Spintronics and Spin–Torque, an Overview and Some Results.

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In addition to its charge, an electron has spin = ½, and thus a magnetic moment that can orient 'up' or 'down' relative to a chosen axis. An electron with moment along that of a ferromagnetic (F) metal through which it passes, is scattered differently (usually more weakly) than one with moment opposite to that of the F–metal. Thus, an unpolarized electriccurrent sent through an F–metal emerges at least partly spin–polarized. If this spin–polarized current impinges on a second, similar F–metal, whose moment is parallel (P) to that of the first one, it passes much more easily than if the second F–metal' s moment is anti–parallel (AP) to that of the first. The resistance in the P state is thus less (sometimes much less) than that in the AP state. This phenomenon is called Giant Magnetoresistance (GMR), since the relative orientation of the two F–moments can be controlled by applying a magnetic field. The discovery of GMR has generated several devices, and hoped–for new devices, in the process spawning a new subfield of magnetism, 'spintronics' , the study of magnetic systems where electron spin is important in transport, giving potential for new electronic devices. In 1996, Slonczewski and Berger independently predicted a new phenomenon involving electron–spin, 'spin–torque' , whereby a spin–polarized current exerts a torque on an F–metal when the directions of spin–polarization and magnetization are not collinear. In such a case, a large enough dc spin–polarized current density can generate excitations involving precession of the magnetization at GHz frequencies, and in some circumstances can flip (reverse) the direction of magnetization. Spin–torque thus has promise both as a generator of high frequency radiation and for writing magnetic random access memory (MRAM). In 1998, Tsoi et al., using a point contact to an F/N multilayer to generate a large enoughlocal current density, showed the first evidence for GHz excitations. Subsequent studies, with both point contacts and magnetic nanopillars, have shown both switching and generation of GHz radiation in F/N/F metallic samples, F/I/F (I = insulator) tunneling samples, and even in single F–layers contacted by an N point contact. Current–induced switching is now being used in prototype MRAM, and work is progressing on developing GHz radiation devices. After a brief review of the underlying physics and experimental issues, I will highlight some important experimental discoveries and briefly indicate progress on devices.