the end of the stack of magnetoresistive layers thereby generating and applying a bias magnetic field uniformly to the free layer. The system is known as a hard bias system and put to practical use. Further, it has been known an exchange bias system of forming an anti-ferromagnetic film on the free layer and applying a bias magnetic field by utilizing the exchange coupling between the free layer and the anti-ferromagnetic film. The hard bias system has been utilized for commercial use.

[0010] In the hard bias system, as shown, for example, in Japanese Patent Laid-open No. 3-125311, a magnetic domain control film comprising a magnet film is disposed on both ends of a free layer. The exchange bias system is a method of laminating an anti-ferromagnetic film on both ends of a long free layer and utilizing the exchange coupling between the anti-ferromagnetic film and the free layer as disclosed, for example, in U.S. Pat. No. 4,663,685.

[0011] Accordingly, the magnetoresistive sensor generally comprises, mainly, a stack of magnetoresistive layers in which a pinned layer or a free layer, or a pinned layer and a free layer are cut into a sheet-shape, and a magnetic domain control film having a permanent magnet film disposed on the end of a free layer cut into a sheet-shape for the magnetic domain control (hard bias system), or a magnetic domain control film of a system disposing an anti-ferromagnetic body on a free layer (exchange bias system), and an electrode film layer for supplying current to the stack of magnetoresistive layers.

[0012] A magnetoresistive sensor of the hard bias system is manufactured by a step of forming a stack of films for forming a stack of magnetoresistive layers, a step of coating a sheet-like resist which is well-defined for the size for forming a stack of magnetoresistive layers into a sheet-shape, a step of fabricating the stack of magnetoresistive layers into a sheet-shape, a step of forming a magnetic domain control film at the end of the free layer fabricated into the sheet-shape, a step of forming an electrode film layer, and a step of removing the resist coated for forming the shape. The magnetoresistive sensor of the exchange bias system is manufactured, for example, by a step of forming a stack of films for forming a stack of magnetoresistive layers, a step of forming an anti-ferromagnetic film on the surface of a free layer, a step of coating a sheet-like resist which is well defined for the size for forming a track width, a step of forming an electrode film layer, a step of removing the coated resist for forming the shape, a step of removing a portion corresponding to the track width of the anti-ferromagnetic layer, and a step of forming a protection film. In the case of the exchange bias system, the exchange coupling force applied to the free layer is weak and the track width has not yet been decided sufficiently in the process described above. In view of the present situation, developments of the material and structure for giving an intense coupling magnetic field and a manufacturing method have been required. Accordingly, the magnetoresistive sensor of the hard bias system is actually applied for commercial use at present.

[0013] As the permanent magnet film used for the magnet domain control film of the hard bias system, Co alloy series materials are used and those with addition of a Pt element have often been used. The Co series alloy thin films have hexagonal closed packed (HCP) crystal structure as the crystal structure and it has been well known that they have strong crystal magnetic anisotropy in the direction of the C axis and good permanent magnets showing high coercivity can be obtained easily. Further, addition of the Pt element to the Co series alloys increases the crystal magnetic anisotropy to show higher coercivity. It is further known that use of Cr or Cr alloy underlayer for the underlayer of the Co alloy thin film enables to control the crystallographic orientation of the Co alloy thin film by the hetero-epitaxy growing mechanism, thereby easily providing a permanent magnet film having higher residual magnetic flux density, coercivity and squareness. The techniques described above have been developed for the magnetic recording media.

[0014] Those used at present are magnetic domain control films of a stack structure of CoPt series alloy/Cr underlayer and they exhibit coercivity of about 2000 Oe and squareness of 0.8 or more. Further, there are those capable of providing coercivity of 3000 Oe or more by improvement of the material and optimization of the manufacturing conditions. The permanent magnet film of the magnet domain control film requires high coercivity since the magnetization state should not be changed by a signal magnetic field or an external input magnetic field. Since the input magnetic field is estimated to be about 600 to 800 Oe, it is possible that the coercivity of 1200 Oe, that is, at least 1.5 times thereof is necessary. Further it is possible that high values are required for the squareness and the coercivity squareness of the magnetization curve. When the squareness of the magnetization curve lowers, the residual magnetization lowers failing to provide a desired bias magnetic field efficiently to the free layer. The bias magnetic field applied to the free layer can be adjusted by changing the magnetic flux density of the permanent magnet film and changing the thickness of the permanent magnet film, while keeping high squareness, and optimization has to be done.

[0015] Generally, to conduct the magnetic domain control to the free layer in the stack of magnetoresistive layers, a magnetic field higher than a certain bias magnetic field has to be applied to the free layer. However, if the bias magnetic field is excessively intense, since the ferromagnetic body at the end of the free layer does not operate even when the signal magnetic field is inputted, a phenomenon of lowering the output occurs. For this reason, it is necessary to optimize the residual magnetic flux density or the film thickness of the permanent magnet film of the magnetic domain control film. Generally, the residual magnetic flux density is adjusted by changing the saturation magnetic flux density, that is, optimizing the alloy composition of the Co series alloy thin film. Further, the film thickness can be easily adjusted by changing the forming conditions and changing the forming time.

[0016] A sensor structure of a magnetoresistive head of a hard bias system in an existent structure is to be described with reference to **FIG. 3**. **FIG. 3** is a schematic view showing a magnetoresistive sensor portion of a magnetic head taken along the cross section of the flying surface thereof. A stack of magnetoresistive layers is formed on a lower gap layer **2** formed on a lower shield **1**. The lower gap layer **2** comprises a highly insulative material, mostly, an Al_2O_3 film. After forming an underlayer **3** for a stack of magnetoresistive layers, an anti-ferromagnetic layer **4**, a pinned layer **5**, a non-magnetic layer **6**, a free layer **7** and a protection layer **8** successively on the Al_2O_3 gap layer **2**, a resist is coated and the stack of magnetoresistive layers is