SUMMARY OF THE INVENTION

[0013] Accordingly, it is an object of the present invention to disclose a spin valve sensor with a highly stabilized free layer which is highly responsive to signals from a rotating magnetic disk.

[0014] It is another object of the present invention to disclose a spin valve sensor with an antiparallel coupled lead/sensor overlap region.

[0015] It is yet another object of the present invention to disclose a spin valve sensor having a thin antiferromagnetic layer exchange coupled to a self-pinned ferromagnetic bias layer in the lead overlap regions.

[0016] It is a further object of the present invention to disclose a method of making a spin valve sensor having a thin antiferromagnetic layer exchange coupled to a self-pinned antiparallel coupled bias layer in the lead overlap regions.

[0017] In accordance with the principles of the present invention, there is disclosed an embodiment of the present invention wherein a spin valve (SV) sensor has a transverse length between first and second side surfaces which is divided into a track width region between first and second passive regions wherein the track width region is defined by first and second lead layers. The SV sensor comprises a pinned layer, a spacer layer and a free layer, wherein the free layer is at the top of the sensor. A ferromagnetic bias layer having a thickness very nearly equal to the thickness of the free layer is antiparallel (AP) coupled to the free layer in the first and second passive regions. An antiferromagnetic (AFM) layer having a thickness less than needed to provide a saturation pinning field of the bias layer is exchange coupled to the bias layer to provide an AFM pinning field to the bias layer in the first and second passive regions. The AFM layer is set to provide a longitudinal pinning field having an orientation in the plane of the SV sensor layers and parallel to the air bearing surface (ABS). In a second embodiment, the AFM layer may be set to provide a transverse pinning field having an orientation perpendicular to the ABS or a canted pinning field directed in a canted direction intermediate between a direction parallel to the ABS and a direction perpendicular to the ABS. The AFM pinning field provides additional stabilization of the free layer particularly at the interfaces of the track width region and the first and second passive regions where the bias layer ends.

[0018] The above as well as additional objects, features, and advantages of the present invention will become apparent in the following written description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] For a fuller understanding of the nature and advantages of the present invention, as well as of the preferred mode of use, reference should be made to the following detailed description read in conjunction with the accompanying drawings. In the following drawings, like reference numerals designate like or similar parts throughout the drawings.

[0020] **FIG. 1** is an air bearing surface view, not to scale, of a prior art SV sensor;

[0021] **FIG. 2** is a simplified diagram of a magnetic recording disk drive system using the SV sensor of the present invention;

[0022] **FIG. 3** is a vertical cross-section view, not to scale, of a "piggyback" read/write magnetic head;

[0023] **FIG. 4** is a vertical cross-section view, not to scale, of a "merged" read/write magnetic head;

[0024] **FIG. 5** is an air bearing surface view, not to scale, of an embodiment of a lead overlay SV sensor of the present invention;

[0025] **FIGS. 6*a*-6*d*** are air bearing surface views, not to scale, of the SV sensor of **FIG. 5** illustrating sequential steps of making the sensor by the method of the present invention;

[0026] **FIG. 7** is an air bearing surface view, not to scale, of a second embodiment of a lead overlay sensor of the present invention;

[0027] **FIG. 8** is a graphical representation of the strength of the AFM pinning field as a function of AFM layer thickness; and

[0028] **FIG. 9** is plan view, not to scale, of a spin valve sensor indicating the orientation directions of longitudinal, transverse and canted bias fields relative to the air bearing surface.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0029] The following description is the best embodiment presently contemplated for carrying out the present invention. This description is made for the purpose of illustrating the general principles of the present invention and is not meant to limit the inventive concepts claimed herein.

[0030] Referring now to **FIG. 2**, there is shown a disk drive **200** embodying the present invention. As shown in **FIG. 2**, at least one rotatable magnetic disk **212** is supported on a spindle **214** and rotated by a disk drive motor **218**. The magnetic recording media on each disk is in the form of an annular pattern of concentric data tracks (not shown) on the disk **212**.

[0031] At least one slider **213** is positioned on the disk **212**, each slider **213** supporting one or more magnetic read/write heads **221** where the head **221** incorporates the SV sensor of the present invention. As the disks rotate, the slider **213** is moved radially in and out over the disk surface **222** so that the heads **221** may access different portions of the disk where desired data is recorded. Each slider **213** is attached to an actuator arm **219** by means of a suspension **215**. The suspension **215** provides a slight spring force which biases the slider **213** against the disk surface **222**. Each actuator arm **219** is attached to an actuator **227**. The actuator as shown in **FIG. 2** may be a voice coil motor (VCM). The VCM comprises a coil movable within a fixed magnetic field, the direction and speed of the coil movements being controlled by the motor current signals supplied by a controller **229**.

[0032] During operation of the disk storage system, the rotation of the disk **212** generates an air bearing between the slider **213** (the surface of the slider **213** which includes the head **321** and faces the surface of the disk **212** is referred to as an air bearing surface (ABS)) and the disk surface **222**