From ab-initio calculations to nanoelectronics: path and challenges for ferroelectric Rashba semiconductors

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Information and communication technology is going to use 20% of the global electricity production by 2030. Architectures far beyond the well-established CMOS platform are required for electronics to switch greener. A remarkable pathway was indicated by Intel in the work titled "Beyond CMOS computing with spin and polarization" [1], where the combination of ferroic order and spin currents is selected as a master choice for attojoule-class logic devices well-beyond CMOS.

Back in 2013, the group of S. Picozzi at CNR-SPIN marked the raising of a new class of materials with huge potential in this sense. Ferroelectric Rashba semiconductors (FERSCs) [2] were predicted by ab-initio calculations to show an intimate connection between ferroelectricity and Rashba-type spin-orbit coupling, which provides the unprecedent capability to control spin currents by non- volatile ferroelectric switching. FERSCs represent a successful case study of the so-called "Theory Guiding Experiments" paradigm.

Most of the experimental work focused on germanium telluride (GeTe) [3], which has robust ferroelectricity far above room temperature. After some time required to establish an exquisite epitaxial growth of GeTe(111) thin films on silicon [4], the interplay between ferroelectric polarization and Rashba effect was demonstrated by spin and angular resolved photoemission measurements on films with opposite ferroelectric polarization [5].

In this talk, I will review the main findings about ferroelectric Rashba semiconductors, with particular emphasis on recent achievements. I will demonstrate that the ferroelectric polarization of epitaxial thin films of GeTe can be reliably switched back and forth by electrical gating and used to effectively reverse a sizeable spin-to-charge conversion by spin Hall effect [6]. Based on these results, I will show the possibility to develop scalable and energy-efficient non-volatile ferroelectric spin-orbit logic devices, in which information is conveniently stored in the ferroelectric state, while processing and read-out are enabled by polarization-dependent spin-to-charge conversion. Doping and alloying with indium and tin will be shown as perspective to achieve control over conductivity and spin-to-charge conversion.

Endowed of monolithic integrability with silicon, GeTe and other FERSCs may represent a viable path towards ultrafast spintronic-based transistors with ultralow power consumption.

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