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Electron spin from Goudsmit and Uhlenbeck to Spintronics

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While the electron's spin was postulated by Goudsmit and Uhlenbeck to explain atomic spectra of gases, it was adopted in a very different setting a decade later to explain the unusual physical and electrical transport properties of ferromagnetic metals. A discovery in 1988 lead to control currents through the spin of the electron, i.e., spintronics. The initial idea of spin dependent transport dates back to Neville Mott's work in the mid- thirties in which he developed the s-d or two current model of conduction in the 3d transition-metal ferromagnetic metals. The methodology used for semiconductor heterostructures lead one to grow high quality metallic multilayers by the 1980's, and it was apparent to Albert Fert and Peter Grünberg [Nobel Laureates in Physics 2007] that one could alter the magnetic configuration in ferromagnetic metals with moderate magnetic fields, and thereby change their resistivities. I will review the principle ideas and developments that lead to this new field, called Spintronics, and focus on developments in three distinct time periods. The first from 1988-1995 which was dominated by metallic multilayers which displayed giant magnetoresistance (GMR), the second from 1995-2000 when reproducible magnetic tunnel junctions (MTJ's) were studied for their tunneling magnetoresistance (TMR), and the third period from 2000-2005 in which the ideas of Berger and Slonczewski were realized on the back action of currents on the magnetic background of the materials doing the conducting, i.e., current induced magnetization switching (CIMS). Current interest has focused on spin dependent transport in oxides and carbon based materials. These developments illustrate the broad range of activities in Spintronics; a field which is barely twenty years old.