MAR13-2012-020076

Abstract for an Invited Paper
for the MAR13 Meeting of
the American Physical Society

Oliver E. Buckley Condensed Matter Prize Lecture: S-d Exchange, Spin Accumulation, And The Roots Of Spintronics

LUC BERGER, Carnegie Mellon University, Physics Dept.

The success of spintronics in metals such as nickel, cobalt, Ni-Fe and Ni-Co is based on the existence of high-mobility spin-up 4s electrons at the Fermi level, which carry most of the current. The spin-up Fermi level is located above the top of the 3d band. This basic fact, first recognized by Mott in 1936, was confirmed by the Hall-effect measurements of Pugh et al. (1950-1965), and by data of deviation from Matthiessen's rule by Campbell, Fert and Jaoul (1967-1977). In order to explain giant magnetoresistance and the existence of the spin-transfer torque, an interaction is needed which couples 4s conduction electrons to magnetic 3d electrons. This is the s-d exchange interaction, introduced by Vonsovskii in 1946 and Zener in 1951. Theories of Gilbert damping, based on s-d exchange, were soon developed (Turov (1955), Mitchell (1957)). But a serious problem was caused by the existence of a momentum gap between spin-up and spin-down Fermi surfaces, which prevents spin switching from happening at low T. The problem can be solved if local defects exist which act as extra sources of momentum. One such source is spin-flip scattering (Turov (1961), Heinrich, Freitova and Kambersky (1967)). A second one is the presence of an interface (Slonczewski (1996), Berger (1996)). Spin accumulation is another concept of importance to spintronics. It represents an imbalance between spin-up and spin-down Fermi levels. Introduced by Aronov in 1976, it was developed by Johnson and Silsbee (1985-1993) and by Valet and Fert (1993). It is the hidden agent through which the current "pumps" energy into many spintronics devices. In semiconductor lasers, the same role is played by the difference between conduction-band and valence-band Fermi levels. A momentum gap problem also exists in lasers made of indirect-gap semiconductors, and it is solved similarly.