



spin Orbit torque memory for cache & multicore processor applications

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D1.4 Final Activity Report (ICN)

Responsible ICN (P. Gambardella)

Dissemination Level Public (PU)

Date of preparation: October 7th, 2013

Particip.	Participant organization name	Short name	Country
1 RES 1	CNRS Spintec	CNRS	France
2 RES 2	Catalan Institute of Nanotechnology	ICN	Spain
3 RES 3	Karlsruher Institut für Technologie	KIT	Germany
4 RES 4	National Center for Scientific Research Demokritos	NCSR D	Greece
5 RES 5	CEA LETI	LETI	France
6 IND 1	In Silicio	INSIL	France
7 IND 2	Singulus	SING	Germany
8 OTHER 1	Toplink Innovation	TLI	France
9 RES 6	Eidgenössische Technische Hochschule Zürich	ETHZ	Switzerland
No.	Advisory Board member	Short name	Country
TAB 1	Micron Technology	MICRON	Italy
TAB 2	Tower Semiconductor	TOWER	Israel
TAB 3	European Nanoelectronics Infr. for Innovation	ENI2	Europe

Work programme topics addressed

Objective ICT-2011.3.1: Very advanced nanoelectronic components: design, engineering, technology and manufacturability

a) "Beyond CMOS technology"

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Abstract

In the frame of spOt 1st period (October 1st 2012 to September 30th 2013), ICN has warned the consortium about a future change in the partnership. Professor Pietro Gambardella, team leader of the group working in spOt and more particularly in WP2 (Single cell fabrication and physical properties), has received an offer as full professor at ETH in Zurich and has moved there with his group from July 1st 2013.

This move won't generate any consequence for spOt project as the added value is in the equipment and in the group members, nevertheless an amendment to spOt's Grant Agreement has been signed between CNRS and EC and Toplink Innovation has fully taken up this administrative phase.

The following pages are describing the expenses that have been declared by ICN during the 9 months period covering its participation to spOt.

Section 1: Costs and resources declaration

1.1 Person-Month Status Table

	WP1	WP2	WP3	WP4	WP5
Actual		14.25			
Planned		14.25			

*Total number of men months reported during the period and comparison to the planned activity
(Figures taken from Annex I -DOW- to the contract).*

1.2 Budget vs. Actual Costs

RTD		Actual Costs in Euros					
Type of Expenditure	Planned Budget	Year 1 (9 months)	Year 2	Year 3	Total	% Spent	Remaining Budget
Personnel costs	54 000,00	63 541,96	-	-	63 541,96	118%	-
Subcontracting	0,00	0,00	-	-	0,00	-	-
Travel / subsistence	2 000,00	6 660,00	-	-	6 660,00	333%	-
Investment	1 500,00	933,31	-	-	933,31	62%	-
Consumables	0,00	443,90	-	-	443,90	-	-
Other Direct Costs	0,00	1 380,78	-	-	1 380,78	-	-
Indirect Costs	34 500,00	43 776,01	-	-	43 776,01	127%	-
TOTAL	92 000,00	116 736,02	-	-	116 736,02	127%	-

Overview of ICN costs breakdown.

1.3 Work Achieved

Provide a brief description of the job achieved during this period for each work package: main realization, main results obtained. The aim is to provide a justification of the major costs incurred and resources deployed, linking them to implemented activities and explaining their necessity.

The work performed by ICN during the first nine months of the project concerned WP2 (RTD). It consisted of the following tasks:

Task 2.1: Material growth and characterization - ICN developed metrology tools to precisely quantify the Spin-Orbit torques (SOT) in anticipation of characterizing and optimizing future devices. These tools allow to measure the SOT direction and amplitude in arbitrary geometries as well as to define the switching time and critical switching current. They include dc and ac adiabatic harmonic Hall measurements, switching diagrams, ultrafast current pulses. The results of this work have been published in Nature Nanotechnology 8, 587-593 (2013), where detailed information can be found.

Task 2.2: Nanofabrication – ICN designed with Spintec the lithography mask for the fabrication of MTJ and test devices.

Task 2.3: Single cell characterization - ICN characterized the SOTs and switching behavior (SOT amplitudes, magnetization dependence, critical switching current versus pulse length and critical current vs external magnetic field) of AlOx/Co/Pt and MgO/CoFeB/Ta magnetic dots 100 to 1000 nm in size. ICN also measured several of the MTJ stacks fabricated by Singulus to find the best material combination and annealing parameters for perpendicularly magnetized memory cells.

Coordination of WP2: ICN coordinated the research efforts within WP2. The main issues here involved the definition of the stacks to be deposited by partners Singulus and NCSR, of nanofabrication and measurements with Spintec, as well as coordinating efforts to meet deadlines and assembling the project foreground for publications and reporting.

ICN postdocs Dr. Kevin Garello and Dr. Abhijit Ghosh, performed most of the research work within WP2, with help from PhD student Can Onur Avci and the team leader Pietro Gambardella. The financial resources allocated to this work concern the salary of the two postdocs as well as travel costs for collaborations and dissemination activities.

1.4 Explanatory note on major cost items and deviations

Personnel involved:

Financed by SPOT: Dr. Kevin Garello (9PM from 01/10/2012 to 30/06/2013), Dr. Abhijit Ghosh (5,3PM from 23/01/2013 to 30/06/2013), were working 100% of their time.

Financed by ICN: Mr. Can Onur Avci, Prof. Dr. Pietro Gambardella

Description of major travel and subsistence costs:

- ✓ Dr. Kevin Garello: Attendance to INTERMAG conference (January 2013, Chicago) as invited speaker, 1424,91 Euro

- ✓ Dr. Kevin Garelo: Attendance to the SPOT kick off meeting (October 2012, Ajaccio), 858,07 Euro.
- ✓ Dr. Kevin Garelo: Attendance to the SPOT progress meeting (April 2013, Baden), 372,93 Euro.
- ✓ Prof. Dr. Pietro Gambardella and Dr. Kevin Garelo: Attendance to the progress report meeting in Spintec (November 2012, Grenoble), 932,23 Euro.
- ✓ Dr. Kevin Garelo and Mr. Can Onur Avci: Attendance to the XVè Colloque Louis Néel (March 2013, Tours), 484,50 Euro.
- ✓ Mr. Can Onur Avci: Attendance to the ELSE UND HERAEUS SEMINAR BAD HONEFF (December 2012, Zurich), 363,66 Euro.
- ✓ Mr. Can Onur Avci: Attendance to the International Conference MAMA-Trend (May 2013, Sorrento), 571,12 Euro.
- ✓ Mr. Can Onur Avci: Laboratory visit for collaborations (November 2012, Lyon), 487,64 Euro.

Total travel costs: 6660,66 Euro.

Total Consumable: 443,90 Euro (laboratory material)

Total Other: 1380,78 Euro (conference registrations, poster prints)

Deviations from budget:

Over the 9 months, ICN has logged 14.25 PM in WP2. This was due to the transfer of the project on 01/07/2013 to the new partner ETH Zurich, where the remaining PM has been carried out. The **deviation** between the 54.000€ planned as a **personnel cost** until 30/06/2013 and the finally 63.541,96€ spent, is due to a mistake on the personnel costs calculation.

Deviations of costs **concerning travel and subsistence** from the planned 2000 Euros to 6660 Euros are due to the participation to international meetings to present results obtained in the early stage of the project, which were not foreseen initially. Additionally, we covered the cost of one week research stays of collaborators, to make samples for the project.

Due to the transfer of the project from ICN to ETHZ, it was agreed by the SPOT consortium that the tasks and person month effort provided by the new partner ETHZ would be the same as that planned for ICN starting from 01.07.2013. This implies no changes in the overall SPOT plan and distribution of resources. Since the costs of manpower are significantly higher in Switzerland compared to Spain, ETHZ will commit own personnel to the project whilst preserving the initial budget figures agreed for ICN.