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Giant tunneling magnetoresistance and tunneling spin polarization in magnetic tunnel junctions with MgO (100) tunnel barriers

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Recent advances in generating, manipulating and detecting spin-polarized electrons and electrical current make possible new classes of spin based sensor, memory and logic devices [1]. One key component of many such devices is the magnetic tunneling junction (MTJ) - a sandwich of thin layers of metallic ferromagnetic electrodes separated by a tunneling barrier, typically an oxide material only a few atoms thick. The magnitude of the tunneling current passing through the barrier can be adjusted by varying the relative magnetic orientation of the adjacent ferromagnetic layers. As a result, MTJs can be used to sense the magnitude of magnetic fields or to store information. The electronic structure of the ferromagnet together with that of the insulator determines the spin polarization of the current through an MTJ – the ratio of 'up' to 'down' spin electrons. Using conventional amorphous alumina tunnel barriers tunneling spin polarization (TSP) values of up to ∼55% are found for conventional 3d ferromagnets, such as CoFe, but using highly textured crystalline MgO tunnel barriers TSP values of more than 90% can be achieved for otherwise the same ferromagnet [2]. Such TSP values rival those previously observed only with half-metallic ferromagnets. Corresponding giant values of tunneling magnetoresistance (TMR) are found, exceeding 350% at room temperature and nearly 600% at 3K. Perhaps surprisingly the MgO tunnel barrier can be quite rough: its thickness depends on the local crystalline texture of the barrier, which itself is influenced by structural defects in the underlayer. We show that the magnitude and the sign of the TMR is strongly influenced by defects in the tunnel barrier and by the detailed structure of the barrier/ferromagnet interfaces. The observation of Kondo-assisted tunneling phenomena will be discussed as well as the detailed dependence of TMR on chemical bonding at the interfaces [3]. [1] .S.S.P. Parkin, X. Jiang, C. Kaiser, et al., Proc. IEEE 91, 661 (2003). [2] S. S. P. Parkin, C. Kaiser, A. Panchula, et al., Nature Mater. 3, 862 (2004). [3] C. Kaiser, S. van Dijken, S.-H. Yang, H. Yang and S.S.P. Parkin, Phys. Rev. Lett. 94, 247203 (2005).