Multiple scattering approach to electron reflection from and transmission through disordered interfaces

Victor Los

Institute of Magnetism, 36b Vernadsky Blvd., 03142 Kiev, Ukraine

e-mail: V.Los@ulrmc.org.ua, Phone: +38 044 230 2266, Fax: +38 044 230 2267

Electron transport in magnetic multilayers is considered, particularly, how it is affected by disorder at the interfaces between layers. A better understanding of the relationship between interfacial structure and spin-dependent scattering at the interfaces, which is believed to be of crucial importance for the giant and tunneling magnetoresistance effects (GMR and TMR), is badly needed. An approach based on the multiple-scattering theory has been developed allowing for analytical and numerical study of the electron transport through disordered interfaces. The interfacial disorder has been modelled by the point-like scatterers (impurities) located at the interface, while the electronic spectrum has been considered in the effective-mass approximation with different (in general) masses in different layers. It has been shown that the electron specular reflection of and transmission through a single disordered interface are defined by the average one-particle Green's function (average T-scattering matrix), and the vertex function in the expression for average two-particle Green's function describes the electron diffuse scattering at the interface (the vertex function is defined by the variance of T-matrix from its average value). The closed analytical expressions for the specular and diffuse factors for electron reflection and transmission are obtained in the non-self-consistent and self-consistent (coherent potential) approaches. These results clearly indicate that the specular and diffuse reflection and transmission depend on the electron momentum parallel to the layers, $\mathbf{k}_{\|}$, or equivalently on the angle, at which an electron strikes an interface. Moreover, these dependencies are different for reflection and transmission. Some approximations for the specular and diffuse factors of reflection and transmission have been explored, such as the weak scattering case, single-site and coherent potential approximation (CPA). Numerical evaluation of the specular and diffuse factors for transmission and reflection has been conducted in the lowest (second) order in the interface impurity potential strength. In this approximation, increased surface roughness can only reduce the specular transmission across the interface. For systems that approximate free electrons such as the majority spin channel of Co|Cu, the specularity parameter is highest for normal electron incidence. For the case of reflection, interfacial disorder can either increase or decrease the specular reflection depending on the electron velocities for each material at a particular value of $\mathbf{k}_{\|}$. This work provides the tools necessary to build a model that incorporates *ab-initio* band structure information including a reasonable model of interfacial scattering.

References

[1] D. A. Stewart, W. H. Butler, X.-G. Zhang, and V. F. Los, Phys. Rev. B (2003).