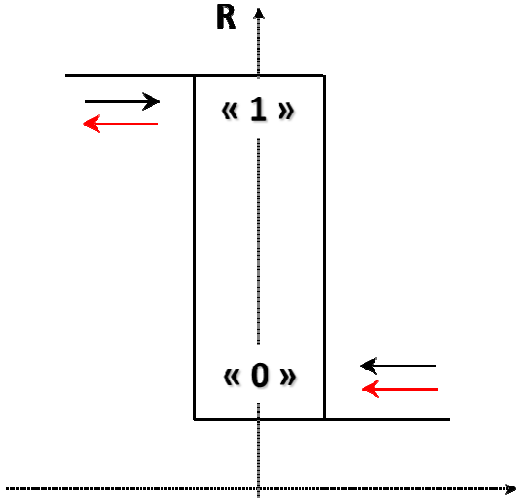
Parallel moments

low R state

Anti-parallel moments

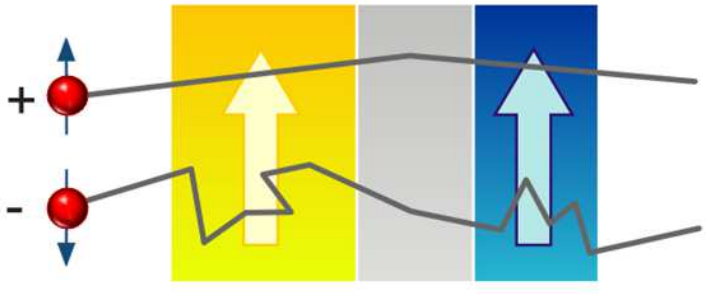
high R state

Magnetoresistance

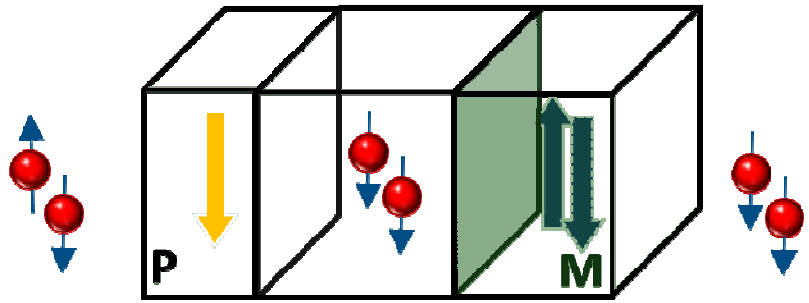


$$TMR = \frac{R_{\uparrow\downarrow} - R_{\uparrow\uparrow}}{R_{\uparrow\uparrow}}$$

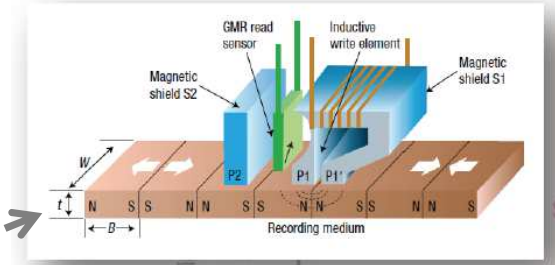
Magnetic hererostructures

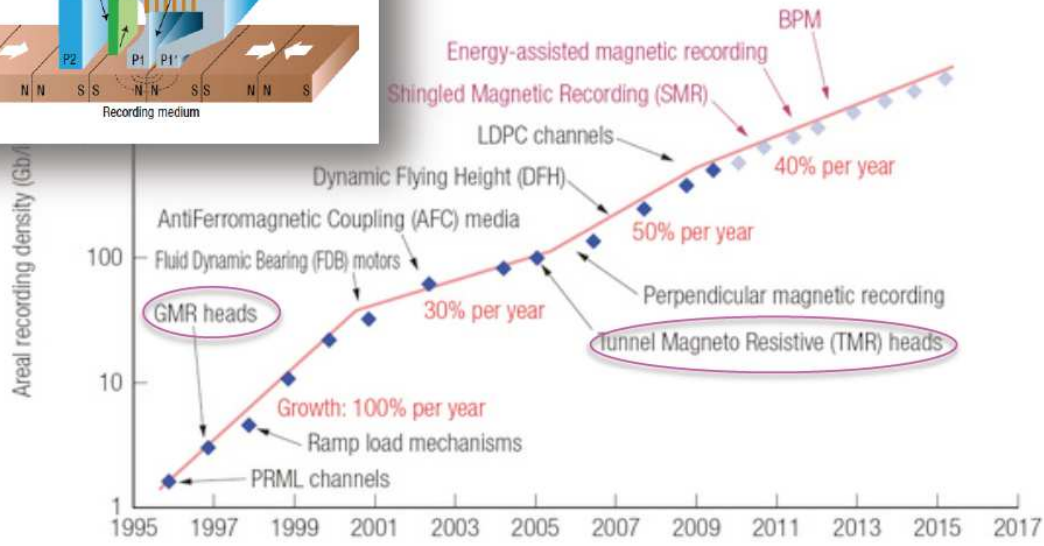


Spin transfer torque

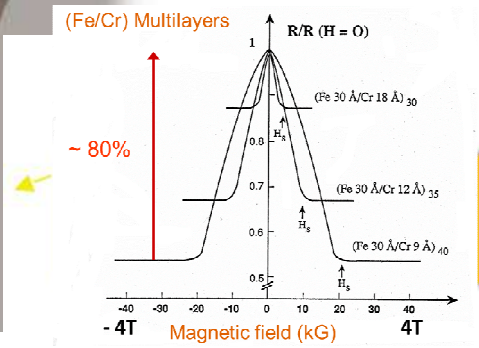


Success story : data storage



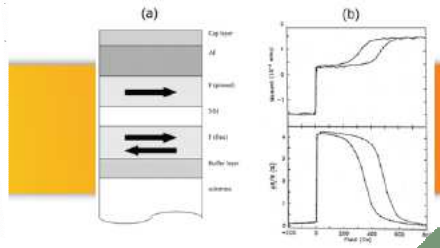


1988



Disccovery (Fe/Cr)

1991-92



Practical Implementation (spin valve)

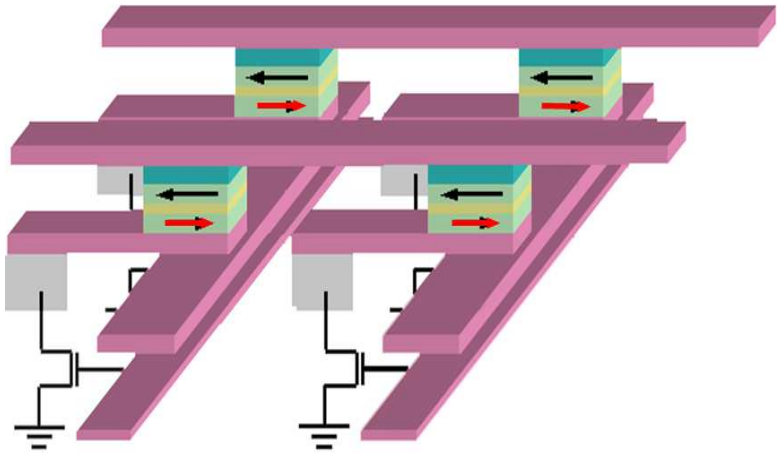
1997

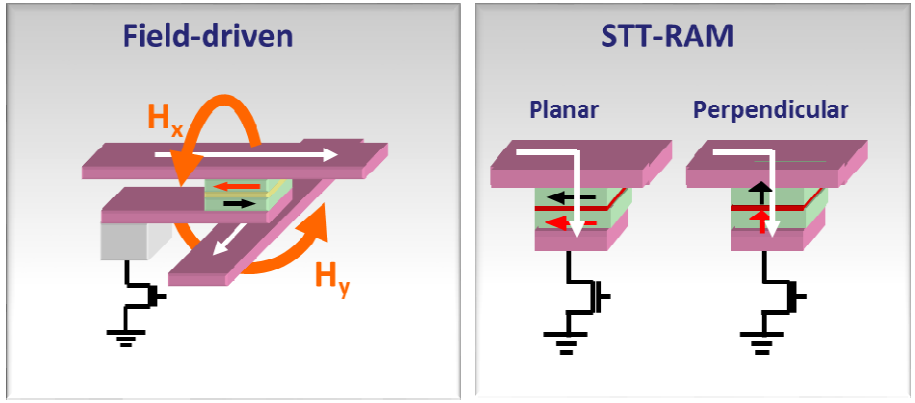
Commercial product

MRAM in microelectronics

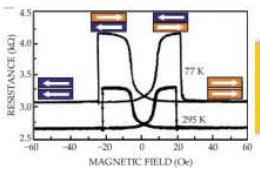
For portable devices and « instant on » computing, industry needs a universal memory, that combine together low cost, low power, non volatility and speed.

S.Lai, Intel VP Technology

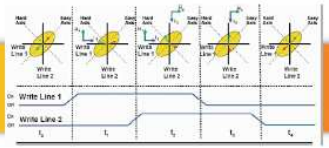




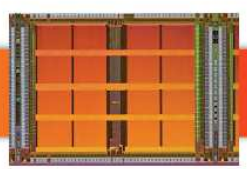
1995



2002



2006



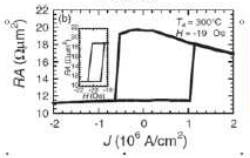
Toggle MRAM

1996

$$T = \frac{1}{\Omega}\int_{\Omega} d\Omega\left(-\nabla\cdot\mathcal{J} - \frac{1}{\tau_{sf}}\mathbf{m}\right)$$

Theoretical prediction

2005



Practical implementation

2013

Product

STT MRAM

MRAM in microelectronics

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spintec SPIN IN ELECTRONICS

Samsung ready to mass produce MRAM chips using 28nm FD-SOI process

Yiling Lin, Taipei; Jessie Shen, DIGITIMES [Tuesday 26 September 2017]

Samsung Foundry will soon be ready to enter mass production of magnetoresistive random-access memory (MRAM) chips built using 28nm fully depleted silicon-on-insulator (FD-SOI) process technology, according to Korea media reports.

Samsung is reportedly teaming up with NXP and has completed the tape-out of its 28nm FD-SOI embedded MRAM, which will be first applied to NXP's new low-power i.MX-series solution targeted at automotive, multimedia and display panel applications.

In related news, Synopsys announced recently its Design Platform has been fully certified for use on Samsung Foundry's 28nm FD-SOI process technology. A PDK and a comprehensive reference flow, compatible with Synopsys' Lynx Design System, containing scripts, design methodologies and best s now available.

TSMC to start eMRAM production in 2018

Jun 08, 2017 **MRAM production**

According to reports, Taiwan Semiconductor Manufacturing Company (TSMC) is aiming to start producing embedded MRAM chips in 2018 using a 22 nm process. This will be initial "risk production" to gauge market reception.

GLOBALFOUNDRIES

EVERSPIN TECHNOLOGIES The MRAM Company™

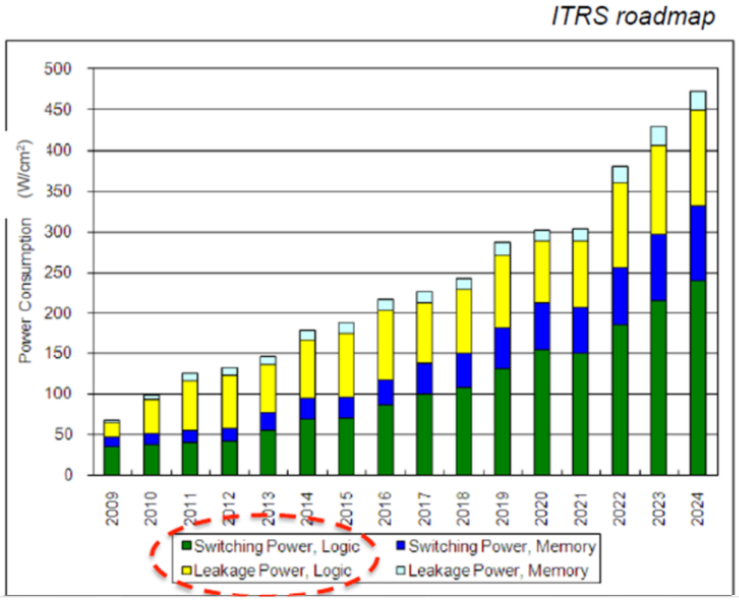
GF-Everspin 2X nm eMRAM with superior data retention - VLSI Symposium

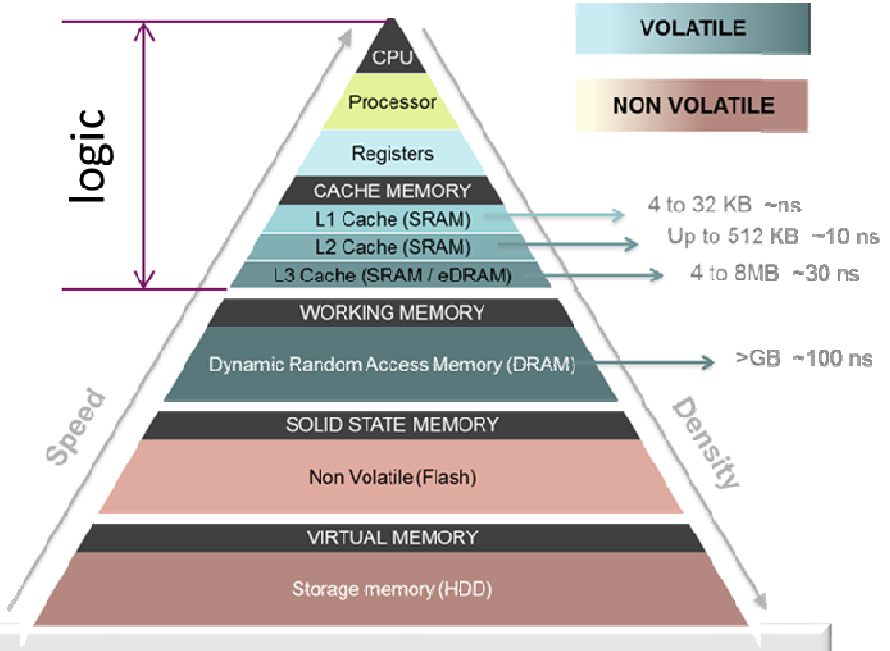
GLOBALFOUNDRIES and Everspin continue to drive embedded MRAM (eMRAM) forward into the 22nm process node! Please see our technical paper presented this week at VLSI Symposium in Japan.

For the first time, we are unveiling eMRAM that can retain data through solder reflow at 260C and 10+ years at 125C, plus read/write with outstanding endurance at 125C.

This is a major breakthrough from GLOBALFOUNDRIES and Everspin that enables eMRAM to be used fc general purpose MCU's and Automotive SOCs.

Need for a non-volatile memory (low power & ultrafast)





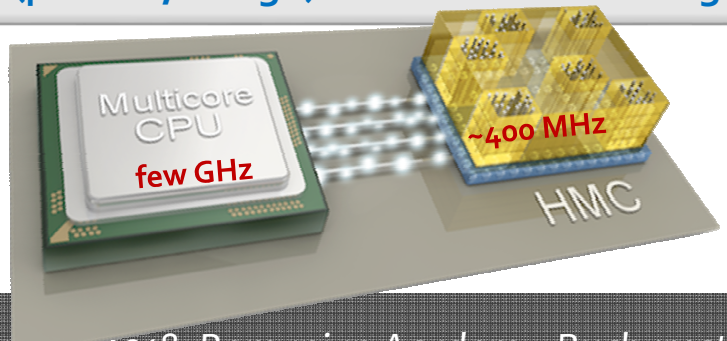
Bring non-volatility close to microprocessors

Need for ultrafast memories (sub-ns) directly integrated (process, design) at the heart of the logic

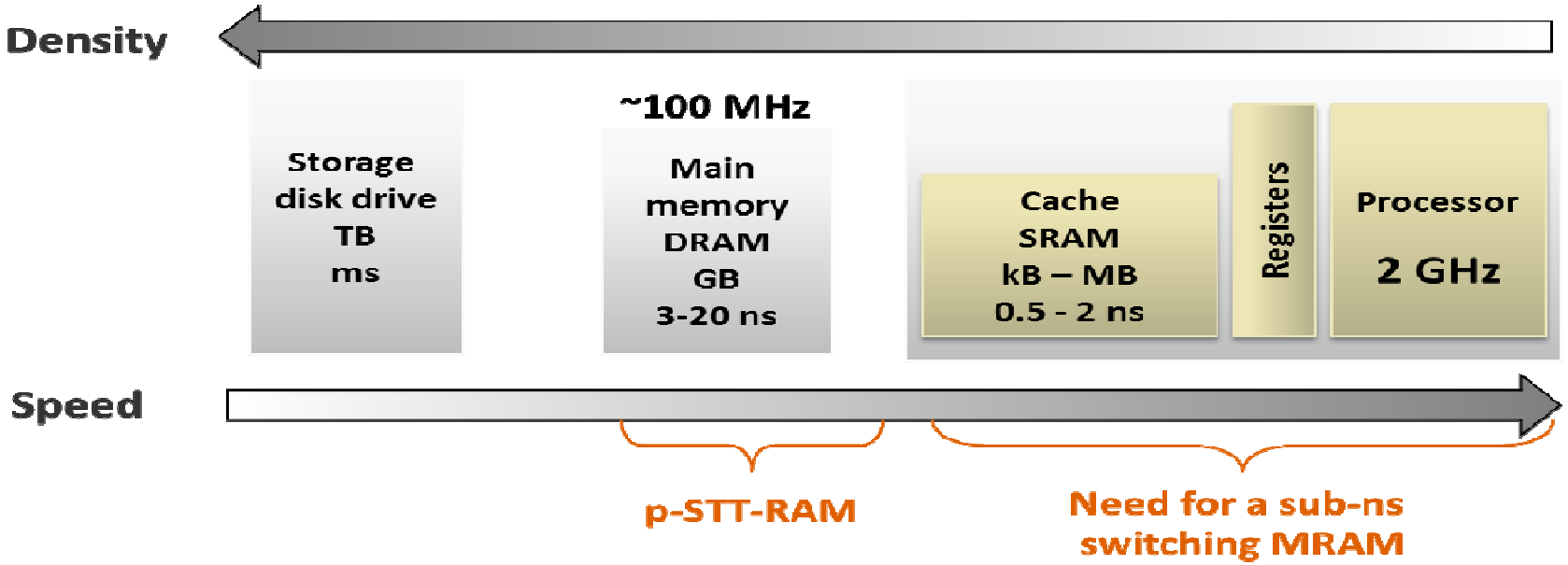
Memory vs. CPU speed mismatch

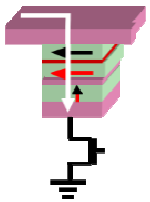
Logic keeps awaiting Data

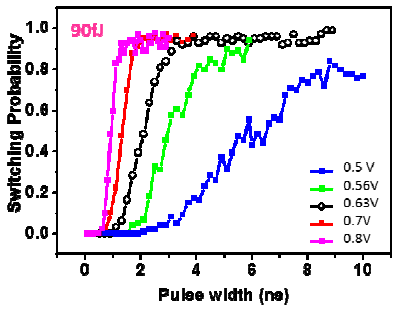
Logic issue is becoming a memory issue !



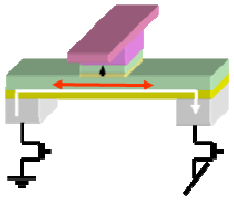
Need for a non-volatile memory (low power & ultrafast)

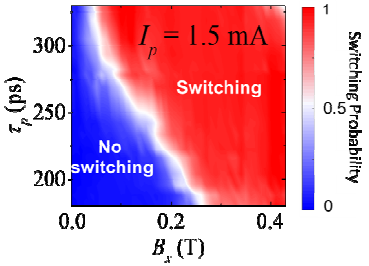




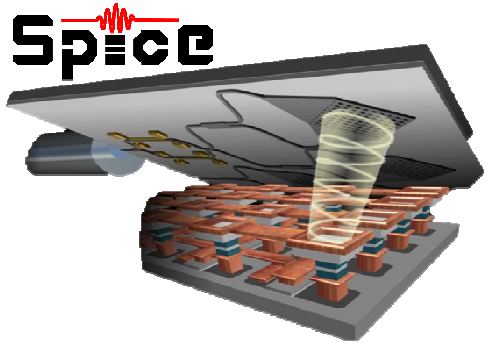


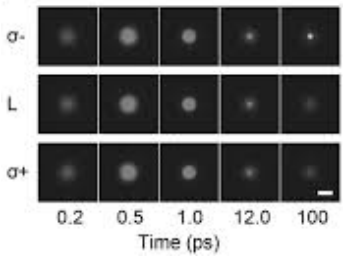
precesionnal





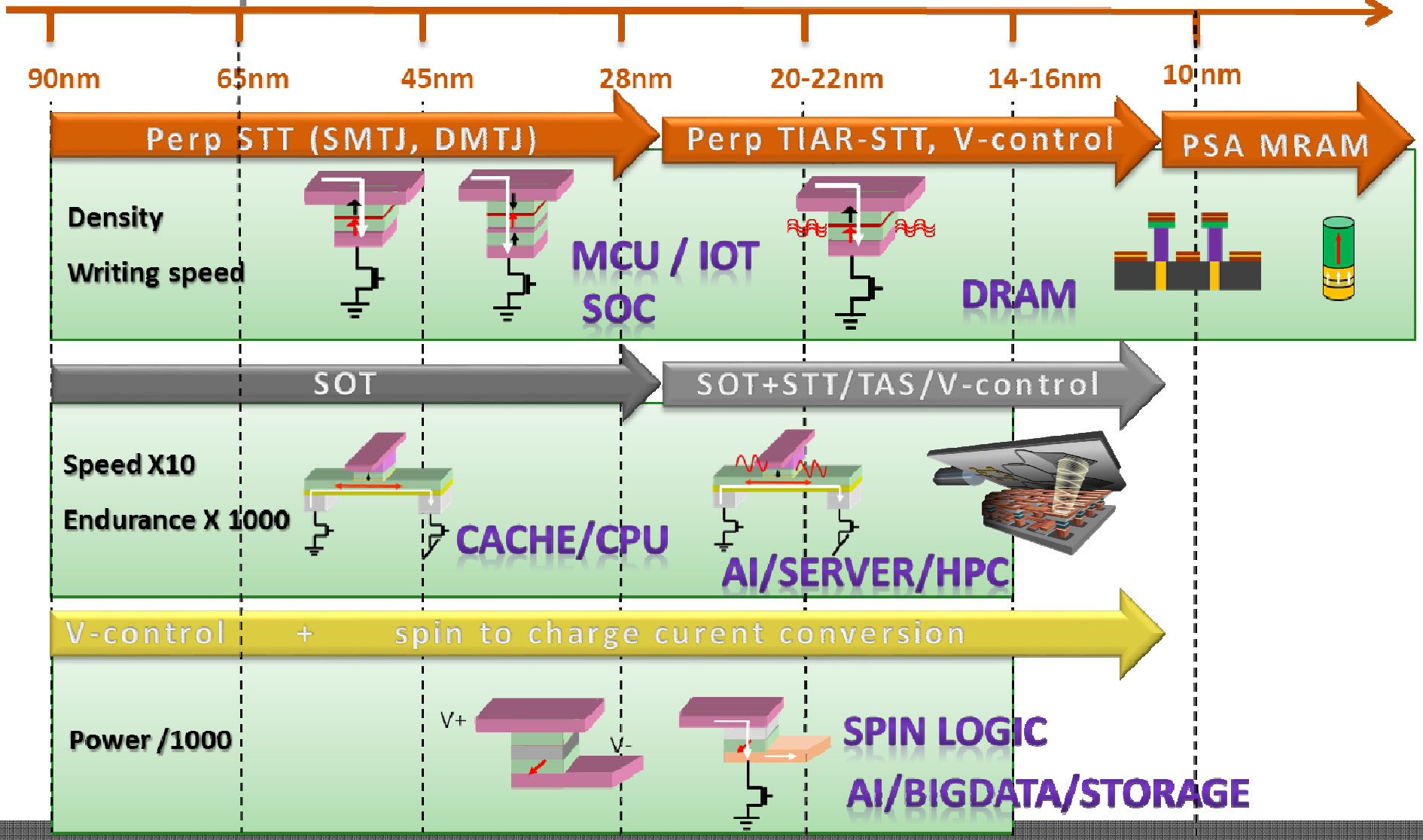
Spin Orbit Torque



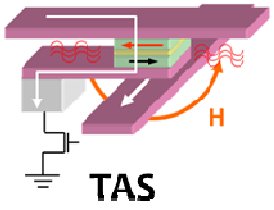


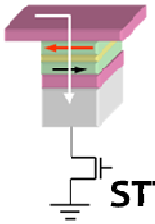
All optical switching

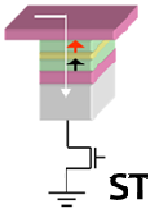
MRAM roadmap

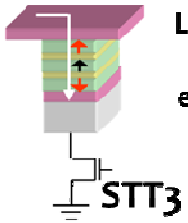


MRAM @ SPINTEC



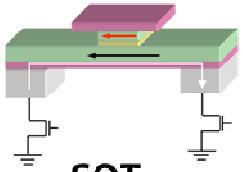


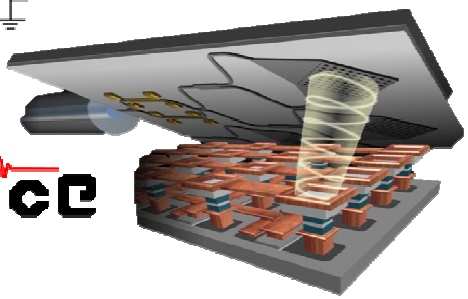




Low-power hybrid electronics

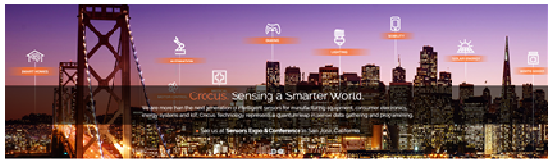
Multifunctional hybrid electronics

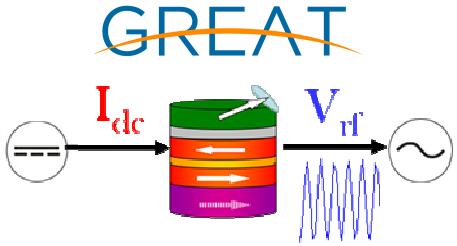


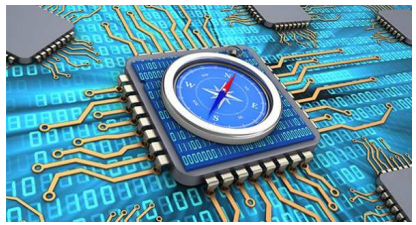


Smart design

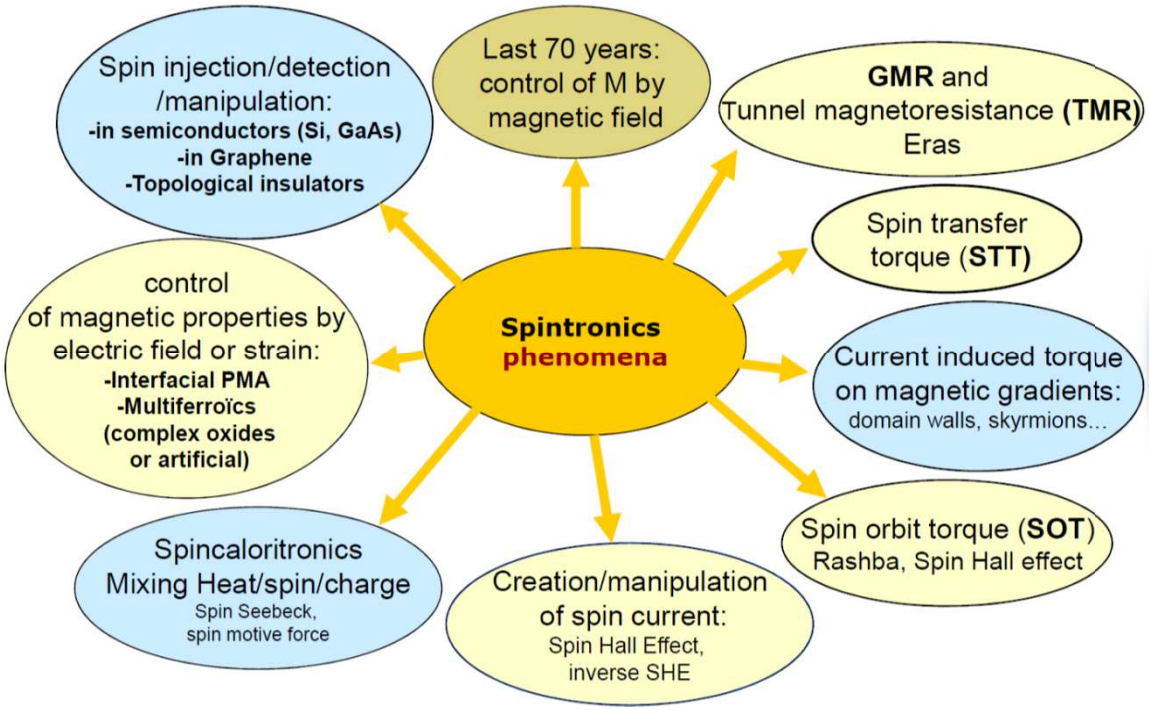
2002 2006 2010 2014 2015 2016 2017

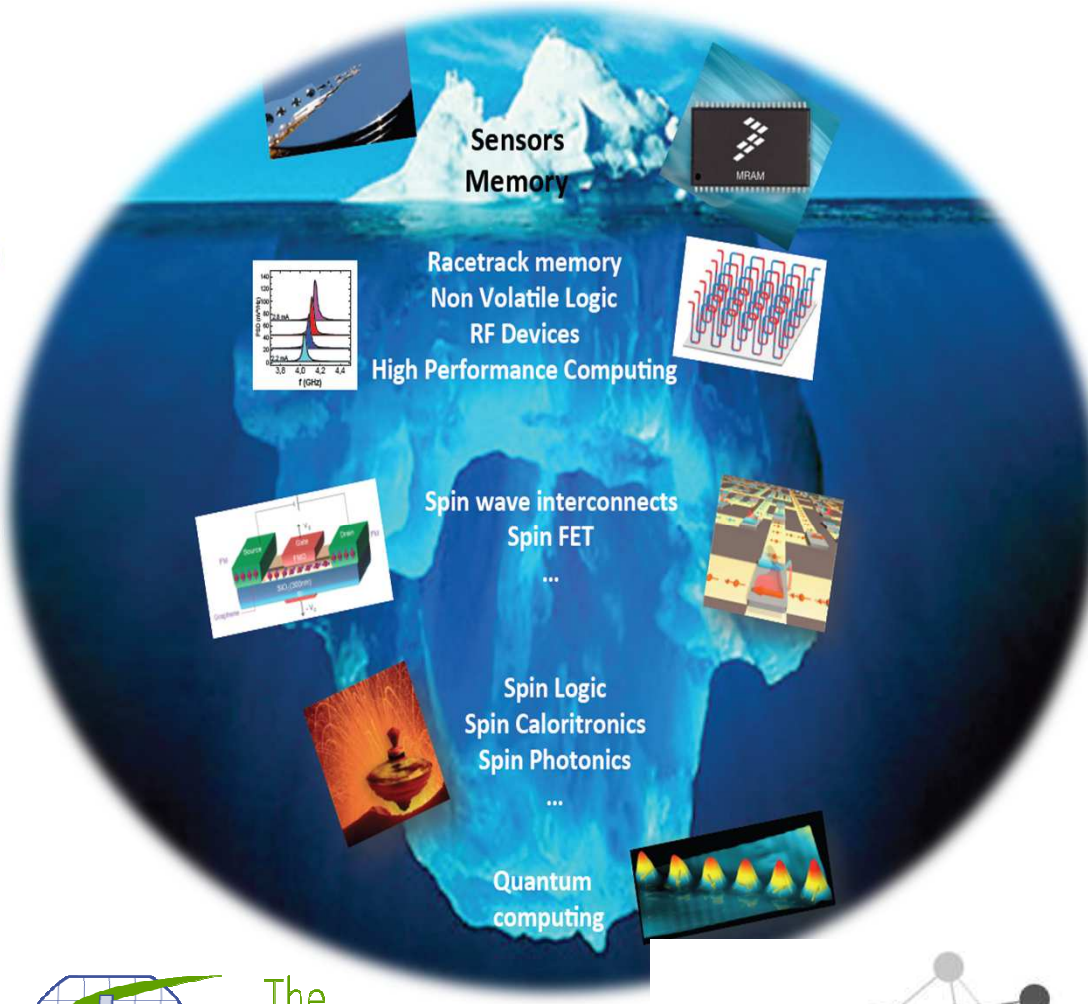






What's next?





FET Proactive TOCHA 2018-2023
Topological insulators

FET-OPEN NANOWAY 2019-2022
2D Materials

The SPINTRONIC FACTORY

NANOENGINEERING FLAGSHIP

Thank you!

Lucian PREJBEANU
lucian.prejbeanu@cea.fr
www.spintec.fr