MAGNETORESISTIVE SENSOR HAVING A HIGH RESISTANCE SOFT MAGNETIC LAYER BETWEEN SENSOR STACK AND SHIELD

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The invention relates to a magnetoresistive sensor, typically used in a magnetic disk drive; and, more specifically, to a magnetoresistive sensor having a high resistance soft magnetic layer in the gap.

[0003] 2. Description of the Background Art

[0004] Disk drives using magnetic recording of digital information store most of the data in contemporary computer systems. A disk drive has at least one rotating disk with discrete concentric tracks of data. Each disk drive also has at least one recording head which typically has a separate write element and read element for writing and reading the data on the tracks. The recording head is constructed on a slider and the slider is attached to a suspension. The combination of the recording head, slider, and suspension is called a head gimbal assembly. In addition, there is an actuator which positions the recording head over a specific track of interest. The actuator first rotates to seek the track of interest. After positioning the recording head over the track, the actuator maintains the recording head in close registration to that track. The disk in a disk drive has a substrate and a magnetic layer formed over the substrate for magnetic recording. The slider carrying the recording head has a disk facing surface upon which an air bearing is constructed. The air bearing allows the slider to float on a cushion of air and to be positioned close to the disk surface. Alternatively, the slider surface facing the disk can be adapted for partial or continuous contact with the disk.

[0005] A magnetoresistive sensor is used as the read element in most contemporary disk drives. A magnetoresistive sensor, most commonly a magnetoresistive spin valve sensor, is a sandwich of layers including a ferromagnetic pinned layer, a nonmagnetic electrically conducting layer, and a ferromagnetic free layer. The sandwich of layers is also called the sensor stack. The sensor stack is disposed between two magnetic shields. There is a thin insulating layer between the sensor stack and each magnetic shield. The distance between the magnetic shields is the magnetic read gap. The resistance of the magnetoresistive sensor is responsive to the direction and magnitude of an applied magnetic field such as the field from a written magnetic transition on a disk. Sense current is passed through the sensor to detect the change in resistance.

[0006] A higher areal density of recorded information is typically required for each new generation of disk drives. The size of the geometrical features of the read sensor must be reduced to be commensurate with the smaller bit sizes needed. One geometrical feature which is critical to the achievement of higher recorded density is the size of the magnetic read gap. It is difficult to reduce the thickness of the sensor stack without degrading magnetic performance. Therefore the read gap has typically been reduced by reducing the thickness of the thin insulating layers. However, the required thickness of an insulating layer is now so thin that the read elements are very susceptible to electrostatic damage and minor defects such as pin holes in the thin insulating layer. A defective or damaged insulating layer between the sensor stack and the magnetic shields may allow sense current to pass through the magnetic shield thus causing significant degradation in the performance of the sensor.

[0007] Thus what is needed is a magnetoresistive sensor that has a very small read gap and that is also insensitive to defects or electrostatic damage.

SUMMARY OF THE INVENTION

[0008] A preferred embodiment of the invention provides a magnetic read element having a layer of high resistance soft magnetic material disposed between at least one of the insulating layers and a magnetic shield. The high resistance soft magnetic layer preferably has a composition of A-B-C where A is selected from the group Fe and Co, B is selected from the group Hf, Y, Ta, and Zr, and C is selected from the group of O and N. The high resistance soft magnetic layer may also be formed from CoFeHfO. A magnetic read element according to the invention provides a narrow magnetic read gap enabling high density magnetic recording while remaining insensitive to electrostatic damage and defects. In another embodiment of the invention, a disk drive is provided having a read element including a high resistance soft magnetic layer disposed between at least one insulating layer and a magnetic shield.

[0009] Other aspects and advantages of the invention will become apparent from the following detailed description, which, when taken in conjunction with the drawings, illustrate by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] **FIG. 1** illustrates a view of a disk drive including a read element according to the present invention;

[0011] **FIG. 2** illustrates a perspective view of a slider and recording head;

[0012] **FIG. 3** illustrates a disk facing view of a magnetoresistive sensor according to the prior art;

[0013] **FIG. 4***a* illustrates a disk facing view of a magnetoresistive sensor having high resistance soft magnetic layers disposed between each of the insulating layers and the magnetic shields;

[0014] **FIG. 4***b* illustrates a disk facing view of a magnetoresistive sensor having a high resistance soft magnetic layer disposed between a bottom insulating layer and a bottom magnetic shield; and,

[0015] **FIG. 4***c* illustrates a disk facing view of a magnetoresistive sensor having a high resistance soft magnetic layer disposed between a top insulating layer and a top magnetic shield.

DETAILED DESCRIPTION OF THE INVENTION

[0016] A preferred embodiment of the invention provides a magnetic read element having a high resistance soft magnetic layer disposed between at least one of the insulating layers and a magnetic shield. The high resistance soft magnetic layer allows the magnetic read gap to be reduced without increasing the read element susceptibility to electrostatic damage and defects. In another embodiment of the