MAGNETORESISTIVE SENSOR WITH A THIN ANTIFERROMAGNETIC LAYER FOR PINNING ANTIPARALLEL COUPLED TABS

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] This invention relates in general to spin valve magnetoresistive sensors for reading information signals from a magnetic medium, in particular, to a lead overlay spin valve sensor with a thin antiferromagnetic layer for pinning an antiparallel coupled lead/sensor overlap (tab) region.

[0003] 2. Description of the Related Art

[0004] Computers often include auxiliary memory storage devices having media on which data can be written and from which data can be read for later use. A direct access storage device (disk drive) incorporating rotating magnetic disks is commonly used for storing data in magnetic form on the disk surfaces. Data is recorded on concentric, radially spaced tracks on the disk surfaces. Magnetic heads including read sensors are then used to read data from the tracks on the disk surfaces.

[0005] In high capacity disk drives, magnetoresistive (MR) read sensors, commonly referred to as MR sensors, are the prevailing read sensors because of their capability to read data from a surface of a disk at greater track and linear densities than thin film inductive heads. An MR sensor detects a magnetic field through the change in the resistance of its MR sensing layer (also referred to as an "MR element") as a function of the strength and direction of the magnetic flux being sensed by the MR layer.

[0006] The conventional MR sensor operates on the basis of the anisotropic magnetoresistive (AMR) effect in which an MR element resistance varies as the square of the cosine of the angle between the magnetization in the MR element and the direction of sense current flowing through the MR element. Recorded data can be read from a magnetic medium because the external magnetic field from the recorded magnetic medium (the signal field) causes a change in the direction of magnetization in the MR element, which in turn causes a change in resistance in the MR element and a corresponding change in the sensed current or voltage.

[0007] Another type of MR sensor is the giant magnetoresistance (GMR) sensor manifesting the GMR effect. In GMR sensors, the resistance of the MR sensing layer varies as a function of the spin-dependent transmission of the conduction electrons between magnetic layers separated by a nonmagnetic layer (spacer) and the accompanying spin-dependent scattering which takes place at the interface of the magnetic and nonmagnetic layers and within the magnetic layers.

[0008] GMR sensors using only two layers of ferromagnetic material (e.g., Ni—Fe) separated by a layer of non-magnetic material (e.g., copper) are generally referred to as spin valve (SV) sensors manifesting the SV effect.

[0009] **FIG. 1** shows a prior art SV sensor **100** comprising end regions **104** and **106** separated by a central region **102**. A first ferromagnetic layer, referred to as a pinned layer **120**, has its magnetization typically fixed (pinned) by exchange coupling with an antiferromagnetic (AFM) layer **125**. The magnetization of a second ferromagnetic layer, referred to as a free layer **110**, is not fixed and is free to rotate in response to the magnetic field from the recorded magnetic medium (the signal field). The free layer **110** is separated from the pinned layer **120** by a non-magnetic, electrically conducting spacer layer **115**. Hard bias layers **130** and **135** formed in the end regions **104** and **106**, respectively, provide longitudinal bias for the free layer **110**. Leads **140** and **145** formed on hard bias layers **130** and **135**, respectively, provide electrical connections for sensing the resistance of SV sensor **100**. IBM's U.S. Pat. No. 5,206,590 granted to Dieny et al., incorporated herein by reference, discloses a GMR sensor operating on the basis of the SV effect.

[0010] Another type of spin valve sensor is an antiparallel (AP) spin valve sensor. The AP-pinned valve sensor differs from the simple spin valve sensor in that an AP-pinned structure has multiple thin film layers instead of a single pinned layer. The AP-pinned structure has an antiparallel coupling (APC) layer sandwiched between first and second ferromagnetic pinned layers. The first pinned layer has its magnetization oriented in a first direction by exchange coupling to the antiferromagnetic pinning layer. The second pinned layer is immediately adjacent to the free layer and is antiparallel exchange coupled to the first pinned layer because of the minimal thickness (in the order of 8 (E) of the APC layer between the first and second pinned layers. Accordingly, the magnetization of the second pinned layer is oriented in a second direction that is antiparallel to the direction of the magnetization of the first pinned layer.

[0011] The AP-pinned structure is preferred over the single pinned layer because the magnetizations of the first and second pinned layers of the AP-pinned structure subtractively combine to provide a net magnetization that is less than the magnetization of the single pinned layer. The direction of the net magnetization is determined by the thicker of the first and second pinned layers. A reduced net magnetization equates to a reduced demagnetization field from the AP-pinned structure. Since the antiferromagnetic exchange coupling is inversely proportional to the net pinning magnetization, this increases exchange coupling between the first pinned layer and the antiferromagnetic pinning layer. The AP-pinned spin valve sensor is described in commonly assigned U.S. Pat. No. 5,465,185 to Heim and Parkin which is incorporated by reference herein.

[0012] A typical spin valve sensor has top and bottom surfaces and first and second side surfaces which intersect at an air bearing surface (ABS) where the ABS is an exposed surface of the sensor that faces the magnetic disk. Prior art read heads employ first and second hard bias layers and first and second lead layers that abut the first and second side surfaces for longitudinally biasing and stabilizing the free layer in the sensor and conducting a sense current transversely through the sensor. The track width of the head is measured between the centers of the side surfaces of the free layer. In an effort to reduce the track width to submicron levels it has been found that the hard bias layers make the free layer magnetically stiff so that its magnetic moment does not freely respond to field signals from a rotating magnetic disk. Accordingly, there is a strong-felt need to provide submicron track width spin valve sensors which are still sensitive to the signals from the rotating magnetic disk along with longitudinal biasing of the free layer transversely so that the free layer is kept in a single magnetic domain state.