Spin Orbit Effects in the 2DEG of Semiconductor Quantum Wells

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Following the seminal paper of Datta and Das in 1990 [1] where a new kind of device called the spin polarized field effect transistor (spin FET) was introduced for the first time, and in which current flow between source and drain is spin dependent, the study of spin-orbit effects in semiconductor research both by experimentalists and theoreticians has grown tremendously in the last few years thus giving rise to the emerging field of spintronics where the new nano-devices exploit the spin degree of freedom on a large scale. In their original proposal, using a simple model capturing the essential physics Datta and Das show that provided a phenomenological constant α called the Rashba parameter can be tuned by a gate voltage Vg, spin related current modulation follows and a thorough understanding of this parameter was therefore more than necessary.

The experimental as well as the theoretical study of this parameter turned out to be less obvious than first thought due mainly to its sensitivity to many variables such as doping concentration, 2D electron density, non-parabolicity, heterostructure design etc …

In the present contribution and as a follow up to our previous work [2], for heterostructures made of semiconductors with wide to medium size gaps we investigate with the help of our electronic structure calculation codes the relative importance of the main spin orbit mechanisms known as Rashba and Dresselhaus. We also monitor their variations with the applied gate voltage and pay particular attention to their interesting interference effects.

Moreover, we study in detail the influence of the heterostructure design and pay special attention to steps in either the confining potential or the bulk band structure parameters such as the effective mass. Furthermore, in an effort to gain more control on spin orbit importance in heterostructures, we also explore the intricate effects of the interfaces and the barriers and how these together combine to yield the well width dependence of the spin orbit splitting. In addition, particular attention is paid to the effect of tunneling that we monitor as a function of the applied gate voltage.

[1] S. Datta and B. Das, Appl. Phys. Lett. 56, 665 (1990)
[2] S. Lamari, Phys. Rev. B 75 , 155302 (2007)