MAGNETORESISTIVE SENSOR AND MAGNETORESISTIVE HEAD, AND MANUFACTURING METHOD THEREOF

CROSS-REFERENCES TO RELATED APPLICATIONS

[0001] This application claims priority to Japanese application No. 2002-278326, filed Sep. 25, 2002, the disclosure of which is incorporated by reference.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to a magnetoresistive sensor for reading information from a magnetic recording medium by utilizing a magnetoresistive effect and a magnetoresistive head constituted by including the magnetoresistive sensor. Further, the present invention relates, particularly, to a magnetoresistive head for use in a hard disk drive capable of reading at high recording density and relates to a structure of a magnetoresistive sensor for increasing the sensitivity of reading signals at high speed and high density recording and for attaining high signal reproducibility to improve the quality and a manufacturing method thereof. In particular, the present invention relates to a structure and a manufacturing method of a magnetic domain control film disposed in a magnetoresistive sensor for improving the sensitivity of a magnetoresistive sensor and attaining high signal reproducibility. According to the present invention, a magnetic head of high signal quality and reliability can be provided and a hard disk drive of high performance with low error rate can be provided by use of the magnetic head.

[0004] 2. Description of Related Art

[0005] A magnetic head for use in a hard disk drive (HDD) comprises a writing head for recording information as magnetization signals into a magnetic recording medium (hard disk) and a reading head (sensor) for reading signals recorded as magnetization signals in the magnetic recording medium. Electric signals are converted by the writing head into magnetized information and recorded in the magnetic recording medium, while the recorded magnetized information is converted by the reading head into electric signals and taken out. In recent years, a magnetoresistive head of reading magnetized information by utilizing a magnetoresistive effect has been developed, which can read weak written magnetized information and attain a remarkable improvement on the recording density to greatly contribute to the information industry.

[0006] The sensor portion of the magnetoresistive head is composed of a stack of magnetoresistive layers comprising a plurality of magnetic thin films and non-magnetic thin films. The structure of the stack of magnetoresistive layers of the magnetoresistive head includes several types, which are classified, for example, into an AMR head, a GMR head and a TMR head based on the principle of magnet resistivity to be used. Input magnetic field information entered from the magnetic recording medium to the reading head is taken out as the change of voltage by utilizing the AMR effect (Magnetoresistive effect), GMR effect (Giant Magnetoresistive effect) and TMR effect (Tunnel Magnetoresistive effect), respectively.

[0007] The stack of magnetoresistive layers of the magnetoresistive head mainly comprises a magnetic layer referred to as a free layer that receives the input information magnetic field from the magnetic recording medium to conduct magnetization rotation, a pinned layer the magnetization direction of which is fixed by a coupling magnetic field of an anti-ferromagnetic body, and a non-magnetic layer put between them. Since the electric resistance of the stack of magnetoresistive layers changes in accordance with the change of the relation between the magnetization direction of the pinned layer and the magnetization direction of the free layer, when current is being supplied to the stack of electric resistant layers, a change in voltage according to the direction of the magnetization rotation of the free layer is generated and the direction of the magnetized information given to the free layer can be judged by observing the change in voltage. As described above, the reading head portion of the magnetoresistive head has a structure of functioning as a magnetic sensor by utilizing the magnetoresistive effective of the stack of magnetoresistive layers.

[0008] Since the magnetization direction of the pinned layer in the stack of magnetoresistive layers lowers the output signal intensity and allows the signal output to fluctuate when it is changed by the input signal magnetic field or other external magnetic field, the magnetization direction has to be fixed strongly by the coupling magnetic field of the anti-ferromagnetic body. For this purpose, an MnIr alloy thin film or MnPt alloy thin film having a strong coupling magnetic field is selected as the anti-ferromagnetic film, while a Co alloy film formed of a material having an intense coupling magnetic field or a stack of thin films thereof is selected as the pinned layer ferromagnetic film, and conditions for increasing the coupling magnetic fields are selected also for the thin film forming conditions. On the other hand, it is necessary that the magnetization of the free layer reacts sensitively to a weak external input magnetic field and has high reproducibility of the magnetization curve in accordance with plus, minus and zero of the external input magnetic field. For this purpose, an NiFe-Parmalloy alloy thin film or a Co series alloy soft magnetic film of excellent soft magnetic property, and a stack of thin films thereof are often used generally as the free layer. Also for the same purpose, materials and layer structures of the stack of magnetoresistive layers, as well as conditions and methods of manufacture have been studied and improved.

[0009] On the other hand, the Parmalloy thin film or the Co alloy thin film as the soft magnetic material used for the free layer are used in the sheet-like shape and they are used under application of induced magnetic anisotropy for attaining stable magnetization state even in a case where external input magnetic field is not present. However, it has been known that the soft magnetic thin films have no simple magnetic domain structure but form magnetic domain structures depending on the film thickness or the shape of the sheet. In particular, it has been known that circulation magnetic domain structures are formed at the end of the sheet-shape to generate disturbance in the magnetization direction, and the disturbed magnetic domain structures are changed by external magnetic fields. The noise generated due to by the change of the magnetic domain structures is referred to as Barkhausen noise which is generally known. In order to avoid the noise of the above mentioned type, a uniform bias magnetic field has to be applied to a sheet-like free layer to form a univalent magnetic domain structure so as not to generate circulation magnetic domains in the free layer. For this purpose, a permanent magnet is disposed at