the underlayer at the inclined portion of the end of the stack of magnetoresistive layers is increased to also result in a problem that the gap distance is enlarged between the free layer and the magnetic domain control film.

[0033] Accordingly, it has been found that when it is intended to form the structure by aligning the height between the free layer of the stack of magnetoresistive layers and the Co alloy thin film of the magnetic domain control film, the crystallographic orientation of the Co alloy thin film cannot be optimized and the magnetic characteristics as the permanent magnet layer are deteriorated, so that no appropriate bias magnetic field can be applied to the free layer.

[0034] That is, in the prior art, it is difficult to apply an appropriate magnetic field to the free layer while maintaining the magnetic characteristics of the magnetic domain control film. Further, the bias magnetic field is applied not only to the free layer but also to the pinned layer and, also in view of a strict consideration, the end of the pinned layer also undergoes the bias magnetic field of the magnetic domain control film to incline the magnetizing direction of the pinned layer, thus forming a dead area.

[0035] It is an object of the present invention is to provide, in a magnetoresistive sensor adopting a hard bias system, a structure capable of applying an appropriate magnetic field from a magnetic domain control film to a free layer, by controlling the crystal structure of a Co alloy magnetic thin film used as the magnetic domain control film and, forming and disposing the Co alloy magnetic thin film in an appropriate shape at the end of the stack of magnetoresistive layers. As a result, it is possible to decrease the dead area of the free layer, improve the signal output and, further, decrease the Barkhausen noise, output fluctuation and asymmetry in the output waveforms, thereby improving the signal quality during high recording density.

SUMMARY OF THE INVENTION

[0036] To solve the foregoing problems, it is preferred to form a Cr series alloy thin film used as a magnetic domain control film so as not to undergo the effect of the thin film crystal structure constituting a stack of magnetoresistive layers and make the crystal structure of the Cr series alloy thin film into a structure with a layered constitution capable of optimizing the crystal structure of a Co alloy thin film used as a magnetic domain control film. That is, in order not to undergoes the effect of the crystal structure of the thin film constituting the stack of magnetoresistive layers, it is preferred to form an amorphous metal thin film on the stack of magnetoresistive layers-thin-film and form a Cr underlayer and a Co alloy magnetic film on the amorphous metal thin film. Further, it is preferred to adopt a structure and a manufacturing method of selecting the material for the amorphous metal thin film, introducing an oxidation process and controlling the degree of the oxidation on the amorphous metal thin film thereby controlling the surface energy of the amorphous thin film to control the crystallographic orientation and the crystal grain size of the Cr alloy underlayer thin film. When a Co alloy magnetic film is formed on the Cr alloy thin film underlayer controlled with the crystal structure, the crystal structure of the Co alloy thin film can be optimized to obtain good magnetic characteristics. When the new amorphous metal thin film is formed between the stack of magnetoresistive layers and the magnetic domain control film, magnetic characteristics of the magnetic domain control film are improved and a structure capable of easily aligning the vertical positions of the free layer and the magnetic domain control film can be provided to localize and optimize the free layer bias magnetic field applied to the free layer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0037] **FIG. 1** shows the first embodiment of the present invention.

[0038] **FIG. 2** shows the second embodiment of the present invention.

[0039] **FIG. 3** is a view showing a cross sectional structure of a magnetic domain control film of a prior art.

[0040] **FIG. 4** is a schematic view of an end of a stack of magnetoresistive layers.

[0041] **FIG. 5** is a view showing manufacturing process of a preferred embodiment of the present invention.

[0042] **FIG. 6** is a schematic cross sectional view of a crystal orientation.

[0043] **FIG. 7** is a view for explaining the operating principle of a magnetoresistive transfer curve measured for evaluating whether a bias magnetic field of the magnetic domain control film is appropriately applied to the stack of magnetoresistive layers or not in the embodiment of the present invention.

[0044] **FIG. 8** is a view for explaining Vhc showing the amount of magnetic resistance change ΔR and the deviation of the transfer curve as the characteristic values of the transfer curve measured in the embodiment of the present invention.

[0045] **FIG. 9** is a graph showing the change of the static magnetic properties of the magnetic domain control film when the oxidation conditions on the magnetic domain control amorphous film are changed in Embodiment 2 of the present invention.

[0046] **FIG. 10** is a graph showing the change of the characteristic values of the magnetoresistive transfer curve when the oxidation conditions on the magnetic domain control amorphous film are changed in Embodiment 2 of the present invention.

[0047] **FIG. 11** shows X-ray diffraction waveforms when the crystallographic orientation of the magnetic domain control film and the magnetic domain control underlayer is examined by X-ray diffractiometry when the oxidation conditions on the magnetic domain control amorphous film are changed.

[0048] **FIG. 12** is a graph showing the dependence of the magnetic properties of the magnetic domain control film on the thickness of the magnetic domain control film Cr underlayer in Embodiment 3 of the present invention.

[0049] **FIG. 13** is a graph showing the dependence of the magnetic properties of the magnetic domain control film on the thickness of the magnetic domain control film NiTa amorphous film in Embodiment 3 of the present invention.