

## **Semiconductor spintronics: From spin injection to spin-controlled logic**

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Conventional spintronic devices are based on metallic magnetic multilayers which utilize the magnetic moment associated with the spin to read magnetically stored information, leading to a nonvolatility and an impressive improvement in the performance of computer hard drives and magnetic random access memories. However, these applications employ two-terminal spin valves which are of limited use for advanced functionalities appropriate for signal processing and digital logic. While semiconductor-based three-terminal devices are natural candidates for spin logic, they remain inadequately investigated and even a simple understanding of their integration with CMOS is still missing.<sup>1</sup>

In this talk we address several basic elements and current challenges relevant for schemes in semiconductor spintronics. We focus on the process of spin injection and contrast conventional methods for optical detection of spin in semiconductors with those which could also be applied to indirect band-gap semiconductors such as silicon. In particular, we consider an interplay of nonequilibrium spin and equilibrium magnetization leading to the spin-voltaic effect, a spin-analog of the photo-voltaic effect. The direction of the charge current, which can even flow at no applied bias, can be switched by reversal of the equilibrium magnetization or by reversal of the polarization of the injected spin. We discuss some implications of the spin-voltaic effect in magnetic bipolar transistors, active spintronic devices, which could provide spin-switching and spin-controlled gain.

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1. I. Zutic, J. Fabian, S. Das Sarma, *Rev. Mod. Phys.* **76**, 323 (2004).