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Predicition and Discovery of High Tunneling Magnetoresistance in Magnetic Tunnel Junctions with Crystalline Barriers[1]

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Tunneling magnetoresistance in excess of 200% has recently been observed in magnetic tunnel junctions using bcc Fe or bcc CoFe electrodes with crystalline MgO tunnel barriers[1,2]. These results demonstrate that tunneling magnetoresistance depends on more than the "electrode polarization". This talk will describe the calculations that predicted high TMR in these and other systems[3,4,5]. These calculations helped us to understand certain principles that may lead to high TMR through coherent electron tunneling. They can be briefly summarized as follows: (1) If the symmetry of a Bloch state can be preserved as electrons cross the interfaces between the electrode and the tunnel barrier, this be used to advantage for spin filtering. (2) Evanescent states of different symmetries decay at different rates in the barrier. (3) Interfacial bonding can be very important in determining the probability that an electron can traverse the interface. (4) Electrons of disallowed symmetry cannot propagate in an electrode. Once these simple principles are understood, simple band codes can be used to screen and to develop heterostructures with the proper symmetries to obtain high TMR. [1] S. S. P. Parkin, C. Kaiser, A. Panchula, P. M. Rice, B. Hughes, M. Samant AND S.-H. Yang, "Giant tunnelling magnetoresistance at room temperature with MgO (100) tunnel barriers," Nature Materials, Advance Online Publication [2] S. Yuasa, T. Nagahama, A. Fukushima, Y. Suzuki, K. Ando, "Giant room-temperature magnetoresistance in single-crystal Fe/MgO/Fe magnetic tunnel junctions," Nature Materials, Advance Online Publication [3] W. H. Butler, X.-G. Zhang, T. C. Schulthess, and J. M. MacLaren, "Spin-dependent tunneling conductance of Fe | MgO | Fe sandwiches" Phys. Rev. B **63**, 054416 (2001) [4] J. Mathon, A. Umerski, "Theory of tunneling magnetoresistance of an epitaxial Fe/MgO/Fe(001) junction," Phys. Rev. B **63**, 220403(R) (2001). [5] X.-G. Zhang, and W. H. Butler, "Large magnetoresistance in bcc Co/MgO/Co and FeCo/MgO/FeCo tunnel junctions," Phys. Rev. B **70**, 172407 (2004)

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