

Spin-dependent tunneling conductance of Fe|MgO|Fe sandwiches

WH Butler, XG Zhang, TC Schulthess, JM MacLaren

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Abstract

We present first-principles based calculations of the tunneling conductance and magnetoconductance of epitaxial Fe (100)| MgO (100)| Fe (100) sandwiches. Our results indicate that tunneling is much more interesting and complicated than the simple barrier model used previously. We obtain the following general results:(1) Tunneling conductance depends strongly on the symmetry of the Bloch states in the electrodes and of the evanescent states in the barrier layer.(2) Bloch states of different symmetry decay at different rates within the barrier. The decay rate is determined by the complex energy bands of the same symmetry in the barrier.(3) There may be quantum interference between the decaying states in the barrier. This leads to an oscillatory dependence of the tunneling current on $k_{\parallel}$ and a damped oscillatory dependence on barrier thickness.(4) Interfacial resonance states can allow particular Bloch states to tunnel efficiently through the barrier. For Fe (100)| MgO (100)| Fe (100) our calculations indicate that quite different tunneling mechanisms dominate the conductance in the two spin channels. In the majority channel the conductance is primarily via Bloch electrons with small transverse momentum. One particular state with $\Delta 1$ symmetry is able to effectively couple from the Fe into the MgO. In the minority channel the conductance is primarily through interface resonance states especially for thinner layers. We predict a large magnetoresistance that increases with barrier thickness.



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