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Electrical creation of spin polarization in silicon at room temperature

RON JANSEN, University of Twente, The Netherlands

The integration of magnetism and mainstream semiconductor electronics could impact information technology in ways beyond imagination. A pivotal step is the implementation of spin-based electronic functionality in silicon devices. Much of the interest in silicon derives from its prevalence in semiconductor technology and from the robustness and longevity of spin as it is only weakly coupled to other degrees of freedom in the material. Recently it has become possible to induce and detect spin polarization in otherwise non-magnetic semiconductors (GaAs and Si) using all-electrical structures, but so far at temperatures below 150 K and only in n-type material. The main challenges are: (i) to design fully electrical silicon-based spintronic devices with large spin signals, (ii) to demonstrate device operation at room temperature, (iii) to do so for n-type and p-type material, and (iv) to find ways to manipulate spins and spin flow with a gate electric field. After a brief overview of the state of affairs, our recent advances in these areas are described. In particular, we demonstrate room-temperature electrical injection of spin polarization into n-type and p-type silicon from a ferromagnetic tunnel contact, spin manipulation using the Hanle effect, and the electrical detection of the induced spin accumulation. It is shown that a spin splitting as large as 2.9 meV can be created in Si at room temperature, corresponding to an electron spin polarization of 4.6%. The results open the way to the implementation of spin functionality in complementary silicon devices and electronic circuits operating at ambient temperature, and to the exploration of their prospects as well as the fundamental rules that govern their behavior.

[1] S.P. Dash, S. Sharma, R.S. Patel, M.P. de Jong and R. Jansen, Nature **462**, 491 (2009).