[0005] However, in the case of using the battery case of the above Patent Document 1 as a battery case of a battery using a strong alkaline electrolyte solution, such as an alkaline battery, a nickel hydrogen battery or the like, a problem of this case is that the contact resistance value of the inner surface of the battery case contacting with the electrolyte solution rises along with lapse of time to impair the battery characteristics. With regard to this problem, further improvements of battery characteristics are demanded, including the suppression of impairing the battery characteristics after lapse of time.

[0006] An object of the present disclosure is to provide a surface-treated steel sheet excellent in battery characteristics and capable of suppressing impairing the battery characteristics also after lapse of time, in the case of its use as a battery case of a battery using a strong alkaline electrolyte solution. The present disclosure has also an object to provide a method for manufacturing such a surface-treated steel sheet.

MEANS FOR SOLVING THE PROBLEM

[0007] As a result of exhaustive studies to achieve the above objects, the present inventors have found that the above objects can be achieved by a surface-treated steel sheet including a steel sheet and a nickel-cobalt-iron diffusion layer as an outermost surface layer formed on the steel sheet when controlling the content of Co and the content of Fe in the surface of the nickel-cobalt-iron diffusion layer within respective specific ranges, as determined by a radio frequency glow discharge optical emission spectrometry on the surface-treated steel sheet, and this finding has led to the completion of the present disclosure.

[0008] Specifically, according to one aspect of the present disclosure, there is provided a surface-treated steel sheet comprising a steel sheet and a nickel-cobalt-iron diffusion layer formed as an outermost surface layer on the steel sheet, wherein when a content of Ni, a content of Co and a

content of Fe of the nickel-cobalt-iron diffusion layer are determined based on a Ni intensity, a Co intensity and a Fe intensity each sequentially measured in the depth direction from the surface side of the nickel-cobalt-iron diffusion layer by a radio frequency glow discharge optical emission spectrometry, a content of Co at a specific depth position D, In_{Co_D}, is 8.59% by mass or higher and 65% by mass or lower, a content of Fe at the specific depth position D, In_{Fe_D}, is 18% by mass or higher and 70% by mass or lower, a content of Ni at the specific depth position D, In_{Ni_D}, is 5% by mass or higher and 60% by mass or lower, the specific depth position D being a position where the Ni intensity is 0.5% of the maximum value of the Ni intensity, and the total content of nickel and cobalt in the nickel-cobalt-iron diffusion layer is 10.0 g/m^2 or lower.

[0009] In the surface-treated steel sheet according to the present disclosure, it is preferable that the nickel-cobalt-iron diffusion layer have a content of cobalt of 0.2 g/m^2 or higher.

In the surface-treated steel sheet according to the present disclosure, it is preferable that the nickel-cobalt-iron diffusion layer has $R_{Fe/Co}$ (In_{Fe_D}/In_{Co_D}) of 0.5 to 20, the $R_{Fe/Co}$ (In_{Fe_D}/In_{Co_D}) being a ratio of the content of Fe, In_{Fe_D}, with respect to the content of Co, In_{Co_D}.

It is preferable that the surface-treated steel sheet according to the present disclosure further comprise an iron-nickel diffusion layer between the steel sheet and the nickel-cobalt-iron diffusion layer.

[0010] According to another aspect of the present disclosure, there is provided a battery case comprising a surface-treated steel sheet as defined herein.

According to another aspect of the present disclosure, there is further provided a battery comprising a battery case as defined herein.

[0011] According to another example of the present disclosure, there is also provided a method for manufacturing a surface-treated steel sheet comprising a step of forming a nickel plating layer having a content of nickel of lower than 11.0 g/m^2 on a steel sheet, a step of forming a nickel-cobalt alloy plating layer having a total content of nickel and cobalt of 7.5 g/m^2 or lower on the nickel plating layer, and a step of subjecting the steel sheet having the nickel plating layer and the nickel-cobalt alloy plating

layer formed thereon to a heat treatment at a temperature of 480 to 900°C to thereby form a nickel-cobalt-iron diffusion layer as an outermost surface layer. At this time, it is preferable that the total content of nickel and cobalt of the nickel plating layer and the nickel-cobalt alloy plating layer be 11.5 g/m^2 or lower.

[0012] According to another example of the present disclosure, there is further provided a method for manufacturing a surface-treated steel sheet comprising a step of forming a nickel-cobalt alloy plating layer having a total content of nickel and cobalt of 11.5 g/m^2 or lower on a steel sheet, and

a step of subjecting the steel sheet having the nickel-cobalt alloy plating layer formed thereon to a heat treatment at a temperature of 480 to 900°C to thereby form a nickel-cobalt-iron diffusion layer as an outermost surface layer.

EFFECTS OF DISCLOSURE

[0013] According to the present disclosure, there can be provided a surface-treated steel sheet which is excellent in battery characteristics and can suppress impairing the battery characteristics also after lapse of time when used as a battery case of a battery using a strong alkaline electrolyte solution. According to the present disclosure, there can be also provided a method for manufacturing such a surface-treated steel sheet.

BRIEF DESCRIPTION OF DRAWINGS

[0014] Figure 1 is a perspective view illustrating one embodiment of a battery to which the surface-treated steel sheet according to the present invention is applied.

Figure 2 is a cross-sectional view taken along line II-II of Figure 1.

CLAIMS

1. A surface-treated steel sheet, comprising:

a steel sheet; and

a nickel-cobalt-iron diffusion layer formed as an outermost surface layer on the steel sheet,

wherein when a content of Ni, a content of Co and a content of Fe of the nickel-cobalt-iron diffusion layer are determined based on a Ni intensity, a Co intensity and a Fe intensity each sequentially measured in the depth direction from the surface side of the nickel-cobalt-iron diffusion layer by a radio frequency glow discharge optical emission spectrometry, a content of Co at a specific depth position D, In_{Co_D}, is 8.59% by mass or higher and 65% by mass or lower, a content of Fe at the specific depth position D, In_{Fe_D}, is 18% by mass or higher and 70% by mass or lower, a content of Ni at the specific depth position D, In_{Ni_D}, is 5% by mass or higher and 60% by mass or lower , the specific depth position D being a position where the Ni intensity is 0.5% of the maximum value of the Ni intensity, and the total content of nickel and cobalt in the nickel-cobalt-iron diffusion layer is 10.0 g/m^2 or lower.

2. The surface-treated steel sheet according to claim 1, wherein the nickel-cobalt-iron diffusion layer has a content of cobalt of 0.2 g/m^2 or higher.

3. The surface-treated steel sheet according to claim 1 or 2, wherein the nickel-cobalt-iron diffusion layer has $R_{Fe/Co}$ (In_{Fe_D}/In_{Co_D}) of 0.5 to 20, the $R_{Fe/Co}$ (In_{Fe_D}/In_{Co_D}) being a ratio of the content of Fe, In_{Fe_D}, with respect to the content of Co, In_{Co_D}.

4. The surface-treated steel sheet according to any one of claims 1 to 3, further comprising an iron-nickel diffusion layer between the steel sheet and the nickel-cobalt-iron diffusion layer.

5. A battery case comprising a surface-treated steel sheet according to any one of claims 1 to 4.

6. A battery comprising a battery case according to claim 5.

7. A method for manufacturing the surface-treated steel sheet according to any one of claims 1 to 4, comprising:

a step of forming a nickel plating layer having a content of nickel of lower than 11.0 g/m^2 on a steel sheet;

a step of forming a nickel-cobalt alloy plating layer having a total content of nickel and cobalt of 7.5 g/m^2 or lower on the nickel plating layer; and

a step of subjecting the steel sheet having the nickel plating layer and the nickel-cobalt alloy plating layer formed thereon to a heat treatment at a temperature of 480 to 900°C to thereby form a nickel-cobalt-iron diffusion layer as an outermost surface layer.

8. A method for manufacturing the surface-treated steel sheet according to any one of claims 1 to 4, comprising:

a step of forming a nickel-cobalt alloy plating layer having a total content of nickel and cobalt of 11.5 g/m^2 or lower on a steel sheet, and

a step of subjecting the steel sheet having the nickel-cobalt alloy plating layer formed thereon to a heat treatment at a temperature of 480 to 900°C to thereby form a nickel-cobalt-iron diffusion layer as an outermost surface layer.