MAGNETORESISTIVE SENSOR WITH REDUCED SIDE-READING EFFECT

BACKGROUND OF THE INVENTION

The present invention relates generally to a magnetoresistive sensor for use in a magnetic read head. In particular, the present invention relates to a magnetoresistive read sensor having reduced side-reading.

Magnetoresistive read sensors, such as giant magnetoresistive (GMR) read sensors, are used in magnetic data storage systems to detect magnetically-encoded information stored on a magnetic data storage medium such as a magnetic disc. A time-dependent magnetic field from a magnetic medium directly modulates the resistivity of the GMR read sensor. A change in resistance of the GMR read sensor can be detected by passing a sense current through the GMR read sensor and measuring the voltage across the GMR read sensor. The resulting signal can be used to recover the encoded information from the magnetic medium.

A typical GMR read sensor configuration is the GMR spin valve, in which the GMR read sensor is a multi-layered structure formed of a nonmagnetic spacer layer positioned between a ferromagnetic pinned layer and a ferromagnetic free layer. The magnetization of the pinned layer is fixed in a predetermined direction, typically normal to an air bearing surface of the GMR read sensor, while the magnetization of the free layer rotates freely in response to an external magnetic field. The resistance of the GMR read sensor varies as a function of an angle formed between the magnetization direction of the free layer and the magnetization direction of the pinned layer. This multi-layered spin valve configuration allows for a more pronounced magnetoresistive effect, i.e. greater sensitivity and higher total change in resistance, than is possible with anisotropic magnetoresistive (AMR) read sensors, which generally consist of a single ferromagnetic layer.

GMR spin valves are configured to operate in either a current-in-plane (CIP) mode or a current-perpendicular-to-plane (CPP) mode. In CIP mode, the sense current is passed through in a direction parallel to the layers of the read sensor. In CPP mode, the sense current is passed through in a direction perpendicular to the layers of the read sensor.

A tunneling magnetoresistive (TMR) read sensor is similar in structure to a GMR spin valve configured in CPP mode, but the physics of the device are different. For a TMR read sensor, rather than using a spacer layer, a barrier layer is positioned between the free layer and the pinned layer. Electrons must tunnel through the barrier layer. A sense current flowing perpendicularly to the plane of the layers of the TMR read sensor experiences a resistance which is proportional to the cosine of an angle formed between the magnetization direction of the free layer and the magnetization direction of the pinned layer.

One principal concern in the performance of magnetoresistive read sensors is the side-reading effect of the sensor. Current read sensors not only sense magnetic flux from a track located directly beneath the read sensor on the magnetic medium, but they also typically sense magnetic flux from adjacent tracks located up to 3 μ-inches outside the edge of the read sensor. This is known as the side-reading effect and results in an effective increase of up to 6 μ-inches in reader width. This magnetic flux leakage from adjacent tracks limits the read sensor's ability to accurately sense magnetic flux from the track located directly beneath it. In addition, the effective increase in reader width of the read

sensor limits the density of tracks (and thus data) on a magnetic medium.

The present invention addresses these and other needs, and offers other advantages over current devices.

BRIEF SUMMARY OF THE INVENTION

The present invention is a read sensor for use in a magnetic read head. The read sensor includes a magnetoresistive stack having a plurality of layers, and first and second shield regions positioned adjacent to the magnetoresistive stack. Each of the shield regions includes a first soft magnetic layer for shunting flux from an adjacent track to the shield region instead of the magnetoresistive stack.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a layer diagram of a first embodiment of a read sensor of the present invention.

FIG. **1A** is a layer diagram of a second embodiment of a read sensor of the present invention.

FIG. **2** is a layer diagram of a third embodiment of a read sensor of the present invention.

FIG. **3** is a layer diagram of a fourth embodiment of a read sensor of the present invention.

FIG. **4** is a layer diagram of a fifth embodiment of a read sensor of the present invention.

FIG. **5** is a layer diagram of a sixth embodiment of a read sensor of the present invention.

FIG. **6** is a layer diagram of a seventh embodiment of a read sensor of the present invention.

FIG. **7** is a layer diagram of an eighth embodiment of a read sensor of the present invention.

FIG. **8** is a layer diagram of a ninth embodiment of a read sensor of the present invention.

DETAILED DESCRIPTION

FIG. **1** is a layer diagram of a first embodiment of a read sensor **10** of the present invention. Read sensor **10** includes a magnetoresistive stack **11**, shield regions **12**A and **12**B, and contacts **14**A and **14**B. Magnetoresistive stack **11** is a giant magnetoresistive (GMR) stack configured to operate in a current-in-plane (CIP) mode wherein a sense current flows substantially parallel to the layers of the stack Shield region **12**A is positioned adjacent to a side surface of GMR stack **11**, and includes a permanent magnet layer **16**A, a seed layer **18**A, and a ferromagnetic layer **20**A. Seed layer **18**A is positioned between permanent magnet layer **16**A and ferromagnetic layer **20**A. Shield region **12**B is positioned adjacent to a side surface of GMR stack **11** opposite to shield region **12**A, and includes a permanent magnet layer **16**B, a seed layer **18**B, and a ferromagnetic layer **20**B. Seed layer **18**B is positioned between permanent magnet layer **16**B and ferromagnetic layer **20**B. Contact **14**A is positioned adjacent to ferromagnetic layer **20**A, and contact **14**B is positioned adjacent to ferromagnetic layer **20**B.

Contacts **14**A and **14**B provide a sense current through GMR stack **11**. The GMR signal produced by GMR stack **11** is generated by the sense current flowing parallel to the layers of GMR stack **11**. Permanent magnet layers **16**A and **16**B are preferably selected from the group consisting of CoPt, CoCrPt and SmCo, and preferably have a thickness in the range of about 100 Å to about 300 Å. Seed layers **18**A and **18**B are preferably selected from the group consisting of Ti, Rh, Ta, Cu, Au and Ru, and preferably have a thickness in the range of about 30 Å to about 50 Å. Ferromagnetic