BIPOLAR-DRIVEN LARGE MAGNETORESISTANCE IN SILICON

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Magnetoresistance (MR) effect in non-magnetic silicon has gained a renewed interest in recent years because the effect is large and shows non-saturating (linear) magnetic field dependence, which makes it a good candidate for magnetic field sensing applications.[1-3] It is known that the presence of “static” inhomogeneities like impurities, defects, and voids in non-magnetic material generate large, linear MR.[4] For example, in silicon with inhomogeneous phosphorus doping, where the spatial distribution of ionized donors is disordered, the MR is large and linear at low temperature.[2] Similarly, inhomogeneity can also be introduced “dynamically” into silicon devices. This can be done by injecting electrons and/or holes into a low-doped silicon device.[1,3,5] Here, unipolar charge injection generates space-charge effect, which causes inhomogeneous distribution of electric field inside the device.[1,5] Whereas, bipolar injection induces the formation of the so-called p-n boundary, which provides strong current distortion site in the device3. These dynamic inhomogeneities induce large, linear MR in silicon, which persists even at room temperature.[1,3] However, the MR is small and shows quadratic magnetic field dependence below 500 millitesla, which limits its application for ultralow magnetic field sensing applications.

In this workshop, I will present an alternative approach in enhancing the MR effect in a non-magnetic silicon in very low magnetic fields, even without inhomogeneities and geometric effects. I will show that, when electrons and holes are simultaneously injected into a silicon device to induce electron-hole plasma formation, it shows large, linear MR below 250 millitesla at room temperature.[5,6] As for the underlying mechanism, I will demonstrate that the modulation of the electron density in the electron-hole plasma by the magnetic field causes the induction of the large, linear MR in low fields.[6]