SISPIN

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Coordinator: Jérôme PLANÈS (administrative contact)

Location

CEA Grenogle France
45° 11' 20.8428" N, 5° 43' 58.44" E
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It is widely believed that next-generation electronic devices will exploit the quantum mechanical nature of electrons, as opposed to the classical operating principles of current electronics. This is one of the leading paradigms at the origin of quantum spintronics, a developing field whose goal is to create useful device functionalities out of the spin degree of freedom of electrons. So far, quantum spintronics has remained a matter of basic research. In spite of some remarkable progress, a number of hurdles remain to be overcome so that disruptive solutions and radically new approaches are needed.

The “Silicon platform for Quantum Spintronics” (SiSPIN) project brings together a multidisciplinary team of recognised European experts with a strong track record of cooperative work in the field of ultra-sensitive measurements of nanostructures at low temperature and in extreme conditions. SiSPIN Technological implications range from improving the switching performance of classical logic gates (e.g. towards lower energy consumption) up to the implementation of quantum computing devices based on spin qubits.

Objectives

Quantum spintronics aims at utilizing the quantum nature of individual spins to bring new functionalities into logic circuits, either to make classical information processing more efficient or to implement spin-based quantum algorithms. Two critical aspects for quantum spintronics are a long spin coherence time and a strong, tunable spin-orbit interaction for fast electrical manipulation of spins. Up to now, experiments have mainly focused on III-V semiconductor nanostructures, where hyperfine coupling with nuclear spins limits electron-spin coherence. Low nuclear spin materials, and in particular group-IV semiconductors, were found to be a natural alternative. However, in most of the currently studied group-IV based systems, spin-orbit coupling is very weak, preventing fast electrical manipulation of spins.

We propose to investigate a new direction based on p-type SiGe nanostructures. This system has the unique combination of low hyperfine and strong spin-orbit couplings. Aside from developing demonstrator devices such as spin-filters or single spin qubits, we aim at exploring recently proposed schemes for long range spin-spin coupling, an essential requirement for scalable qubit circuits. To investigate hole-spin dynamics and achieve quantum spintronic functionalities, novel types of concepts will be experimentally investigated (spin-polarized helical states, spin-orbit mechanisms for spin-selective tunnelling and long-range spin-spin coupling, etc.). Because of the higher complexity of hole-type systems, a dedicated theoretical framework will be developed in support to experiments. In addition to a bottom-up approach which has been successful in providing nanowire and quantum-dot heterostructures, we shall realize SiGe quantum devices by means of state-of-the-art CMOS technology. This will allow us to know how spin-based functionalities demonstrated in bottom-up nanostructures can be implemented into a truly scalable silicon platform.

- EC - FP7
- Quantum Metrology, Sensing and Imaging
- Other