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APPLICATIONS OF SPINTRONICS – MAGNETIC TUNNEL HEAD AND MRAM

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After discovery of high tunnel magnetoresistance at room temperatures in 1995 computer industry began to invest in R&D of Magnetic Tunnel Junctions. A great progress in manufacturing of MTJ was achieved and recently two new spintronics products emerged - hard drive Tunnel Magnetoresistive Reader and Magnetic Random Access Memory. Both products are based on the same physical phenomena – elastic spin polarized tunneling of electrons between two thin ferromagnetic layers.

Tunnel magnetoresistive reader of a modern hard drive has perpendicular to device plane current flow – very different in comparison to older GMR type reader. This transition in device geometry raised a series of manufacturing problems which will be discussed. Tunnel reader has higher sensitivity and can read much narrower tracks. Shield to shield distance can be greatly reduced in comparison to GMR reader. As a result, modern tunnel reader can read much smaller bits. In 2006 Seagate demonstrated unreal density above 400 Gb/in^2 by using novel perpendicular disc media and tunnel reader. The largest material challenge in the process of developing tunnel readers was lowering resistance time area product to meet typical channel requirements of the existing GMR readers. During the last 10 years RA product was reduced about 6 orders of magnitude and MR signal increased about 10 times. This progress was achieved by using novel deposition tools and by developing new barrier materials.

In the second part I will describe toggle magnetic random access memory, which from the manufacturing point of view currently looks the most promising. Free layer in toggle MRAM is made of two well balanced thin ferromagnetic layers, which are anti-ferromagnetically coupled through a thin metallic spacer. Magnetic flux is closed inside an individual memory cell what ensures low level of magnetic interactions between neighbors cells and opens a way to scale the design to high densities. The largest challenge in developing MRAM is integration of CMOS processes with the specific processes needed for MTJ. Only recently, special tools and processes were developed and a great progress in manufacturing MRAM was possible. The 16 Mbit toggle MRAM chip developed by IBM will be described. Details of chip design and selected process steps related with magnetic layers will be described. Finally, scaling of MRAM to high densities and spin momentum transfer MRAM will be briefly discussed.