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Nanoscale Magnetic Field Sensors For Magnetic Recording[1]

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I present two possible paths to achieving magnetic sensitivity to mT magnetic fields on the tens of nm length scale at GHz frequencies, required by future magnetic recording systems. Extraordinary Magneto Resistance (EMR) is based on the synergistic combination of two effects derived from the Lorentz force acting on charge carriers in hybrid structures comprising a high mobility semiconductor and a metal shunt: Hall and Corbino (where current is directed away from a metal inclusion in a semiconductor when magnetic field is applied). Our earlier devices (resolution 150nm) were built from InAs 2DEGs and provided sensitivities S = 5 microV/Oe, comparable to GMR sensors. Recently we have employed graphene as the high mobility channel, greatly improving the potential spatial resolution since it is only one atom thick and easily located near the sensor surface. We obtain S =10 microV/Oe when both electrons and holes are present near the Dirac point. The Spin Torque Oscillator Sensor, also sensitive to mT fields on the nanoscale, has two ferromagnetic layers (reference and sense) a few nm thick separated by a non-magnetic conductor in a pillar a few tens of nm in diameter. The current from the reference layer is spin polarized, and is used to excite persistent oscillations of the magnetization in the sense layer, whose frequency of oscillation changes with magnetic field. Our modeling shows that dispersions of 150 GHz/T are possible, or a few GHz shift in response to the field above recorded bits. The change in frequency is measured by a phase detector sensitive to the oscillating voltage signal generated by the GMR that arises as the sense layer precesses with respect to the reference layer. Model results show that high SNR may be possible.

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