SPINTRONICS

manjeet chavhan[@??]

[@]manjeetschavhan@gmail.com

Introduction

Spintronics (a portmanteau meaning spin transport electronics[1][2][3]), also known as spin electronics, is the study of the intrinsic spin of the electron and its associated magnetic moment, in addition to its fundamental electronic charge, in solid-state devices.[4] The field of spintronics concerns spin-charge coupling in metallic systems; the analogous effects in insulators fall into the field of multiferroics.

Spintronics fundamentally differs from traditional electronics in that, in addition to charge state, electron spins are exploited as a further degree of freedom, with implications in the efficiency of data storage and transfer. Spintronic systems are most often realised in dilute magnetic semiconductors (DMS) and Heusler alloys and are of particular interest in the field of quantum computing and neuromorphic computing.. This is as shown in (Fig 1) **??**.

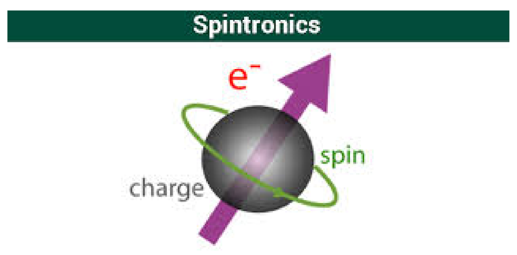

Figure 1: pintronics

The simplest method of generating a spin-polarised current in a metal is to pass the current through a ferromagnetic material. The most common applications of this effect involve giant magnetoresistance (GMR) devices. A typical GMR device consists of at least two layers of ferromagnetic materials separated by a spacer layer. When the two magnetization vectors of the ferromagnetic layers are aligned, the electrical resistance will be lower (so a higher current flows at constant voltage) than if the ferromagnetic layers are anti-aligned. This constitutes a magnetic field sensor.

Theory

The mechanisms of decay for a spin polarized population can be broadly classified as spin-flip scattering and spin dephasing. Spin-flip scattering is a process inside a solid that does not conserve spin, and can therefore switch an incoming spin up state into an outgoing spin down state. Spin dephasing is the process wherein a population of electrons with a common spin state becomes less polarized over time due to different rates of electron spin precession. In confined structures, spin dephasing can be suppressed, leading to spin lifetimes of milliseconds in semiconductor quantum dots at low temperatures.

Doped semiconductor materials display dilute ferromagnetism. In recent years, dilute magnetic oxides (DMOs) including ZnO based DMOs and TiO2-based DMOs have been the subject of numerous experimental and computational investigations.[24][25] Non-oxide ferromagnetic semiconductor sources (like manganese-doped gallium arsenide GaMnAs),[26] increase the interface resistance with a tunnel barrier,[27] or using hot-electron injection.[28]

History

Spintronics emerged from discoveries in the 1980s concerning spin-dependent electron transport phenomena in solid-state devices. This includes the observation of spin-polarized electron injection from a ferromagnetic metal to a normal metal by Johnson and Silsbee (1985)[6] and the discovery of giant magnetoresistance independently by Albert Fert et al.[7] and Peter GrÃijnberg et al. (1988).[8] The origin of spintronics can be traced to the ferromagnet/superconductor tunneling experiments pioneered by Meservey and Tedrow and initial experiments on magnetic tunnel junctions by Julliere in the 1970s.[9] The use of semiconductors for spintronics began with the theoretical proposal of a spin field-effect-transistor by Datta and Das in 1990[10] and of the electric dipole spin resonance by Rashba in 1960.[11]

Application

Motorola developed a first-generation 256 kb magnetoresistive random-access memory (MRAM) based on a single magnetic tunnel junction and a single transistor that has a read/write cycle of under 50 nanoseconds.[19] Everspin has since developed a 4 Mb version.[20] Two second-generation MRAM techniques are in development: thermal-assisted switching (TAS)[21] and spin-transfer torque (STT).[22]

Another design, racetrack memory, encodes information in the direction of magnetization between domain walls of a ferromagnetic wire.

Magnetic sensors can use the GMR effect.[citation needed]

In 2012, persistent spin helices of synchronized electrons were made to persist for more than a nanosecond, a 30-fold increase over earlier efforts, and longer than the duration of a modern processor clock cycle.[23]