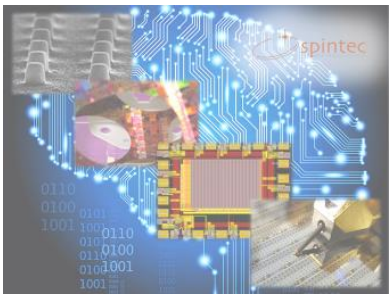
PhD grant: exploring new designs addressing fabrication and read/write bottlenecks of Perpendicular-Shape-Anisotropy MRAM



SPINTEC

Positioned at the crossroad of science and technology, SPINTEC (SPINtronique et TEchnologie des Composants, https://www.spintec.fr) is one of the leading spintronics research laboratories worldwide. SPINTEC was created in 2002 and rapidly expanded to currently exceed 100 persons, of which 48 permanent staff from CEA, CNRS and Grenoble-Alpes University. The lab aims at bridging the gap between fundamental research and applications in spin electronics. As such, the outcome of the laboratory is not only scientific publications and communications at international conferences, but also a consistent patent portfolio and implementation of relevant functional demonstrators and device nanofabrication. The lab has launched four start-up companies in the past 12 years, and another two are in the pipes. This synergy has placed SPINTEC at the forefront of spintronics research, having actively contributed to the emergence in industry of spintronic memories called MRAM, on which the laboratory holds key patents.

SPINTEC benefits from an idea local environment with a large spectrum of opportunities:

- SPINTEC belongs with the Interdisciplinary Research Institute of Grenoble (IRIG), gathering 10 laboratories with of total of 1000 researchers, technicians, doctoral and post-doctoral students. IRIG covers interdisciplinary skills (physics, chemistry, biology), and provides access to cutting-edge scientific and technological platforms such as PTA cleanroom, and nano-characterization PFNC.
- The Giant Campus Site (also called Scientific Presqu'Île) offers an exceptional scientific environment with partners such as CEA-LETI, Néel Institute and major European facilities (ESRF and ILL on the EPN Campus).
- The entire Campus of Grenoble Alpes University, whose excellence was recently recognized by the national IDEX award, bears a collective dynamics of research challenges in all fields of knowledge.

Grenoble is a cosmopolitan city at the heart of the French Alps. One out of five people living there works in the field of research, innovation or higher education. In addition, Grenoble offers various cultural and sportive opportunities all year round.

CONTEXT

Context. Magnetic Random Access Memories (MRAMs) are one of the flagship technological achievements that have been made possible by fundamental research and discoveries in spintronics. MRAMs have several strengths, including zero consumption in the idle state (as opposed to SRAM and DRAM), very high endurance (as opposed to flash), and near-nanosecond switching time. Most of the founders and semiconductor worldwide have included integrated MRAMs in their technological portfolio. The market for MRAM is growing significantly, but at present it remains positioned in a few niches: cache memory for data transfer for speed, or in FPGAs and IoT for low power consumption, for example. Addressing other large-scale markets (high-density DRAMs, or high-temperature constraints in robotics and the automotive industry) requires the development of new fundamental concepts to reinforce their thermal stability, particularly at the most aggressive technological nodes.

Context at SPINTEC. In 2018 two worldwide players in spintronics independently proposed and developed a new concept: the Tohoku Center in Japan, and SPINTEC in Europe. This is the 3D MRAM memory, also called Perpendicular-Shape Anisotropy MRAM (PSA-MRAM), whose thermal stability and

thus retention capacity are based on the magnetic shape anisotropy of a vertical nanopillar. It is intrinsically large thanks to the large volume involved, contrary to ultrathin stacks as used for standard MRAMs, which are prone to thermal fluctuations due to their low dimensionality. The work carried out has allowed us to demonstrate a fabrication routes for pillars down to sub-10 nm in diameter, and to show the ability to write/read cells by an electric current, and has resulted in a combination of patents and publications. Two main aspects have still to be validated for future technological implementation: the reduction of the critical current density needed for switching as well as innovative fabrication process capable to produce high-density and high yield integration.

POSITION

The objective of the PhD project is to explore disruptive fabrication routes, cell and material designs to lift the two bottlenecks, related to fabrication and efficiency of the write operation with a spin-polarized current. While the motivation and objective is to give a real application potential to the proof of concept achieved so far, the means to do so requires to address a number of issues pertaining to fundamental spintronics and materials science, and pushing further the knowledge of the micromagnetics and spintronics of extreme nanosized elements.

Practical work will consist in handling simulation micromagnetics to refine the design proposed for the memory cells, the experimental development of the steps required for their fabrication (thin film and patterning steps), the nanomagnetic and electric testing of individual nanomagnets and memory cells, up to read-write proof of concept. SPINTEC provides a readily available environment to conduct the work, ranging from micromagnetic codes and computing farms, state-of-the-art thin film and clean room facilities, and a series of advanced magnetic microscopy techniques and electric testing tools. The work will also benefit from the collaboration with other laboratories for specific steps: Institut Néel and CEA-LETI in Grenoble, and Institut Jean Lamour in Nancy (France).

The expected profile for the applicants is a Master-2 degree in a field related to condensed-matter physics, nanophysics or engineering, a clear taste for experiments and teamwork.

How to apply:

- Contacts: Olivier Fruchart (olivier.fruchart@cea.fr) and Lucian Prejbeanu (lucian.prejbeanu@cea.fr)
- Deadline: 1st June 2023. The position can be closed before this date if a suitable candidate is identified
- Starting date: 1st October 2023
- Gross monthly salary 2300€, to which extra bonus and various social benefits apply (e.g. contribution to publication transportation etc).