A magnetoelastic spin valve

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A new coil-less sensor that is sensitive to torsion, magnetic field and strain is presented. It is based on magneto-elasticity and magneto-electronic transport processes in a soft magnetic ribbon. The ribbon is electrically divided into an excitation section and a receiving section, providing a “non-local” four-point measurement geometry (see fig.1). Thus the sensor output signal is free of ohmic voltage drops due to the excitation current sent through the AB contacts. Prototype sensor dimensions are 20x1x0.02mm with the potential of miniaturization.

The initial goal was to investigate voltage pulses predicted by L. Berger [1] to occur along the current-free section CD upon injection of current pulses into the AB section due to domain wall motion into the CD section. With a *plane* structure (fig.1a) virtually no signal was observed between the contacts C and D. However, upon twisting (fig.1b) and simultaneously applying a weak static external longitudinal magnetic field, voltage pulses in the mV range appear between C and D with some time delay with respect to the flanks of the current pulses. The signal pulse shape, sign and amplitude depend on the current pulse polarity, the twisting angle and the external magnetic field. The maximum signal is obtained for a material-dependent combination of those quantities. Strain applied to the twisted sensor affects the signal with sensitivity much larger than in conventional strain gauges. The sensor is named a magnetoelastic spin valve since the output signal is controlled by twisting.

Fig.2 shows the dependence of the amplified and rectified sensor signal on the twisting angle and the external magnetic field, for a Co-based amorphous ribbon. It is seen that with a small magnetic field of about 0.2 Oe the signal increases monotonically between 0 and 60° twisting angle. The quantitative characteristics however depend strongly on the alloy composition and the annealing conditions. The virtual absence of the signal for a flat strip is common to all studied materials. An induced permanent helical anisotropy might break this rule.

I will present quantitative characterizations of the sensor for the parameters mentioned above, for several sensor materials. I will also discuss a model on the origin of the effect.

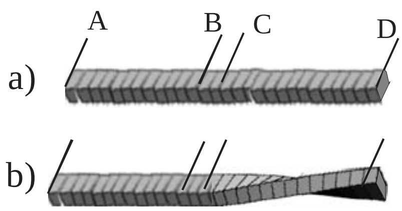

Fig.1: Sketch of the sensor structure, plane (a) and twisted (b). Unipolar current pulses of about 10 mA with MHz frequency are injected into the section AB. Voltage pulses between C and D appear in registry with the flanks of the current pulses in the twisted structure, in the presence of a longitudinal magnetic field. Symmetry relations exist between the signal polarity, the signs of the magnetic field, the twist angle, and the current pulse polarity.

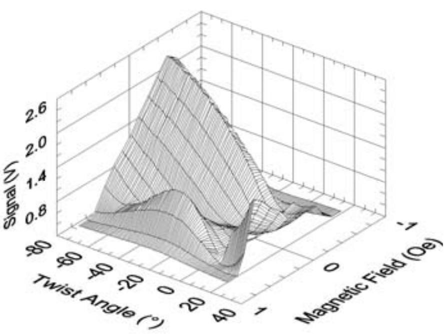

Fig.2: Dependence of the sensor signal on the twist angle and an external magnetic field for Cobalt based amorphous ribbon.

[1] L. Berger, J. Appl. Phys. 50, 7102 (1979).

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