SPINTRONIC DEVICES FOR MEMORY AND LOGIC APPLICATIONS.

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Giant magnetoresistance[1] found its first application in magnetoresistive spin-valve heads for hard-disk drives[2]. Low field magnetic sensors for position encoders were also developed based on this technology[3] as well as MRAM using pseudo spin-valves[4].

Later on, the observation of large magnetoresistance at room temperature in magnetic tunnel junctions (MTJ)[5,6] opened new prospects of applications. Thanks to the current-perpendicular-to-plane geometry, new MRAM architecture could be conceived allowing to reach much higher density than in earlier spin-valve MRAM design[7]. The first generations of MRAM were based on field induced switching with its improved version named "toggle switching"[8]. Freescale launched a first 4Mbit toggle MRAM product in 2006.

The discovery of the possibility to manipulate the magnetization of magnetic nanostructure by a spin-polarized current constituted another major breakthrough in the development of spinelectronics. Berger already observed in 1982 that electrical currents could have a direct influence on the propagation of domain walls[9]. However, it is the prediction[10,11] and observation[12] of the possibility to switch the magnetic configuration of spin-valves or MTJ which triggered a considerable interest of the scientific community for these so-called spin-transfer effects. This effect provides a new way to write information in magnetic nanostructures and especially MRAM. The advantages of using spin-transfer writing in MRAM are a better scalability of MRAM design, lower power consumption and better write selectivity[13,14]. In addition, thermal assisted write scheme combined with either field or spin-transfer writing were proposed, offering the ultimate scalability in MRAM design[15]. Intense R&D efforts are in progress in large companies as well as start-ups to bring these advanced MRAM designs to production. Besides standalone MRAM applications, the combination of CMOS components with embedded MTJ in above-IC technology allows conceiving all sorts of innovative hybrid logic components such as reprogrammable logic gates in which MTJs are used as variable resistance influencing the switching threshold of the CMOS circuits. Innovative architecture of complex electronic devices can also be conceived in which logic and memory are much more intimately intertwined than with CMOS only components. Significant power consumption saving (>70%) can be expected in these devices.

In an historical perspective, the talk will review these present and future developments.

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