

SPECIFICATION

TITLE OF INVENTION: HOT-DIP PLATED STEEL SHEET

Technical Field

[0001]

5 The present invention relates to a hot-dip plated steel sheet.

 Priority is claimed on Japanese Patent Application No. 2022-094358, filed June 10, 2022, the content of which is incorporated herein by reference.

Background Art

[0002]

10 Hot-dip plated steel sheets have excellent corrosion resistance, and among them, a Zn-Al-Mg-based hot-dip plated steel sheet has particularly excellent corrosion resistance. Such a hot-dip plated steel sheet is widely used in various manufacturing industries such as building materials, home electric appliances, and automobile fields, and the use amount thereof has increased in recent years.

15 [0003]

 Incidentally, there is a case where characters, design drawings, and the like are displayed on a surface of a hot-dip plated layer of a hot-dip plated steel sheet by subjecting the hot-dip plated layer to a step such as printing or coating for the purpose of displaying characters, design drawings, and the like on the surface of the hot-dip plated
20 layer.

[0004]

 However, when steps such as printing and coating are performed on the hot-dip plated layer, there is a problem in that the cost and time for applying characters, designs, and the like increase. Furthermore, when characters, designs, and the like are displayed
25 on the surface of the plated layer by printing or coating, not only is the metallic gloss

external appearance favored by consumers lost, but durability is also poor due to problems of degradation of the coating film itself with time and degradation of adhesion of the coating film with time, and characters, designs, and the like may disappear over time. Furthermore, when characters, designs, and the like are displayed on the surface of the plated layer by stamping the ink, cost and time are relatively suppressed, but corrosion resistance of the hot-dip plated layer may be reduced by the ink.

[0005]

As shown in the following Patent Documents, various technical developments have been made in the field of Zn-Al-Mg-based hot-dip plated steel sheets, but there is no known technique for improving the durability when characters, designs, and the like are displayed on the surface of a plated layer.

[0006]

Regarding Zn-Al-Mg-based hot-dip plated steel sheets, there are prior art techniques aimed at improving the satin-like plating appearance of these Zn-Al-Mg-based hot-dip plated steel sheets to make them more beautiful.

[0007]

For example, Patent Document 1 describes a Zn-Al-Mg-based hot-dip plated steel sheet having a satin-like external appearance with fine texture and many smooth glossy portions, that is, a Zn-Al-Mg-based hot-dip plated steel sheet having a good satin-like external appearance in which the number of white portions per unit area is large and the ratio of the area of the glossy portions is large. In addition, Patent Document 1 describes that an unfavorable satin state is a state where a surface appearance in which indefinite white portions and circular glossy portions are mixed and scattered on the surface is exhibited.

[0008]

In addition, Patent Document 2 describes a Zn-Al-Mg-based plated steel sheet in which, in a cross section of a plated layer in a thickness direction, a part where Al crystals are not present between an interface between the plated layer and a base metal and a plated surface layer occupies 10% to 50% of a length of the cross section in a width direction, thereby improving plating appearance.

[0009]

Further, Patent Document 3 describes a hot-dip galvanized steel sheet having excellent formability, in which a center line average roughness Ra of a surface of the plated steel sheet is 0.5 to 1.5 μm , a PPI (the number of peaks having a size of 1.27 μm or more included per 1 inch (2.54 cm)) is 150 to 300, and Pc (the number of peaks having a size of 0.5 μm or more included per 1 cm) is $Pc \geq PPI/2.54 + 10$.

[0010]

Furthermore, Patent Document 4 describes a highly corrosion-resistant hot-dip galvanized steel sheet in which a ternary eutectic structure of Al/MgZn₂/Zn is refined to increase glossiness of a plated layer as a whole and improve external appearance evenness.

[0011]

However, a technique for improving the durability and preventing the corrosion resistance from being lowered when characters or the like are displayed on the surface of the plated layer is not conventionally known.

Citation List

Patent Document

[0012]

Patent Document 1

Japanese Patent No. 5043234

Patent Document 2

Japanese Patent No. 5141899

Patent Document 3

Japanese Patent No. 3600804

5 Patent Document 4

PCT International Publication No. WO 2013/002358

Summary of Invention

Technical Problem

[0013]

10 The present invention has been made in view of the above circumstances, and an object of the present invention is to provide a hot-dip plated steel sheet which can display characters, designs, and the like on the surface of a plated layer, has excellent durability thereof, and also has excellent corrosion resistance.

Solution to Problem

15 [0014]

The gist of the present invention is as follows.

[1] A hot-dip plated steel sheet, including:

a steel sheet; and a hot-dip plated layer formed on a surface of the steel sheet, in which

20 the hot-dip plated layer, in terms of average composition, contains 5 to 22 mass% of Al and 1.0 to 10 mass% of Mg with a remainder including Zn and impurities, the hot-dip plated layer includes a pattern portion and a non-pattern portion, the pattern portion and the non-pattern portion each includes one or two of a first region and a second region obtained by the following measurement method, and

25 an absolute value of a difference between an area fraction of the first region in

the pattern portion and an area fraction of the first region in the non-pattern portion is 30% or more.

[Measurement Method]

Assuming that a thickness of the hot-dip plated layer is t , a cross section of 1 to 5 mm square parallel to a surface of the hot-dip plated layer is exposed at any position of $3t/4$ position, $t/2$ position, or $t/4$ position from the surface of the hot-dip plated layer, virtual lattice lines are drawn at intervals of 0.5 mm on each of the cross sections, a region in which a proportion (B/A (%)) of an area fraction B of a [Zn phase] to a total area fraction A of the [Zn phase] and an [Al/MgZn₂/Zn ternary eutectic structure] is 20% or more in each of a plurality of regions partitioned by the virtual lattice lines is defined as the first region, and a region in which the proportion (B/A (%)) is less than 20% is defined as the second region.

[2] A hot-dip plated steel sheet, including:

a steel sheet and a hot-dip plated layer formed on a surface of the steel sheet, in which

the hot-dip plated layer, in terms of average composition, contains 5 to 22 mass% of Al and 1.0 to 10 mass% of Mg with a remainder including Zn and impurities,

the hot-dip plated layer further contains one or two selected from the group consisting of a group A and a group B below,

the hot-dip plated layer includes a pattern portion and a non-pattern portion,

the pattern portion and the non-pattern portion each includes one or two of a first region and a second region obtained by the following measurement method, and

an absolute value of a difference between an area fraction of the first region in the pattern portion and an area fraction of the first region in the non-pattern portion is

30% or more.

[Group A] Si: 0.0001 to 2 mass%

[Group B] 0.0001 to 2 mass% in total of one or more of Ni, Ti, Zr, Sr, Fe, Sb, Pb, Sn, Ca, Co, Mn, P, B, Bi, Cr, Sc, Y, REM, Hf, and C

[Measurement Method]

5 Assuming that a thickness of the hot-dip plated layer is t , a cross section of 1 to 5 mm square parallel to a surface of the hot-dip plated layer is exposed at any position of $3t/4$ position, $t/2$ position, or $t/4$ position from the surface of the hot-dip plated layer, virtual lattice lines are drawn at intervals of 0.5 mm on each of the cross sections, a region in which a proportion (B/A (%)) of an area fraction B of a [Zn phase] to a total
10 area fraction A of the [Zn phase] and an [Al/MgZn₂/Zn ternary eutectic structure] is 20% or more in each of a plurality of regions partitioned by the virtual lattice lines is defined as the first region, and a region in which the proportion (B/A (%)) is less than 20% is defined as the second region.

[3] The hot-dip plated steel sheet described in [1] or [2], in which the pattern
15 portion is disposed to have a shape of any one of a straight line portion, a curve portion, a dot portion, a figure, a number, a symbol, and a character, or a combination of two or more thereof.

[4] The hot-dip plated steel sheet described in any one of [1] to [3], in which an
adhesion amount of the hot-dip plated layer is 30 to 600 g/m² in total on both surfaces of
20 the steel sheet.

[5] The hot-dip plated steel sheet described in any one of [2] to [4], in which the hot-dip plated layer has an average composition containing the group A in terms of mass%.

[6] The hot-dip plated steel sheet described in any one of [2] to [5], in which the
25 hot-dip plated layer has an average composition containing the group B in terms of

mass%.

Advantageous Effects of Invention

[0015]

According to the present invention, it is possible to provide a hot-dip plated steel
5 sheet which can present characters, designs, and the like on the surface of a hot-dip
plated layer, which has excellent durability thereof, and which also has excellent
corrosion resistance.

Brief Description of Drawings

[0016]

10 FIG. 1 is a schematic cross-sectional view explaining a cross section (exposed
surface) for measuring a microstructure of plating of a hot-dip plated layer in a Zn-Al-
Mg-based hot-dip plated steel sheet according to an embodiment of the present invention.

FIG. 2 is a perspective view explaining an exposed surface for measuring a
microstructure of plating of a hot-dip plated layer in a Zn-Al-Mg-based hot-dip plated
15 steel sheet according to the embodiment of the present invention.

FIG. 3 is a schematic view of a first region and a second region of a Zn-Al-Mg-
based hot-dip plated steel sheet according to the embodiment of the present invention.

FIG. 4 is a schematic view of a metal sheet having a lattice shape used for
transferring Zn powder to a sheet surface of Example.

20 Description of Embodiments

[0017]

The present inventors investigated in detail a plated layer of a Zn-Al-Mg-based
hot-dip plated steel sheet having a satin-like external appearance. The satin-like
external appearance is provided by a mixture of a fine metallic glossy part exhibiting
25 metallic gloss and a fine white part exhibiting white. Among them, when the

microstructure of the plated layer in the metallic glossy part was examined, it was found that the area fraction of the [Zn phase] on the surface of the plated layer was smaller than that in the white part. On the other hand, when the microstructure of the plated layer in the white part was examined, it was found that the ratio of the [Zn phase] to the

5 [Al/MgZn₂/Zn ternary eutectic structure] was higher than that in the metallic glossy part.

[0018]

Therefore, the present inventors studied whether it is possible to control the distribution state of the metallic glossy part and the white part in the hot-dip plated layer, and found that a region including a relatively large number of metallic glossy parts can

10 be intentionally disposed on the surface of the hot-dip plated layer by adjusting the chemical composition of the hot-dip plated layer and performing hot-dip plating after disposing a region having relatively low cleanliness on the sheet surface into an intentional shape before immersing the steel sheet in a hot-dip plating bath, thereby completing the present invention.

15 [0019]

Hereinafter, the hot-dip plated steel sheet according to an embodiment of the present invention will be described.

As shown in FIGS. 1 to 3, the hot-dip plated steel sheet of the present embodiment is a hot-dip plated steel sheet including: a steel sheet 1; and a hot-dip plated

20 layer 2 formed on a surface of the steel sheet 1, the hot-dip plated layer 2, in terms of average composition, contains 5 to 22 mass% of Al and 1 to 10 mass% of Mg with the remainder including Zn and impurities, the hot-dip plated layer 2 includes a pattern portion 21 and a non-pattern portion 22, the pattern portion 21 and the non-pattern portion 22 each includes one or two of a first region A1 and a second region A2 obtained

25 by the following measurement method, and the absolute value of the difference between

the area fraction of the first region A1 in the pattern portion 21 and the area fraction of the first region A1 in the non-pattern portion 22 is 30% or more.

[0020]

The method for measuring the area fraction of the first region A1 in the pattern portion 21 and the area fraction of the first region A1 in the non-pattern portion 22 is as follows. Assuming that the thickness of the hot-dip plated layer 2 is t , a cross section of 1 to 5 mm square parallel to a surface 2a of the hot-dip plated layer 2 is exposed at any position of $3t/4$ position, $t/2$ position, or $t/4$ position from the surface of hot-dip plated layer 2. Then, as shown in FIG. 3, virtual lattice lines are drawn at intervals of 0.5 mm in each cross section, and in each of a plurality of regions partitioned by the virtual lattice lines, a region in which a proportion (B/A (%)) of an area fraction B of the [Zn phase] to a total area fraction A of the [Zn phase] and the [Al/MgZn₂/Zn ternary eutectic structure] is 20% or more is defined as the first region A1, and a region in which the proportion (B/A (%)) is less than 20% is defined as the second region A2.

The exposed surface for measurement shown in FIG. 3 is a square of 5 mm square. In the exposed surface, the number of regions partitioned by the virtual lattice line is 100. When the pattern portion is small and an exposed surface of 5 mm square cannot be formed inside the pattern portion, the size of the exposed surface may be reduced. In this case, a plurality of exposed surfaces are formed, whereby the total value of the number of regions partitioned by the virtual lattice line is set to 100. For example, when the exposed surface is a square of 1 mm square, the number of regions partitioned by the virtual lattice line in one exposed surface is four. When the exposed surface of 1 mm square is formed at 25 locations, the total value of the number of regions partitioned by the virtual lattice line is 100.

Note that the number of pattern portions may be two or more. In this case, the

exposed surface for measurement may be formed on each of the plurality of pattern portions.

When the pattern portion is extremely narrow and the number of regions partitioned by the virtual lattice lines cannot be set to 100, the interval between the virtual lattice lines may be narrowed. For example, the interval between the virtual lattice lines may be changed to a value of 0.2 mm or more and less than 0.5 mm. By narrowing the interval between the virtual lattice lines, the number of regions (that is, measurement points) partitioned by the virtual lattice lines can be set to 100 inside the extremely narrow pattern portion.

When a plurality of exposed surfaces are formed inside the pattern portion, the distance between the exposed surfaces is reduced as much as possible. A plurality of exposed surfaces formed inside the pattern portion may be in contact with each other. Even when a plurality of exposed surfaces are formed inside the non-pattern portion, the distance between the plurality of exposed surfaces is preferably reduced as much as possible, and the plurality of exposed surfaces may be in contact with each other.

In addition, when the area fraction of the first region A1 in the pattern portion 21 and the area fraction of the first region A1 in the non-pattern portion 22 are measured, it is preferable to reduce the distance between the exposed surface formed inside the pattern portion and the exposed surface formed inside the non-pattern portion as much as possible.

[0021]

In the hot-dip plated steel sheet of the present embodiment, when a cross section of 1 to 5 mm square is exposed at any position of $3t/4$ position, $t/2$ position, or $t/4$ position from the surface of the hot-dip plated layer 2, and virtual lattice lines are drawn at intervals of 0.5 mm in the cross section, a plurality of regions partitioned by the virtual

lattice lines are divided into either the first region A1 or the second region A2. Which region is divided into the first region A1 and the second region A2 is determined according to the proportion (B/A (%)) of the area fraction B of the [Zn phase] to the total area fraction A of the [Zn phase] and the [Al/MgZn₂/Zn ternary eutectic structure].

5 [0022]

The first region A1 is a region where the proportion (B/A (%)) is 20% or more. Since the proportion (B/A (%)) of the first region A1 is high, a location including a large number of the first regions in the hot-dip plated layer 2 looks white or nearly white when observed with the naked eye or under a microscope. On the other hand, the second
 10 region A2 is a region in which the proportion (B/A (%)) is less than 20%. Since the proportion (B/A (%)) of the second region A2 is low, a location where a large number of the second regions A2 is included and the number of first regions A1 is reduced in the hot-dip plated layer looks like the location has a metallic gloss when observed with the naked eye or under a microscope. Further, the external appearance of a location where
 15 the first region A1 and the second region A2 are mixed and the area fraction of the first region A1 is 30 to 70% looks satin-like.

[0023]

As described above, depending on the area fraction of the first region A1, the surface 2a of the hot-dip plated layer 2 looks white or nearly white, metallic glossy, or
 20 satin-like. Here, in order to make characters, figures, lines, dots, and the like visible on the surface 2a of the hot-dip plated layer 2, it is only required that the pattern portions 21 constituting these characters and the like and the other non-pattern portions 22 can be identified. For this purpose, the area percentage of the first region A1 in the pattern portion 21 and the area percentage of the first region A1 in the non-pattern portion 22
 25 may be different.

[0024]

Specifically, the difference between the area fraction of the first region A1 in the pattern portion 21 and the area fraction of the first region A1 in the non-pattern portion 22 is preferably 30% or more in absolute value. Thus, the pattern portion 21 and the non-pattern portion 22 can be identified from each other. When the difference in area fraction is evaluated, it is not necessary to evaluate the entire region of the pattern portion 21 and the non-pattern portion 22. As shown in FIG. 3, the area fraction of the first region A1 in a 1 to 5 mm square surface (exposed surface) for measurement provided inside the pattern portion 21 can be regarded as the area fraction of the first region A1 in the entire pattern portion 21. Similarly, the area fraction of the first region A1 in a 1 to 5 mm square surface (exposed surface) for measurement provided inside the non-pattern portion 22 can be regarded as the area fraction of the first region A1 in the entire non-pattern portion 22.

From the viewpoint of further improving the visibility of the pattern portion 21, the absolute value of the difference between the area fraction of the first region A1 in the pattern portion 21 and the area fraction of the first region A1 in the non-pattern portion 22 may be 40% or more, 45% or more, or 50% or more. Although it is not necessary to provide an upper limit of the absolute value of the difference between the area fraction of the first region A1 in the pattern portion 21 and the area fraction of the first region A1 in the non-pattern portion 22, for example, the absolute value of the difference between the area fraction of the first region A1 in the pattern portion 21 and the area fraction of the first region A1 in the non-pattern portion 22 may be 95% or less, 90% or less, or 85% or less.

[0025]

For example, when the area percentage of the first region A1 in the pattern

portion 21 is 75%, the pattern portion 21 looks white or nearly white. In addition, when the area percentage of the first region A1 in the non-pattern portion 22 is 45% or less, the first region A1 looks satin-like or metallic glossy. When the difference in area fraction between the first regions A1 in the pattern portion 21 and the non-pattern portion 22 is 30% or more, the pattern portion 21 and the non-pattern portion 22 can be identified from each other due to such a difference in external appearance.

[0026]

When the area percentage of the first region A1 of the pattern portion 21 is approximately 65% and the area fraction of the first region A1 of the non-pattern portion 22 is approximately 35%, although both the pattern portion 21 and the non-pattern portion 22 look satin-like, since the area fraction of the first region A1 in the pattern portion 21 is large, the pattern portion 21 has a whiter appearance than the non-pattern portion 22. When the difference in area fraction between the first regions A1 in the pattern portion 21 and the non-pattern portion 22 is 30% or more, the pattern portion 21 and the non-pattern portion 22 can be identified from each other due to such a difference in external appearance.

[0027]

Furthermore, when the first region A1 of the pattern portion 21 is 50%, the pattern portion 21 looks satin-like. In addition, when the area fraction of the first region A1 in the non-pattern portion 22 is 20% or less, the first region A1 looks satin-like or metallic glossy. When the difference in area fraction between the first regions A1 in the pattern portion 21 and the non-pattern portion 22 is 30% or more, the pattern portion 21 and the non-pattern portion 22 can be identified from each other due to such a difference in external appearance.

[0028]

As described above, when the difference between the area fraction of the first region A1 in the pattern portion 21 and the area fraction of the first region A1 in the non-pattern portion 22 is 30% or more in absolute value, external appearances of the pattern portion 21 and the non-pattern portion 22 become different, and thus the pattern portion 21 can be clearly identified. That is, in the visible-light image of the surface 2a of the plated layer 2, the difference in hue, luminosity, saturation, and the like between the pattern portion 21 and the non-pattern portion 22 increases, and thus the pattern portion 21 and the non-pattern portion 22 can be identified.

[0029]

On the other hand, when the difference between the area fraction of the first region A1 in the pattern portion 21 and the area fraction of the first region A1 in the non-pattern portion 22 is less than 30% in absolute value, there is no difference in external appearance between the pattern portion 21 and the non-pattern portion 22, and the pattern portion 21 cannot be clearly identified. That is, in the visible-light image of the surface 2a of the plated layer 2, the difference in hue, luminosity, saturation, and the like between the pattern portion 21 and the non-pattern portion 22 decreases, and thus the pattern portion 21 and the non-pattern portion 22 cannot be identified.

[0030]

As described above, an example of an abundance ratio of the first region A1 in the pattern portion 21 and the non-pattern portion 22 has been described. However, it is sufficient that the difference between the area fraction of the first region A1 in the pattern portion 21 and the area fraction of the first region A1 in the non-pattern portion 22 is 30% or more in absolute value, and it is not necessary to limit an existence ratio of the first region A1 in each of the pattern portion 21 and the non-pattern portion 22.

[0031]

The material of the steel sheet as a base of the hot-dip plated layer is not particularly limited. Although details will be described later, general steel or the like can be used as a material without particular limitation, Al-killed steel or some high alloy steel can also be applied, and the shape is also not particularly limited. The hot-dip plated layer according to the present embodiment is formed by applying a hot-dip plating method described later to the steel sheet.

[0032]

Next, the chemical composition of the hot-dip plated layer will be described.

The hot-dip plated layer, in terms of average composition, contains 5 to 22 mass% of Al and 1.0 to 10 mass% of Mg, and contains Zn and impurities as the remainder. Preferably, in terms of average composition, 5 to 22 mass% of Al and 1.0 to 10 mass% of Mg are contained, and the remainder consisting of Zn and impurities.

Further, the hot-dip plated layer may contain at least one or two selected from the group consisting of the following group A and group B.

[Group A] Si: 0.0001 to 2 mass%

[Group B] 0.0001 to 2 mass% in total of one or more of Ni, Ti, Zr, Sr, Fe, Sb, Pb, Sn, Ca, Co, Mn, P, B, Bi, Cr, Sc, Y, REM, Hf, and C

[0033]

The content of Al is in the range of 5 to 22 mass% in terms of average composition. Al may be contained in order to ensure corrosion resistance. When the content of Al in the hot-dip plated layer is 5 mass% or more, the effect of improving corrosion resistance is further enhanced. When the content is 22 mass% or less, the plated layer can be stably formed. When the content is more than 22 mass%, the effect of improving corrosion resistance is saturated. The content of Al is more preferably 6 mass% or more, 8 mass% or more, or 11 mass% or more from the viewpoint of corrosion

resistance. The content of Al is more preferably 20 mass% or less, 19 mass% or less, or 17 mass% or less from the viewpoint of corrosion resistance.

[0034]

The content of Mg is in the range of 1.0 to 10 mass% in terms of average composition. Mg may be contained in order to improve corrosion resistance. When the content of Mg in the hot-dip plated layer is 1.0 mass% or more, the effect of improving corrosion resistance is further enhanced. When the content is more than 10 mass%, dross is generated significantly in the plating bath, and it is difficult to stably manufacture a hot-dip plated steel sheet. The content of Mg is preferably 1.5 mass% or more, 2 mass% or more, or 4 mass% or more from the viewpoint of the balance between corrosion resistance and dross generation. The content of Mg is preferably 8 mass% or less, 7 mass% or less, or 6 mass% or less from the viewpoint of the balance between corrosion resistance and dross generation.

[0035]

The hot-dip plated layer may contain Si in the range of 0.0001 to 2 mass%. Si may be contained because Si may improve adhesion of the hot-dip plated layer. When Si is contained in an amount of 0.0001 mass% or more, an effect of improving adhesion is exhibited, and therefore Si is preferably contained in an amount of 0.0001 mass% or more. On the other hand, even when Si is contained in an amount exceeding 2 mass%, the effect of improving plating adhesion is saturated, and therefore the content of Si is set to 2 mass% or less. The content of Si is preferably 0.0100 mass% or more, 0.0300 mass% or more, or 0.1000 mass% or more from the viewpoint of plating adhesion. The content of Si may be 1 mass% or less, 0.9 mass% or less, or 0.8 mass%.

[0036]

The hot-dip plated layer may contain, in terms of average composition, 0.0001

to 2 mass% in total of one or more of Ni, Ti, Zr, Sr, Fe, Sb, Pb, Sn, Ca, Co, Mn, P, B, Bi, Cr, Sc, Y, REM, Hf, and C. By containing these elements, corrosion resistance can be further improved. REM is one or more of rare earth elements of atomic number 57 to 71 in the periodic table.

5 [0037]

The remainder of the chemical composition of the hot-dip plated layer is zinc and impurities. Examples of impurities include impurities inevitably contained in base metals such as zinc, and impurities contained when steel is melted in a plating bath.

[0038]

10 The average composition of the hot-dip plated layer can be measured by the following method. First, the surface layer coating film is removed with a coating film peeling agent (for example, NEOREVER SP-751 manufactured by Sansai Kako Co. Ltd.) that does not erode plating, then the hot-dip plated layer is melted with hydrochloric acid containing an inhibitor (for example, HIBIRON manufactured by Sugimura
15 Chemical Industry Co., Ltd.), and the obtained solution is subjected to inductively coupled plasma (ICP) emission spectrometry, whereby the surface layer coating film can be obtained. In addition, when there is no surface layer coating film, the work of removing the surface layer coating film can be omitted.

[0039]

20 Next, the microstructure of the hot-dip plated layer will be described. The hot-dip plated layer containing Al, Mg, and Zn contains the [Al phase] and the [Al/Zn/MgZn₂ ternary eutectic structure]. The [Al phase] is included in the base material of [Al/Zn/MgZn₂ ternary eutectic structure]. Further, the base material of the [Al/Zn/MgZn₂ ternary eutectic structure] includes the [MgZn₂ phase] or the [Zn phase].

25 When Si is added, the [Mg₂Si phase] may be contained in the base material of

[Al/Zn/MgZn₂ ternary eutectic structure].

[0040]

Here, the [Al/Zn/MgZn₂ ternary eutectic structure] is a ternary eutectic structure of an Al phase, a Zn phase, and an intermetallic compound MgZn₂ phase, and the Al phase forming the ternary eutectic structure corresponds to, for example, an “Al” phase” (Al solid solution containing Zn as a solid solution, containing a small amount of Mg) at a high temperature in a ternary system equilibrium state diagram of Al-Zn-Mg. The Al” phase at a high temperature is usually displayed as a fine Al phase and a fine Zn phase that are separated at room temperature. The Zn phase in the ternary eutectic structure is a Zn solid solution in which a small amount of Al is solid-solved, and in some cases, a further small amount of Mg is solid-solved. The MgZn₂ phase in the ternary eutectic structure is an intermetallic compound phase present in the vicinity of Zn: approximately 84 mass% in the binary equilibrium state diagram of Zn-Mg. As far as can be seen from the phase diagram, other additive elements are not solid-solved in each phase, or even when the additive elements are solid-solved, the amount thereof is considered to be extremely small but the amount thereof cannot be clearly distinguished by normal analysis. Therefore, a ternary eutectic structure consisting of these three phases is referred to as [Al/Zn/MgZn₂ ternary eutectic structure] in the present specification.

[0041]

In addition, the [Al phase] is a phase that looks like an island with a clear boundary in the base material of the ternary eutectic structure, and this corresponds to, for example, the Al” phase (Al solid solution containing Zn as a solid solution, containing a small amount of Mg) at a high temperature in the ternary system equilibrium state diagram of Al-Zn-Mg.

The Al” phase at a high temperature has a difference in the amount of Zn or Mg

to be solid-solved depending on the Al or Mg concentrations of the plating bath. The Al'' phase at a high temperature is usually separated into a fine Al phase and a fine Zn phase at room temperature, but the island-like shape seen at room temperature may be considered to retain the shape of the Al'' phase at a high temperature. As far as can be seen from the phase diagram, other additive elements are not solid-solved in this phase, or even when the additive elements are solid-solved, the amount thereof is considered to be extremely small but the amount thereof cannot be clearly distinguished by normal analysis. Therefore, a phase derived from the Al'' phase at a high temperature and shape-wisely retaining a form of the Al'' phase is referred to as an [Al phase] in the present specification. This [Al phase] can be clearly distinguished from the Al phase forming the ternary eutectic structure under microscopic observation.

[0042]

In addition, the [Zn phase] is a phase that looks like an island with a clear boundary in the base material of the ternary eutectic structure, and actually, a small amount of Al or a small amount of Mg may be solid-solved. As far as can be seen from the phase diagram, other additive elements are not solid-solved in this phase, or even when the additive elements are solid-solved, the amount thereof is considered to be extremely small. This [Zn phase] is a region having a circle equivalent diameter of 2.5 μm or more, and can be clearly distinguished from the Zn phase forming the ternary eutectic structure under microscopic observation.

[0043]

In addition, the [MgZn₂ phase] is a phase that looks like an island with a clear boundary in the base material of the ternary eutectic structure, and actually, a small amount of Al may be solid-solved. As far as can be seen from the phase diagram, other additive elements are not solid-solved in this phase, or even when the additive elements

are solid-solved, the amount thereof is considered to be extremely small. This [MgZn₂ phase] can be clearly distinguished from the MgZn₂ phase forming the ternary eutectic structure under microscopic observation. The plated layer of the present invention may not contain the [MgZn₂ phase] depending on the manufacturing conditions, but the
5 [MgZn₂ phase] is contained in the plated layer under most manufacturing conditions.
[0044]

In addition, the [Mg₂Si phase] is a phase that looks like an island with a clear boundary in the solidified microstructure of the plated layer when Si is added. As far as can be seen from the phase diagram, Zn, Al, and other additive elements are not solid-
10 solved in this phase, or even when Zn, Al, and other additive elements are solid-solved, the amount thereof is considered to be extremely small. This [Mg₂Si phase] can be clearly distinguished under microscopic observation during plating.
[0045]

Next, the pattern portion, the non-pattern portion, the first region, and the second
15 region on the surface layer of the hot-dip plated layer will be described.
[0046]

The pattern portion and the non-pattern portion are formed on the surface of the hot-dip plated layer of the present embodiment. From the viewpoint of ensuring the aesthetic appearance of the pattern portion, the pattern portion is preferably disposed to
20 have a predetermined shape. From the viewpoint of ensuring the visibility of the pattern portion, the size of the pattern portion is preferably as large as possible. For example, the pattern portion preferably has an artificial shape. The pattern portion is preferably disposed in an intentional shape. The pattern portion is preferably disposed to have a shape of any one of a straight line portion, a curve portion, a dot portion, a figure, a
25 number, a symbol, and a character, or a combination of two or more thereof. For

example, a character string, a numeric string, a symbol, a mark, a diagram, a design drawing, a combination thereof, or the like including a pattern portion appears on the surface of the hot-dip plated layer. Each of the straight line portion and the curve portion in the pattern portion preferably has a length of 1 mm or more. By showing
5 these shapes, it can be said that the pattern portion is intentionally formed. The straight line portion and the curve portion in the pattern portion preferably have a width that can be visually recognized as described later, and each has a length of 1 mm or more. The dot portion in the pattern portion preferably has a circle equivalent diameter of 1 mm or more and less than 10 mm, and more preferably, a plurality of dot portions are regularly
10 arranged. When the pattern portion is a figure, a number, a symbol, a pattern, or a character, it is preferable that these shapes can be visually recognized as described later. By showing such dimensions and shapes, it can be said that the pattern portion is formed more intentionally. The non-pattern portion is a region other than the pattern portion. The shape of the pattern portion is allowed as long as the pattern portion can be
15 recognized as a whole even when a part of the pattern portion is missing like dot missing. The non-pattern portion may have a shape that borders a boundary of the pattern portion. [0047]

When any one of a straight line portion, a curve portion, a dot portion, a figure, a number, a symbol, and a character, or a combination of two or more of these shapes are
20 disposed on the surface of the hot-dip plated layer, these regions can be used as pattern portions, and the other regions can be used as non-pattern portions. This shape is a shape intentionally or artificially formed by a manufacturing method to be described later, and is not formed naturally.

The boundary between the pattern portion and the non-pattern portion can be
25 grasped with the naked eye. The boundary between the pattern portion and the non-

pattern portion may be grasped from an enlarged image by an optical microscope, a magnifying glass, or the like.

[0048]

The pattern portion may be formed in such a size that the presence of the pattern
5 portion can be determined with the naked eye, under a magnifying glass, or under a microscope. The non-pattern portion is a region that occupies most of the hot-dip plated layer (the surface of the hot-dip plated layer).

The pattern portion is disposed in the non-pattern portion. Specifically, in the non-pattern portion, the pattern portion is disposed to have a shape of any one of a
10 straight line portion, a curve portion, a figure, a dot portion, a figure, a number, a symbol, and a character, or a combination of two or more thereof. By adjusting the shape of the pattern portion, any one of a straight line portion, a curve portion, a figure, a dot portion, a figure, a number, a symbol, and a character, or a combination of two or more thereof, appears on the surface of the hot-dip plated layer. For example, a character string, a
15 numeric string, a symbol, a mark, a diagram, a design drawing, a combination thereof, or the like including a pattern portion appears on the surface of the hot-dip plated layer. This shape is a shape intentionally or artificially formed by a manufacturing method to be described later, and is not formed naturally. A person skilled in the art who knows the external appearance of an ordinary hot-dip plated layer can easily distinguish between a
20 pattern portion having an artificial shape and a non-pattern portion.

From the viewpoint of improving the visibility of the pattern portion, the area fraction of the pattern portion on the surface of the hot-dip plated layer is preferably significantly smaller than that of the non-pattern portion. For example, the area fraction of the pattern portion on the surface of the hot-dip plated layer is preferably 30% or less,
25 25% or less, 20% or less, or 15% or less.

[0049]

As described above, the pattern portion and the non-pattern portion are regions formed on the surface of the hot-dip plated layer, and the pattern portion and the non-pattern portion each includes one or two of the first region and the second region.

5 [0050]

Since the first region is a region having a proportion (B/A (%)) of 20% or more, a location having a large number of first regions in the hot-dip plated layer looks white or nearly white. On the other hand, since the second region is a region having a proportion (B/A (%)) of less than 20%, a location having a large number of second regions in the
 10 hot-dip plated layer looks like the location has a metallic gloss. In addition, the external appearance of a location where the first region and the second region are dispersed and gathered and the area fraction of the first region is 30 to 70% looks satin-like.

[0051]

The first region and the second region are determined as follows. Assuming
 15 that the thickness of the hot-dip plated layer is t , the hot-dip plated layer is cut out such that exposed surface 3, 4, or 5 parallel to the surface 2a and having a square shape of 1 to 5 mm square in plane view appears at any position of $3t/4$ position, $t/2$ position, or $t/4$ position from the surface of the hot-dip plated layer. Thereby, an exposed surface (cross section) of 1 to 5 mm square parallel to the surface of the hot-dip plated layer is formed.
 20 Virtual lattice lines are drawn at intervals of 0.5 mm on each exposed surface. In each of a plurality of regions partitioned by the virtual lattice lines, a region in which a proportion (B/A (%)) of the area fraction B of the [Zn phase] to the total area fraction A of the [Zn phase] and the [Al/MgZn₂/Zn ternary eutectic structure] is 20% or more is defined as the first region, and a region in which the proportion (B/A (%)) is less than
 25 20% is defined as the second region.

[0052]

Hereinafter, a specific method of determining the first region and the second region will be described.

As shown in FIGS. 1 and 2, the thickness of the hot-dip plated layer 2 formed on the steel sheet 1 is t , and the exposed surface 3, 4, or 5 having a 1 to 5 mm square parallel to the surface at any position of $3t/4$ position, $t/2$ position, or $t/4$ position from the surface 2a of the hot-dip plated layer 2 is formed. When the pattern portion and/or the non-pattern portion is small to such an extent that an exposed surface of 5 mm square cannot be formed inside the pattern portion and/or the non-pattern portion, the shape of the exposed surface may be 1 mm square at the minimum. In this case, the area of the region for measurement is ensured by increasing the number of exposed surfaces.

[0053]

When these exposed surfaces 3, 4, or 5 are formed, the hot-dip plated layer is scraped off by means such as grinding or argon sputtering. In addition, the exposed surface is desirably a mirror surface, and for example, the maximum height R_z of the exposed surface is desirably $0.2\ \mu\text{m}$ or less. The exposed surface to be observed may be an exposed surface at any position of $3t/4$ position, $t/2$ position, and $t/4$ position from the surface of the hot-dip plated layer. An exposed surface preferably at the $t/2$ position may be selected. The B/A proportion obtained on the exposed surface at the $t/2$ position is likely to have an equivalent value at other positions.

[0054]

Next, as shown in FIG. 3, virtual lattice lines are drawn at intervals of 0.5 mm on the exposed surface to be observed, and the proportion (B/A (%)) is measured in each of the plurality of regions partitioned by the virtual lattice lines.

A region having a proportion (B/A (%)) of 20% or more is a first region, and a

region having a proportion (B/A (%)) of less than 20% is a second region.

[0055]

The proportion (B/A (%)) is measured as follows. A microstructure of plating is observed for each region by a secondary electron image of a scanning electron microscope (SEM) to identify the [Zn phase] and the [Al/MgZn₂/Zn ternary eutectic structure]. When each phase and microstructure is identified, elemental analysis by an energy dispersive X-ray elemental analyzer attached to the SEM is used in combination, and the phases and microstructures are identified while the distributions of Zn, Al, and Mg are confirmed. Then, the proportion (B/A (%)) of the area fraction B of the [Zn phase] to the total area fraction A of the [Zn phase] and the [Al/MgZn₂/Zn ternary eutectic structure] is obtained. The [Zn phase] in a region having a circle equivalent diameter of 2.5 μm or more is measured as the [Zn phase]. Thus, the Zn phase and the [Zn phase] in the [Al/MgZn₂/Zn ternary eutectic structure] are distinguished.

[0056]

The pattern portion includes a plurality of regions partitioned by virtual lattice lines, and each region is classified into one of the first region and the second region. The non-pattern portion also includes a plurality of regions partitioned by virtual lattice lines, and each region is classified into one of the first region and the second region. That is, the pattern portion may include only one of the first region and the second region, or may include two types of the first region and the second region. Similarly, the non-pattern portion may include only one of the first region and the second region, or may include two types of the first region and the second region.

[0057]

Here, in the pattern portion, the area percentage of each of the first region and the second region can be obtained. When the area fraction of the first region exceeds

70%, the pattern portion looks white or nearly white. When the area fraction of the first region is 30% or more and 70% or less, the pattern portion looks satin-like. When the area fraction of the first region is less than 30%, the pattern portion looks like the pattern portion has a metallic gloss. As described above, the external appearance of the pattern
5 portion depends on the area fraction of the first region.

[0058]

On the other hand, in the non-pattern portion, the area percentage of each of the first region and the second region can be obtained. Similarly to the pattern portion, the external appearance of the non-pattern portion depends on the area fraction of the first
10 region.

[0059]

When the difference between the area percentage of the first region in the pattern portion and the area fraction of the first region in the non-pattern portion is 30% or more in absolute value, the pattern portion and the non-pattern portion can be
15 identified from each other. When the difference in area percentage is less than 30%, the difference between the area fraction of the first region in the pattern portion and the area fraction of the first region in the non-pattern portion is small, and the external appearance of the pattern portion and the non-pattern portion becomes similar, and it becomes difficult to identify the pattern portion. The larger the difference in area percentage, the
20 better, and the difference is more preferably 40% or more and still more preferably 60% or more.

[0060]

The pattern portion and the non-pattern portion may be visually identifiable with the naked eye, or may be visually identifiable under a magnifying glass or under a
25 microscope. The expression “visually identifiable under a magnifying glass or under a

microscope” means that, for example, the shape constituted by the pattern portion may be visually identifiable in a visual field of 50 times or less. Since the pattern portion has an artificial predetermined shape, the pattern portion and the non-pattern portion can be identified by the difference in external appearance as long as the visual field is 50 times or less. The pattern portion and the non-pattern portion can be identified at preferably 20 times or less, more preferably 10 times or less, and more preferably 5 times or less.

The hot-dip plated steel sheet according to the present embodiment may have a chemical treatment layer or a coating film layer on the surface of the hot-dip plated layer. Here, the types of the chemical treatment layer and the coating film layer are not particularly limited, and known chemical treatment layers and coating film layers can be used.

[0061]

Above, the hot-dip plated steel sheet according to a first embodiment of the present invention has been described. Next, a hot-dip plated steel sheet according to a second embodiment of the present invention will be described. The hot-dip plated steel sheet according to the second embodiment includes: a steel sheet; and a hot-dip plated layer formed on a surface of the steel sheet, the hot-dip plated layer, in terms of average composition, contains 5 to 22 mass% of Al and 1.0 to 10 mass% of Mg with the remainder including Zn and impurities, the surface of the hot-dip plated layer includes one or two of a first region and a second region obtained by the following measurement method, and the absolute value of the difference between the area fraction of the first region in a first part, which is a region of 1.0 mm square or more, and an area fraction of the first region in a second part, which is a region of 1.0 mm square or more adjacent to the first part, is 30% or more.

[Measurement Method]

Assuming that the thickness of the hot-dip plated layer is t , a cross section of 1 to 5 mm square parallel to a surface of the hot-dip plated layer is exposed at any position of $3t/4$ position, $t/2$ position, or $t/4$ position from the surface of the hot-dip plated layer, virtual lattice lines are drawn at intervals of 0.5 mm on each of the cross sections, a

5 region in which the proportion (B/A (%)) of the area fraction B of the [Zn phase] to the total area fraction A of the [Zn phase] and the [Al/MgZn₂/Zn ternary eutectic structure] is 20% or more in each of the plurality of regions partitioned by the virtual lattice lines is defined as the first region, and a region in which the proportion (B/A (%)) is less than 20% is defined as the second region.

10 Components of the steel sheet and the hot-dip plated layer of the hot-dip plated steel sheet according to the second embodiment are the same as those of the hot-dip plated steel sheet according to the first embodiment.

In the hot-dip plated steel sheet according to the second embodiment, the absolute value of the difference between the area fraction of the first region in the first

15 part, which is a region of 1.0 mm square or more, and the area fraction of the first region in the second part, which is a region of 1.0 mm square or more adjacent to the first part, is 30% or more. Here, the “region of 1.0 mm square or more” refers to a region larger than a square of 1.0 mm square. A region in which the entire 1.0 mm square can be included is the “region of 1.0 mm square or more”. According to this feature, the first

20 part and the second part can be clearly identified by the naked eye. By forming the first part and the second part into any shapes, characters, designs, and the like can be displayed on the surface of the plated layer.

[0062]

Next, the method for manufacturing the hot-dip plated steel sheet of the present

25 embodiment will be described.

In order to manufacture the hot-dip plated steel sheet of the present embodiment by a hot-dip plating method, the steel sheet is immersed in a hot-dip plating bath in which the chemical composition is adjusted, thereby making molten metal adhere to the sheet surface. Next, the steel sheet is pulled up from the plating bath, and the molten metal is solidified after the adhesion amount is controlled by gas wiping. During solidification, depending on the composition, the [Al phase] is first formed, and then the [Al/Zn/MgZn₂ ternary eutectic structure] is formed as the temperature of the molten metal decreases. In addition, the [MgZn₂ phase] and the [Zn phase] are formed in the base material of [Al/Zn/MgZn₂ ternary eutectic structure]. Further, when Si is contained in the hot-dip plated layer, the [Mg₂Si phase] is formed in the base material of the [Al/Zn/MgZn₂ ternary eutectic structure].

[0063]

The present inventors have found that when a coarse [Zn phase] is formed during solidification of hot-dip plating, the proportion of the [Al phase] or the [MgZn₂ phase] in the hot-dip plated layer relatively increases, and these phases are exposed to the plating surface, and thus the external appearance of the surface of the hot-dip plated layer exhibits an appearance which is nearly white. It is presumed that the formation of the [Zn phase] is affected by the number of nucleation points of Zn. That is, the present inventors have found that when the number of nucleation points of Zn is small, Zn in the liquid phase immediately before final solidification does not crystallize as a fine Zn phase in [Al/Zn/MgZn₂ ternary eutectic structure] but crystallizes as a coarse [Zn] phase. As means for reducing the number of nucleation points of Zn, it is conceivable to increase the surface cleanliness of the original steel sheet, and to reduce substances that can be nucleation points of Zn as much as possible.

[0064]

On the other hand, when the number of nucleation points of Zn is large, Zn in the liquid phase immediately before final solidification crystallizes as a fine Zn phase in the [Al/Zn/MgZn₂ ternary eutectic structure], and hardly crystallizes as a coarse [Zn] phase, and thus the external appearance of the surface of the hot-dip plated layer exhibits
5 a metallic gloss appearance. As means for increasing the number of nucleation points of Zn, it is conceivable to dispose substances that can be nucleation points of Zn in a predetermined pattern after enhancing the surface cleanliness of the steel sheet.

[0065]

Hereinafter, the method for manufacturing the hot-dip plated steel sheet of the
10 present embodiment will be described in more detail. In the hot-dip plated steel sheet of the present embodiment, treatment for enhancing the cleanliness of the sheet surface is performed, and then regions having low cleanliness are disposed in a predetermined pattern. Then, the manufacturing is performed by immersing and pulling up the steel sheet in a hot-dip plating bath, and then cooling and solidifying the hot-dip plated layer.

15 [0066]

Specifically, first, a hot-rolled steel sheet is manufactured, and hot-band annealing is performed as necessary. After pickling, cold rolling is performed to obtain a cold band. The cold band is degreased and washed with water, and then annealed (cold-band annealing), and the annealed cold band is immersed in a hot-dip plating bath
20 to form a hot-dip plated layer. Here, during the period from the cold rolling to the cold rolled plate annealing, in order to increase the surface cleanliness, the steel sheet is subjected to alkali electrolytic cleaning, washed with pure water, and then dried under an inert atmosphere, and then transferred to the cold-band annealing step. The cold-band annealing is performed within 10 seconds from the end of the alkali electrolytic cleaning.
25 The end of the alkali electrolytic cleaning is the time of extraction of the final spray

water washing with pure water in the alkali electrolytic cleaning. The annealing conditions are not particularly limited.

[0067]

As the cleaning solution used for the alkaline electrolytic cleaning, for example,
5 an alkaline cleaning solution containing sodium hydroxide or potassium hydroxide is preferable. As a procedure of the alkali electrolytic cleaning, the steel sheet is immersed and cleaned in a cleaning solution, and then the steel sheet is electrolytically cleaned in the cleaning solution. The electrolytic cleaning is preferably alternating electrolytic cleaning. Next, pure water is sprayed onto the sheet surface to wash away
10 the adhered cleaning solution. In the spray water washing, a plurality of spray nozzles may be disposed along the traveling direction of the steel sheet, and pure water may be sprayed from each nozzle. The pure water is preferably water having an electric resistivity of $1\text{ M}\Omega\cdot\text{cm}$ or more.

[0068]

15 It is preferable to remove moisture adhering to the sheet surface as much as possible by performing drying in an inert atmosphere after extraction by spray water washing and before annealing from the viewpoint of being able to suppress adhesion of fine floating particles in the air.

[0069]

20 Organic dirt adhering to the sheet surface is removed by alkaline electrolytic cleaning, and the steel sheet is further dried in an inert atmosphere from the end of final spray water washing with pure water to annealing, and then annealed, whereby fine floating particles in the air can be prevented from adhering to the cold band.

[0070]

25 Next, in order to increase the number of nucleation points of Zn during the

period from cold-band annealing to immersion in hot-dip plating, a Zn powder is adhered to the annealed cold band to have a predetermined shape. The adhesion of the Zn powder to the cold band after the annealing may be performed by a method in which the Zn powder is previously adhered to a roll to have a predetermined shape, and the roll is transferred when the annealed cold band passes.

[0071]

The adhered Zn powder is not completely melted during the hot-dip plating, and becomes a nucleation site of Zn at the time of final solidification of plating. Some of the Zn powder is diffused in the plating bath as a solid. It is not preferable that when the Zn powder is adhered before the cold annealing, Zn is alloyed with the steel sheet at the time of annealing, and the formation of the hot-dip plated layer is inhibited. In addition, when the Zn powder is adhered after immersion in a hot-dip plating bath, the adhered Zn powder causes the surface appearance of plating to be rather rough. The Zn powder to be adhered may be a Zn powder containing Zn and impurities. The average grain size of the Zn powder may be, for example, within the range of 4 to 6 μm . The adhesion amount of the Zn powder is preferably, for example, approximately 1 to 5 g/m^2 . When the average grain size and the adhesion amount are within these ranges, the Zn powder can function as a nucleation site for Zn.

[0072]

Next, the steel sheet is immersed in a hot-dip plating bath. The hot-dip plating bath contains 5 to 22 mass% of Al and 1.0 to 10 mass% of Mg, and includes Zn and impurities as the remainder. Further, the hot-dip plating bath may contain 0.0001 to 2 mass% of Si. Furthermore, the hot-dip plating bath may contain any one or more of Ni, Ti, Zr, Sr, Fe, Sb, Pb, Sn, Ca, Co, Mn, P, B, Bi, Cr, Sc, Y, REM, Hf, and C in an amount of 0.0001 to 2 mass% in total.

The hot-dip plating method is a continuous hot-dip plating method in which a steel sheet continuously passes through a hot-dip plating bath.

[0073]

The temperature of the hot-dip plating bath varies depending on the composition, but is preferably, for example, within the range of 400 to 500°C. This is because a desired hot-dip plated layer can be formed when the temperature of the hot-dip plating bath is within this range.

The adhesion amount of the hot-dip plated layer may be adjusted by means such as gas wiping on the steel sheet pulled up from the hot-dip plating bath. The adhesion amount of the hot-dip plated layer is preferably adjusted such that the adhesion amount of both surfaces of the steel sheet falls within the range of 30 to 600 g/m² in total. When the adhesion amount is less than 30 g/m², corrosion resistance of the hot-dip plated steel sheet is deteriorated, which is not preferable. When the adhesion amount exceeds 600 g/m², molten metal adhering to the steel sheet drips, and the surface of the hot-dip plated layer cannot be smoothed, which is not preferable.

[0074]

After adjusting the adhesion amount of the hot-dip plated layer, the steel sheet is cooled. The cooling conditions are not particularly limited. Cooling of the molten metal adhered to the steel sheet is started after the steel sheet is pulled up from the hot-dip plating bath. Depending on the composition of the hot-dip plating bath, for example, the [Al phase] starts to crystallize from around 430°C. Subsequently, the [MgZn₂ phase] starts to crystallize from around 370°C, the [Al/Zn/MgZn₂ ternary eutectic structure] crystallizes from around 340°C, the [Zn phase] further crystallizes, and the solidification is completed.

[0075]

On the sheet surface before hot-dip plating, a Zn powder adhering region to be a nucleation point of Zn is disposed after the cleanliness is increased over the entire surface. Since the Zn powder adhering region contains a large number of nucleation points of Zn, Zn or MgZn_2 as a eutectic structure is crystallized to form many

5 [Al/Zn/ MgZn_2 ternary eutectic structure], and on the other hand, Zn in the liquid phase is reduced to suppress the formation of coarse [Zn phase]. As a result, in the Zn powder adhering region, the proportion (B/A (%)) of the area fraction B of the [Zn phase] to the total area fraction A of the [Zn phase] and the [Al/ MgZn_2 /Zn ternary eutectic structure] becomes low. On the other hand, in a region where the Zn powder is not adhered and
10 the cleanliness remains relatively high, the proportion (B/A (%)) becomes high.

[0076]

In the hot-dip plated steel sheet of the present embodiment, the pattern portion and the non-pattern portion can be identified from each other by setting the absolute value of the difference between the area fraction of the first region in the pattern portion
15 and the area fraction of the first region in the non-pattern portion in the first region and the second region to 30% or more. Since the formed pattern portion and non-pattern portion are not formed by printing or coating, durability is high. In addition, since the pattern portion and the non-pattern portion are not formed by printing or coating, there is no influence on corrosion resistance of the hot-dip plated layer. Further, the pattern
20 portion and the non-pattern portion are not formed by grinding or the like on the surface of the hot-dip plated layer. Therefore, the thickness of the hot-dip plated layer in the pattern portion does not decrease to such an extent that corrosion resistance deteriorates as compared with the thickness of the hot-dip plated layer in the non-pattern portion.

Therefore, the hot-dip plated steel sheet of the present embodiment has excellent

25 corrosion resistance.

[0077]

According to the present embodiment, it is possible to provide a hot-dip plated steel sheet having high durability of a pattern portion and suitable plating characteristics such as corrosion resistance. In particular, in the present embodiment, a roll with Zn powder adhered to a predetermined shape range is pressed against the annealed cold band with increased cleanliness, the surface shape of the roll is transferred to the annealed cold band, and accordingly, after the hot-dip plating, the surface of the hot-dip plated layer can be formed into an intentional or artificial shape in the range of the pattern portion or the non-pattern portion, and the pattern portion can be disposed to have a shape of any one of a straight line portion, a curve portion, a dot portion, a figure, a number, a symbol, or a character, or a combination of two or more of these. As a result, various designs, trademarks, and other identification marks can be represented on the surface of the hot-dip plated layer without performing printing, coating, or grinding, and the identifiability of the source of the steel sheet, the designability, and the like can be improved. In addition, information necessary for process management, inventory management, and the like and any information required by the consumer can also be given to the hot-dip plated steel sheet by the pattern portion.

This can also contribute to improvement in productivity of the hot-dip plated steel sheet.

20 Examples

[0078]

Hereinafter, Examples of the present invention will be described. The steel sheet after cold rolling was subjected to alkali electrolytic cleaning, washed with ultrapure water, and then transferred to the annealing step within 10 seconds under an inert atmosphere. The cleaning solution used for the alkaline electrolytic cleaning was

an alkaline cleaning solution containing sodium hydroxide. As a procedure of the alkali electrolytic cleaning, the steel sheet was immersed in a cleaning solution to perform immersion cleaning, and then the steel sheet was electrolytically cleaned in the cleaning solution. The electrolytic cleaning was alternating electrolytic cleaning. Next, the adhered cleaning solution was washed off by spray water washing with ultrapure water. As the ultrapure water, water having an electric resistivity of $1 \text{ M}\Omega \cdot \text{cm}$ or more was used. Thereafter, after drying in an inert atmosphere, cold-band annealing was performed. The annealing conditions were a soaking temperature of 800°C and a soaking time of 1 minute.

10 [0079]

After the annealing, a Zn powder having an average grain size in a range of 4 to $6 \mu\text{m}$ was adhered to a metal sheet having a shape to which a lattice-like pattern as shown in FIG. 4 was transferred. The line constituting the lattice-like pattern had a thickness of 10 mm. The interval between the central axes of the lines was 50 mm. Then, the metal sheet was pressed against the annealed steel sheet to transfer the Zn powder to the sheet surface, thereby locally forming nucleation sites of Zn (in a lattice shape at intervals of 50 mm). The adhesion amount of the Zn powder was in a range of 1 to 5 g/m^2 . Thereafter, the steel sheet was immersed in a hot-dip plating bath and then pulled up. Thereafter, the adhesion amount was adjusted by gas wiping, and further cooling was performed. In this manner, hot-dip plated steel sheets of No. 1 to No. 51 shown in Tables 1A to 3B were manufactured.

[0080]

However, the Zn powder was not adhered to some of the steel sheets. The steel sheet to which the Zn powder was not adhered was subjected to plating treatment with a hot-dip plating bath under the same conditions as in Nos. 1 to 48 to manufacture a hot-

dip plated steel sheet. A lattice-like pattern at intervals of 50 mm was printed on the surface of the hot-dip plated layer of the steel sheet by an inkjet method. In this manner, a Zn-Al-Mg-based hot-dip plated steel sheet of No. 52 was manufactured.

[0081]

5 In addition, the steel sheet to which the Zn powder was not adhered was subjected to plating treatment with a hot-dip plating bath under the same conditions as in Nos. 1 to 48 to manufacture a hot-dip plated steel sheet. Thereafter, the surface of the hot-dip plated layer was ground to form a lattice-like pattern at intervals of 50 mm. In this manner, a hot-dip plated steel sheet of No. 53 was manufactured.

10 [0082]

For the obtained hot-dip plated steel sheet, the area fractions of the first region and the second region included in the pattern portion and the non-pattern portion were determined. First, the boundary between the pattern portion and the non-pattern portion was identified by observing the surface of the hot-dip plated layer with the naked eye.

15 When it was difficult to identify the boundary with the naked eye, an enlarged image of a magnifying glass or an optical microscope was used. In an example in which it was difficult to determine the boundary, the area fractions of the first region and the second region were evaluated assuming that a location corresponding to the square pattern on the roll surface was a pattern portion.

20 [0083]

Next, the area fraction of each region included in the pattern portion and the non-pattern portion was obtained by a measurement method described below. First, assuming that the thickness of the hot-dip plated layer formed on the steel sheet was t , an exposed surface of 5 mm square parallel to the surface was formed at the $t/2$ position
25 from the surface of the hot-dip plated layer. However, when $t/2$ exceeded $0.2\ \mu\text{m}$, an

exposed surface was formed at a position of 0.2 μm from the surface. At this time, a 5 mm square exposed surface (that is, the entire exposed surface that corresponds to the pattern portion) completely included in the pattern portion and a 5 mm square exposed surface (that is, the entire exposed surface that corresponds to the non-pattern portion) completely included in the non-pattern portion were formed. When this exposed surface was formed, the hot-dip plated layer was scraped off by grinding. The maximum height R_z of the exposed surface was 0.2 μm or less.

[0084]

Next, on the exposed surface to be observed, virtual lattice lines were first drawn at intervals of 0.5 mm on the surface of the hot-dip plated layer, and the proportion (B/A (%)) was measured in each of a plurality of regions (0.5 mm square) partitioned by the virtual lattice lines.

[0085]

The proportion (B/A (%)) was measured as follows. A microstructure of plating was observed for each region by a secondary electron image of a scanning electron microscope (SEM) to identify the [Zn phase] and the [Al/MgZn₂/Zn ternary eutectic structure]. When each phase and microstructure was identified, elemental analysis by an energy dispersive X-ray elemental analyzer attached to the SEM was used in combination, and the phases and microstructures were identified while the distributions of Zn, Al, and Mg were confirmed. That is, among Zn, Al, and Mg, a region where Zn was mainly detected was defined as a Zn phase, a region where Al was mainly detected was defined as an Al phase, and a region where Zn and Mg were mainly detected was defined as an MgZn₂ phase. From the distribution of the detected phases, the phases were classified into the [Al phase], the [MgZn₂ phase], and the [Zn phase], and the [Al/Zn/MgZn₂ ternary eutectic structure] according to the above-described

method. Then, the proportion (B/A (%)) of the area fraction B of the [Zn phase] to the total area fraction A of the [Zn phase] and the [Al/MgZn₂/Zn ternary eutectic structure] was obtained in each of the plurality of regions (0.5 mm square) partitioned by the virtual lattice line. The [Zn phase] in a region having a circle equivalent diameter of 2.5 μm or more was measured as the [Zn phase]. Thus, the Zn phase and the [Zn phase] in the [Al/MgZn₂/Zn ternary eutectic structure] were distinguished.

[0086]

A region having a proportion (B/A (%)) of 20% or more was defined as a first region, and a region having a proportion (B/A (%)) of less than 20% was defined as a second region.

[0087]

Then, the area fraction of the first region in the pattern portion and the area fraction of the first region in the non-pattern portion were obtained. In addition, the difference between the area fraction of the first region in the pattern portion and the area fraction of the first region in the non-pattern portion was obtained.

[0088]

[Identifiability]

A test plate in an initial state immediately after manufacturing and a test plate in an aged state after being exposed outdoors for 6 months in a test plate provided with a square pattern portion were visually evaluated based on the following criteria. A, B, and C were regarded as acceptable in both the initial state and the aged state.

[0089]

A: The pattern portion could be visually recognized even from 5 m ahead.

B: The pattern portion could not be visually recognized from 5 m ahead, but the visibility from 3 m ahead was high.

C: The pattern portion could not be visually recognized from 3 m ahead, but the visibility from 1 m ahead was high.

D: The pattern portion could not be visually recognized from 1 m ahead.

[0090]

5 [Corrosion Resistance]

The test plate was cut into 150×70 mm, and subjected to a corrosion acceleration test CCT in accordance with JASO-M609 for 30 cycles. Thereafter, the rust generation state was investigated and evaluated based on the following criteria. A, B, and C were regarded as acceptable.

10 A: No rust was generated, and a beautiful design appearance was maintained in both the pattern portion and the non-pattern portion.

B: Rust was not generated, but a slight change in design appearance was recognized in the pattern portion and the non-pattern portion.

15 C: Although the design appearance was slightly impaired, the pattern portion and the non-pattern portion could be visually distinguished.

D: External appearance quality of the pattern portion and the non-pattern portion was significantly deteriorated, and could not be visually distinguished.

[0091]

As shown in the table, in the Zn-Al-Mg-based hot-dip plated steel sheets of
 20 Example Nos. 1 to 45 of the present invention, the chemical composition of the hot-dip plated layer fell within the range specified in the present invention, and hot-dip plating was performed after alkali electrolytic cleaning, spray water washing with ultrapure water, drying, annealing, and adhesion of Zn powder were performed, such that a pattern portion and a non-pattern portion were formed in the hot-dip plated layer, and the
 25 absolute value of the difference between the area fraction of the first region in the pattern

portion and the area fraction of the first region in the non-pattern portion was 30% or more. As a result, both identifiability and corrosion resistance were excellent.

[0092]

5 In the hot-dip plated steel sheet of No. 46, since the Al content of the hot-dip plated layer was small, the absolute value of the difference between the area fraction of the first region in the pattern portion and the area fraction of the first region in the non-pattern portion was less than 30%. As a result, both identifiability and corrosion resistance were deteriorated.

10 In the hot-dip plated steel sheet of No. 47, since the Al content of the hot-dip plated layer was excessive, the pattern portion became thin due to outdoor exposure for 6 months, and the identifiability was deteriorated.

In the hot-dip plated steel sheet of No. 48, since the Mg content of the hot-dip plated layer was low, the pattern portion was thinned by outdoor exposure for 6 months, the identifiability was deteriorated, and the corrosion resistance was also deteriorated.

15 In the hot-dip plated steel sheet of No. 49, the Mg content of the hot-dip plated layer was excessive, and therefore identifiability and corrosion resistance were deteriorated.

In the hot-dip plated steel sheet of No. 50, the components of the hot-dip plated layer were appropriate, but the Zn powder was not adhered. Therefore, in the hot-dip
20 plated steel sheet of No. 50, the absolute value of the difference between the area fraction of the first region in the pattern portion and the area fraction of the first region in the non-pattern portion was less than 30%. Accordingly, identifiability and corrosion resistance were deteriorated.

In the hot-dip plated steel sheet of No. 51, the components of the hot-dip plated
25 layer were appropriate, and the Zn powder was adhered to the sheet surface before the

hot-dip plating treatment. However, in the hot-dip plated steel sheet of No. 51, cleaning of the surface of the steel sheet before adhesion of Zn was insufficient. Therefore, in the hot-dip plated steel sheet of No. 51, the absolute value of the difference between the area fraction of the first region in the pattern portion and the area fraction of the first region in the non-pattern portion was less than 30%. As a result, identifiability was deteriorated.

[0093]

In No. 52 in which a square pattern portion was printed by an inkjet method, the pattern portion was thinned due to outdoor exposure for 6 months, and the identifiability was deteriorated.

In addition, in No. 53 in which a square pattern was formed by grinding, the thickness of the plated layer at the grinding location was reduced, and the corrosion resistance at the grinding location was reduced.

[0094]

[Table 1A]

No.	Manufacturing method	Hot-dip plated layer				
	Manufacturing method	Average composition (mass %) Remainder: Zn and impurities				Adhesion amount of plating (g/m ²)
		Al	Mg	Si	Others	
1	Adhesion of Zn powder to steel sheet having high cleanliness	5	3	-	Ni 0.01%	160
2	Adhesion of Zn powder to steel sheet having high cleanliness	6	3	0.2	Ti 0.01%	320
3	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	Ti 0.01%	290
4	Adhesion of Zn powder to steel sheet having high cleanliness	19	6	0.2	Ni 0.01%	320
5	Adhesion of Zn powder to steel sheet having high cleanliness	22	6	0.2	Ti 0.01%	190
6	Adhesion of Zn powder to steel sheet having high cleanliness	11	1.0	-	-	30
7	Adhesion of Zn powder to steel sheet having high cleanliness	11	1.5	-	-	190
8	Adhesion of Zn powder to steel sheet having high cleanliness	11	2	0.2	-	230
9	Adhesion of Zn powder to steel sheet having high cleanliness	11	6	0.2	-	320
10	Adhesion of Zn powder to steel sheet having high cleanliness	11	8	0.2	-	110
11	Adhesion of Zn powder to steel sheet having high cleanliness	11	10	0.2	-	120
12	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.0001	-	320
13	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.01	-	310
14	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.03	-	310
15	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.08	-	280
16	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	1	-	290
17	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	2	-	600
18	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	Ti 0.01%	290
19	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	Ni 0.01%	300
20	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	Zr 0.01%	300
21	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	Ni 0.01%	310
22	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	Sr 0.01%	320
23	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	Fe 0.01%	270
24	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	Sb 0.01%	290
25	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	Pb 0.01%	320

[0095]

[Table 1B]

No.	Manufacturing method	Hot-dip plated layer				
	Manufacturing method	Average composition (mass %) Remainder: Zn and impurities				Adhesion amount of plating (g/m ²)
		Al	Mg	Si	Others	
26	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	Sn 0.01%	310
27	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	Ca 0.01%	310
28	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	Co 0.01%	270
29	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	Mn 0.01%	290
30	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	P 0.01%	280
31	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	B 0.01%	310
32	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	Bi 0.01%	290
33	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	Cr 0.01%	280
34	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	Sc 0.01%	300
35	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	Y 0.01%	270
36	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	REM 0.01%	280
37	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	Hf 0.01%	300
38	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	C 0.01%	320
39	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	Ti 0.01% + Ca 0.01%	290
40	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	Ti 0.01%	290
41	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	Ti 0.01%	290
42	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	Ti 0.01%	290
43	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	Ti 0.01%	290
44	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	Ti 0.01%	290
45	Adhesion of Zn powder to steel sheet having high cleanliness	11	3	0.2	Ti 0.01%	290
46	Adhesion of Zn powder to steel sheet having high cleanliness	<u>4</u>	3.0	0.2	-	310
47	Adhesion of Zn powder to steel	<u>23</u>	3.0	0.2	-	320

	sheet having high cleanliness					
48	Adhesion of Zn powder to steel sheet having high cleanliness	11	<u>0.5</u>	0.2	-	270
49	Adhesion of Zn powder to steel sheet having high cleanliness	11	<u>11</u>	0.2	-	270
50	Steel sheet having high cleanliness (No adhesion of Zn powder)	11	3	0.2	-	280
51	Adhesion of Zn powder to steel sheet having low cleanliness	11	3	0.2	-	290
52	Printing after plating	11	3	0.2	-	270
53	Grinding after plating	11	3	0.2	-	310

The underlined sections indicate that it is outside the range of the present invention.

[0096]

[Table 2A]

No.	Hot-dip plated layer				
	Pattern portion		Non-pattern portion		Difference in area fraction (area%)
	First region (area%)	Second region (area%)	First region (area%)	Second region (area%)	
1	80	20	30	70	50
2	100	0	60	40	40
3	80	20	20	80	60
4	80	20	20	80	60
5	70	30	10	90	60
6	60	40	20	80	40
7	80	20	30	70	50
8	50	50	90	10	40
9	40	60	80	20	40
10	10	90	60	40	50
11	80	20	30	70	50
12	10	90	60	40	50
13	30	70	80	20	50
14	60	40	10	90	50
15	10	90	80	20	70
16	70	30	30	70	40
17	80	20	10	90	70
18	80	20	40	60	40
19	90	10	10	90	80
20	30	70	80	20	50
21	30	70	80	20	50
22	80	20	20	80	60
23	90	10	50	50	40
24	50	50	10	90	40
25	60	40	30	70	30

[0097]

[Table 2B]

No.	Hot-dip plated layer				
	Pattern portion		Non-pattern portion		Difference in area fraction (area%)
	First region (area%)	Second region (area%)	First region (area%)	Second region (area%)	
26	70	30	20	80	50
27	20	80	90	10	70
28	40	60	80	20	40
29	90	10	50	50	40
30	60	40	20	80	40
31	20	80	80	20	60
32	80	20	40	60	40
33	20	80	60	40	40
34	30	70	80	20	50
35	70	30	10	90	60
36	10	90	80	20	70
37	80	20	40	60	40
38	10	90	50	50	40
39	80	20	30	70	50
40	80	20	20	80	60
41	90	10	40	60	50
42	10	90	50	50	40
43	66	34	33	67	33
44	50	50	10	90	40
45	50	50	90	10	40
46	80	20	70	30	<u>10</u>
47	60	40	20	80	40
48	70	30	30	70	40
49	40	60	10	90	30
50	70	30	70	30	<u>0</u>
51	40	60	20	80	<u>20</u>
52	-	-	-	-	-
53	-	-	-	-	-

The underlined sections indicate that it is outside the range of the present invention.

[0098]

[Table 3A]

No.	Evaluation		
	Identifiability		Corrosion resistance
	Initial state	Aged state	
1	C	C	C
2	A	A	A

3	A	A	A
4	A	A	A
5	A	B	C
6	A	A	C
7	C	C	B
8	B	C	A
9	A	A	A
10	A	A	A
11	A	B	C
12	A	B	A
13	A	A	A
14	A	A	A
15	A	A	A
16	A	A	A
17	A	A	A
18	A	A	A
19	A	A	A
20	A	A	A
21	A	A	A
22	A	A	A
23	A	A	A
24	A	A	A
25	C	C	A

[0099]

[Table 3B]

No.	Evaluation		
	Identifiability		Corrosion resistance
	Initial state	Aged state	
26	A	A	A
27	A	A	A
28	A	A	A
29	A	A	A
30	A	A	A
31	A	A	A
32	A	A	A
33	A	A	A
34	A	A	A
35	A	A	A
36	A	A	A
37	A	A	A
38	A	A	A
39	A	A	A

40	A	A	A
41	A	A	A
42	A	A	A
43	A	A	A
44	A	A	A
45	A	A	A
46	D	D	D
47	B	D	A
48	B	D	D
49	C	D	D
50	D	D	A
51	D	D	A
52	A	D	B
53	B	B	D

Reference Signs List

[0100]

1 Steel sheet

2 Hot-dip plated layer

5 2a Surface of hot-dip plated layer

21 Pattern portion

22 Non-pattern portion

3 Cross section at $t/4$ position

4 Cross section at $t/2$ position

10 5 Cross section at $3t/4$ position

A1 First region

A2 Second region

CLAIMS

[Claim 1] A hot-dip plated steel sheet, comprising:

a steel sheet and a hot-dip plated layer formed on a surface of the steel sheet,

wherein

5 the hot-dip plated layer, in terms of average composition, contains 5 to 22

mass% of Al and 1.0 to 10 mass% of Mg with a remainder including Zn and impurities,

the hot-dip plated layer includes a pattern portion and a non-pattern portion,

the pattern portion and the non-pattern portion each includes one or two of a first
region and a second region obtained by the following measurement method, and

10 an absolute value of a difference between an area fraction of the first region in
the pattern portion and an area fraction of the first region in the non-pattern portion is
30% or more,

[Measurement Method]

assuming that a thickness of the hot-dip plated layer is t , a cross section of 1 to 5
15 mm square parallel to a surface of the hot-dip plated layer is exposed at any position of
 $3t/4$ position, $t/2$ position, or $t/4$ position from the surface of the hot-dip plated layer,
virtual lattice lines are drawn at intervals of 0.5 mm on each of the cross sections, a
region in which a proportion (B/A (%)) of an area fraction B of a [Zn phase] to a total
area fraction A of the [Zn phase] and an [Al/MgZn₂/Zn ternary eutectic structure] is 20%
20 or more in each of a plurality of regions partitioned by the virtual lattice lines is defined
as the first region, and a region in which the proportion (B/A (%)) is less than 20% is
defined as the second region.

[Claim 2] A hot-dip plated steel sheet, comprising:

a steel sheet and a hot-dip plated layer formed on a surface of the steel sheet,

25 wherein

the hot-dip plated layer, in terms of average composition, contains 5 to 22 mass% of Al and 1.0 to 10 mass% of Mg with a remainder including Zn and impurities,

the hot-dip plated layer further contains one or two selected from the group consisting of a group A and a group B below,

5 the hot-dip plated layer includes a pattern portion and a non-pattern portion,

the pattern portion and the non-pattern portion each includes one or two of a first region and a second region obtained by the following measurement method, and

an absolute value of a difference between an area fraction of the first region in the pattern portion and an area fraction of the first region in the non-pattern portion is

10 30% or more,

[Group A] Si: 0.0001 to 2 mass%

[Group B] 0.0001 to 2 mass% in total of one or more of Ni, Ti, Zr, Sr, Fe, Sb, Pb, Sn, Ca, Co, Mn, P, B, Bi, Cr, Sc, Y, REM, Hf, and C

[Measurement Method]

15 assuming that a thickness of the hot-dip plated layer is t , a cross section of 1 to 5 mm square parallel to a surface of the hot-dip plated layer is exposed at any position of $3t/4$ position, $t/2$ position, or $t/4$ position from the surface of the hot-dip plated layer, virtual lattice lines are drawn at intervals of 0.5 mm on each of the cross sections, a region in which a proportion (B/A (%)) of an area fraction B of a [Zn phase] to a total area fraction A of the [Zn phase] and an [Al/MgZn₂/Zn ternary eutectic structure] is 20%
20 or more in each of a plurality of regions partitioned by the virtual lattice lines is defined as the first region, and a region in which the proportion (B/A (%)) is less than 20% is defined as the second region.

[Claim 3] The hot-dip plated steel sheet according to Claim 1 or 2, wherein the pattern

25 portion is disposed to have a shape of any one of a straight line portion, a curve portion, a

dot portion, a figure, a number, a symbol, and a character, or a combination of two or more thereof.

[Claim 4] The hot-dip plated steel sheet according to Claim 1 or 2, wherein an adhesion amount of the hot-dip plated layer is 30 to 600 g/m² in total on both surfaces of the steel sheet.

[Claim 5] The hot-dip plated steel sheet according to Claim 2, wherein the hot-dip plated layer has an average composition containing the group A in terms of mass%.

[Claim 6] The hot-dip plated steel sheet according to Claim 2, wherein the hot-dip plated layer has an average composition containing the group B in terms of mass%.