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TMR-related effects in structures involving semiconductors

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The growth of semiconductor heterostructures incorporating ferromagnetic material is a challenge for today's spintronic. We will report on GaMnAs/III-V and MnAs/III-V tunnel junctions that fulfill this condition. In the case of GaMnAs related junctions, the complexity of the transport mechanisms associated with spin-orbit coupled states make this material a powerful means for finding novel effects and provides new challenges for theoretical understandings. This includes tunnel magnetoresistance (TMR) across single and double barriers [1] and tunnel anisotropic magnetoresistance (TAMR). As an illustration, the resonant TAMR on a GaAs quantum well can be used as a probe of the GAMnAs valence band anisotropy [2]. In the case of MnAs, the necessary low temperature growth mode to avoid intermixing at the interfaces favors the insertion of As anti-site in the III-V spacer layer. We will show how the tunneling magnetoresistance is then modified and how the major role of the defects in the conduction can be taken into account. For this we have proposed an analytical model of spin-dependent resonant tunneling through a 3D assembly of localized states (spread out in energy and in space) in a barrier [3]. An inhomogeneous distribution of localized states leads to resonant tunneling magnetoresistance inversion and asymmetric bias dependence as evidenced with a set of experiments with MnAs/GaAs(7–10 nm)/MnAs tunnel junctions. By extension, we show the possibility of using such spectroscopic measurements to probe the spin asymmetry of ferromagnetic electrodes sandwiching an inhomogeneous tunnel barrier.

[1] R. Mattana et al. Phys. Rev. Lett. 90, 166601 (2003)
[2] M. Elsen et al. Phys. Rev. Lett. 99, 127203 (2007)
[3] V. Garcia et al. Phys. Rev. Lett. 97, 246802 (2006)