MAGNETORESISTIVE-EFFECT DEVICE AND METHOD FOR MANUFACTURING THE SAME

This application is a division of application Ser. No. 09/487,691, now U.S. Pat. No. 6,587,315, filed Jan. 19, 2000, (allowed), which is hereby incorporated by reference herein

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a so-called spin-valve type thin-film device, in which an electrical resistance thereof varies depending on the relationship between the magnetization direction of a pinned magnetic layer and the magnetization direction of a free magnetic layer which is affected by external magnetic field, and, more particularly, to a magnetoresistive-effect device that allows a sense current to effectively flow through a multilayer film and a method for manufacturing the magnetoresistive-effect device.

2. Description of the Related Art

FIG. **33** is a cross-sectional view showing the construction of a conventional magnetoresistive-effect device, viewed from an ABS (air bearing surface) side thereof.

The magnetoresistive-effect device shown in FIG. **33** is the one called a spin-valve type thin-film device, one of the GMR (giant magnetoresistive) devices employing the giant magnetoresistive effect, and detects a magnetic field recorded on a recording medium, such as a hard disk.

This spin-valve type thin-film device includes a multilayer film **9** including a substrate **6**, an antiferromagnetic layer **1**, a pinned magnetic layer **2**, a nonmagnetic electrically conductive **3**, a free magnetic layer **4**, and a protective layer **7**, a pair of hard bias layers **5**, and a pair of electrode layers **8** and **8** respectively deposited on the hard bias layers **5** and **5**, deposited on both sides of the multilayer film **9**. The substrate **6** and the protective layer **7** are made of Ta (tantalum). A track width Tw is determined by the width dimension of the top surface of the multilayer film **9**.

The antiferromagnetic layer **1** is typically an Fe—Mn (iron-manganese) alloy film or an Ni—Mn (nickel-manganese) alloy film, the pinned magnetic layer **2** and the free magnetic layer **4** are typically an Ni—Fe (nickel-iron) alloy film, the nonmagnetic electrically conductive layer **3** is typically a Cu (copper) film, the hard bias layers **5** and **5** are typically Co—Pt (cobalt-platinum) alloy films, and the electrode layers **8** and **8** are typically Cr (chromium) films.

Referring to FIG. **33**, the magnetization of the pinned magnetic layer **2** is placed into a single-domain state in the Y direction (i.e., the direction of a leakage magnetic field from a recording medium, namely, the direction of the height of the multilayer film from the recording medium), and the magnetization of the free magnetic layer **4** is oriented in the X direction under the influence of a bias magnetic field of the hard bias layers **5**.

The magnetization of the pinned magnetic layer **2** is designed to be perpendicular to the magnetization of the free magnetic layer **4**.

In this spin-valve type thin-film device, the electrode layers **8** and **8**, deposited on the hard bias layers **5** and **5**, feed sense currents to the pinned magnetic layer **2**, the nonmagnetic electrically conductive layer **3** and the free magnetic layer **4**. The direction of the advance of the recording medium, such as a hard disk, is aligned with the Z direction. When a leakage magnetic field is given by the recording medium in the Y direction, the magnetization of the free magnetic layer **4** varies from the X direction toward the Y direction. An electric resistance varies depending on the relationship between a variation in the magnetization direction within the free magnetic layer **4** and a pinned magnetization direction of the pinned magnetic layer **2** (this phenomenon is called the magnetoresistive effect), and the leakage magnetic field is sensed from the recording medium based on a variation in the voltage in response to the variation in the electrical resistance.

The magnetoresistive-effect device shown in FIG. **33** suffers from the following problems.

The magnetization of the pinned magnetic layer **2** is pinned in a single-domain state in the Y direction, and the hard bias layers **5** and **5**, magnetized in the X direction, are arranged on both sides of the pinned magnetic layer **2**. The magnetization of the pinned magnetic layer **2** on both ends is therefore affected by the bias magnetic field from the hard bias layers **5** and **5**, and is thus not pinned in the Y direction.

Specifically, the magnetization of the free magnetic layer **4** in the X direction single-domain state and the magnetization of the pinned magnetic layer **2** are not in a perpendicular relationship, particularly on end portions of the multilayer film **9**, under the influence of the X direction magnetization of the hard bias layers **5** and **5**. The magnetization of the free magnetic layer **4** is set to be perpendicular to the magnetization of the pinned magnetic layer **2** because the magnetization of the free magnetic layer **4** is easily varied in response to a weak external magnetic field, causing the electric resistance to greatly vary, and thereby enhancing reproduction gain. Furthermore, the perpendicular relationship results in output waveforms having a good symmetry.

Since the magnetization of the free magnetic layer **4** on end portions thereof is likely to be pinned under the influence of a strong magnetization of the hard bias layers **5** and **5**, the magnetization of the free magnetic layer **4** less varies in response to an external magnetic field. As shown in FIG. **33**, insensitive regions having a poor reproduction gain is formed in the end regions of the multilayer film **9**.

A central portion other than the insensitive regions, of the multilayer film **9**, substantially contributes to the reproduction of the recorded magnetic field, and is thus a sensitive region exhibiting the magnetoresistive effect. The width of the sensitive region is narrower than a track width Tw defined in the formation of the multilayer film **9** by the width dimension of the insensitive regions.

The multilayer film **9** of the magnetoresistive-effect device on both end portions thereof is thus associated with the insensitive regions that contribute nothing to the reproduction output, and these insensitive regions merely increases a direct current resistance (DCR).

In the magnetoresistive-effect device having the construction in which the electrode layers **8** and **8** are deposited on only both sides of the multilayer film **9** as shown in FIG. **33**, the sense current from the electrode layers **8** and **8** easily flows into the hard bias layers **5** and **5**, reducing the percentage of the current flowing into the multilayer film **9**. The presence of the insensitive regions further substantially reduces the quantity of the sense current flowing into the sensitive region. The conventional magnetoresistive-effect device cannot feed an effective sense current to the sensitive region, and suffers from a drop in the reproduction output as the direct current resistance increases.