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Abstract of Presentation

Presentation Title:

Tunnel Magnetoresistance Effect and Its Applications

Abstract :

A magnetic tunnel junctions (MTJ), which consists of an ultra-thin insulator (a tunnel barrier) sandwiched by two ferromagnetic electrode layers, exhibits tunnel magnetoresistance (TMR) effect due to spin-dependent electron tunneling. The TMR effect in MTJs is the most important technology in the field of spintronics. Since the discovery of room-temperature TMR effect in 1995, MTJs with an amorphous Al-O tunnel barrier have been extensively studied and already used in read head of hard disk drive (HDD) and magnetoresistive random-access-memory (MRAM). These conventional MTJs show a magnetoresistance (MR) ratio (a performance index in applications) of up to about 70% at room temperature. However, MTJs with much higher magnetoresistance have been desired for next-generation MRAM and HDD. In 2001, first-principle theories predicted the MR ratios above 1,000% in epitaxial Fe(001)/MgO(001)/Fe(001) MTJs with a crystalline MgO(001) tunnel barrier as a result of coherent spin-dependent tunneling [1]. In 2004, giant MR ratios of about 200% at room temperature (RT) were experimentally achieved in textured and fully epitaxial MgO-based MTJs [2,3]. We also developed novel CoFeB/MgO(001)/CoFeB - MTJ structure, which is highly compatible with mass-manufacturing processes of MRAM and HDD read head, and achieved giant MR ratios above 200% at RT [4] Up to now, even higher MR ratios of up to 500% at RT have been obtained in MgO-based MTJs [5]. This large TMR effect in MgO-based MTJs is now called ‘giant TMR effect’. We also developed ultra-low-resistance MTJ technology for HDD read head application [6], which has already been commercialized in ultrahigh-density HDD [7]. The giant TMR effect and spin-transfer torque in MgO-based MTJs also make it possible to develop high-density spin-torque MRAM (so-called STT-MRAM or SpinRAM) [8] and novel microwave oscillator and detector [9,10]. MgO-based MTJs are the key for next-generation spintronic device applications.

References

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