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GMR in Isolation

Introduction

For more than a decade the Giant Magneto Resistive (GMR) effect has been one of the real applications in the field of nanotechnology, offering many advantages over traditional isolation methods such as optical or capacitive barriers.

The two most significant advantages are the much larger output signal GMR provides, and the high economics of scale this technology enables. Because GMR technology is compatible with integrated circuit technology, it allows for the design of monolithic GMR devices to be included as part of the chip package. This results in smaller, faster, and more precise devices, such as digital and analog isolators and sensors.

GMR is a large change in electrical resistance observed in devices commonly referred to as spin valves (Figure 1).

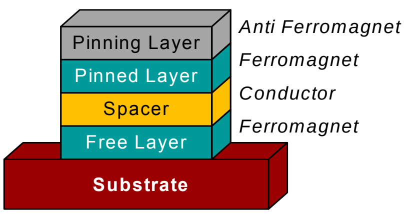

FIGURE 1. SPIN VALVE STRUCTURE

The electric resistivity of GMR materials depends on the relative magnetic alignment of the pinned and free ferromagnetic layers, which are separated by a non-magnetic, conducting spacer. Electrons scatter more frequently when their quantum spin differs from the magnetic orientation of the layer through which they are traveling (Figure 2). Thus, GMR is a type of spintronics, harnessing the spin of electrons rather than their charge.

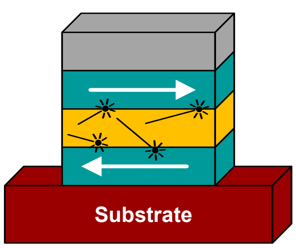

FIGURE 2A. HIGH RESISTANCE DUE TO ANTI-ALIGNED

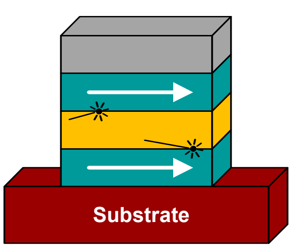

FIGURE 2B. LOW RESISTANCE DUE TO ALIGNED

FIGURE 2. RESISTENCE DUE TO MAGNETIC MOMENTS ALIGNMENT

If the magnetic moments of the ferromagnetic layers are in opposing directions (Figure 2A), electron scattering is maximized and resistance is at its highest. If the magnetic moments of the two layers are aligned, (Figure 2B), electron scattering is minimized and resistance is at its lowest.

A typical spin valve resistance characteristic is shown in Figure 3. At approximately 20 Oe of magnetic field strength, the free layer reverses direction, while the pinned layer remains magnetically fixed due to its exchange bias with the anti-ferromagnetic pinning layer. At fields of approximately 300 Oe, the pinned layer begins changing direction, and at fields of 750 Oe the resistance returns to the aligned value.

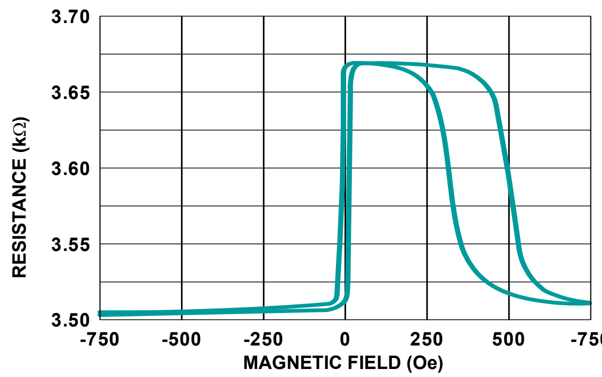

FIGURE 3. TYPICAL SPIN VALVE RESISTANCE

Digital GMR isolators operate in fields where the pinned layer remains fixed, so the resistance of the spin valve is a bistable high or low valve.

The heart of the GMR isolator is a Wheatstone bridge constructed of GMR resistor elements, shown in Figure 4.

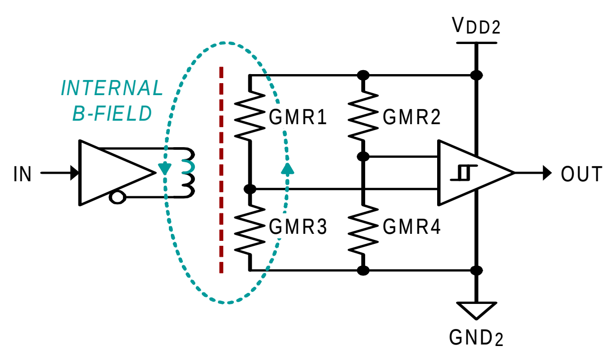

FIGURE 4. SINGLE CHANNEL GMR ISOLATOR

The input signal is buffered and drives a primary coil, whose directional current creates a magnetic field that switches the GMRs in the bridge. This generates a corresponding directional bridge output that drives a comparator whose output signal is identical in phase and shape to the input signal.

The coil, GMR, and support circuitry are integrated on a single chip which allows for small packages, high speed, and low power consumption.

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