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(71) Applicant: **Kabushiki Kaisha Kobe Seiko Sho**
Chuo-ku
Kobe-shi
Hyogo 651-8585 (JP)

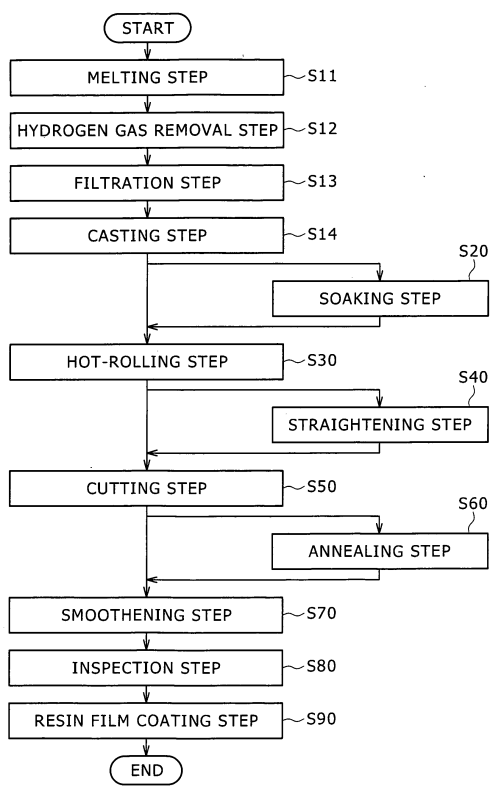
(72) Inventors:
- **KOBAYASHI, Kazunori**
  Tochigi 321-4367 (JP)
- **KATO, Tomoharu**
  Tochigi 321-4367 (JP)
- **INABA, Takashi**
  Tochigi 321-4367 (JP)

(74) Representative: **Müller-Boré & Partner**
Patentanwälte
Grafinger Straße 2
81671 München (DE)

(54) ALUMINUM ALLOY PLATE AND PROCESS FOR PRODUCING THE SAME

(57) An aluminum alloy plate is provided which is suitable for use as members for apparatuses relating to semiconductors. The alloy plate is satisfactory in plate thickness precision and flatness and can be inhibited from having surface defects. Also provided is a process for producing the plate. An aluminum alloy comprising given components is melted (melting step), and hydrogen gas and inclusions are removed therefrom (hydrogen gas removal step and filtration step) . This melt is cast into an ingot (casting step). According to need, the ingot is homogenized by a heat treatment (soaking step). This ingot is hot-rolled to a given thickness (hot-rolling step), cut (cutting step), and finished by smoothening the surfaces (smoothening step) . According to need, the plate may be subjected to straightening (straightening step) and a heat treatment, e.g., annealing (annealing step). The aluminum alloy plate obtained has a surface flatness of 0.2 mm or less per m of rolling-direction length and has fluctuations in plate thickness within ±0.5% of a desired plate thickness.

FIG. 1



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Description

TECHNICAL FIELD

[0001] The present invention relates to an aluminum alloy plate and a process for producing the same.

BACKGROUND ART

[0002] In general, aluminum alloy materials are used for various applications, including devices relating to semiconductors, such as a base substrate, a delivery device, or a chamber for a vacuum device, electric and electronic components, production devices therefor, living wares, mechanical parts, and the like. As die materials used in dies for press, steel, cast steel, or the like is used for mass production, while a zinc alloy casting material, an aluminumalloycastingmaterial, or the like is used for sampling. Further, in recent years, a wrought material, such as a rolled material or a forging material, of an aluminum alloy has been widely used for middle/low volume production with the trend of high-mix low-volume production.

[0003] Among them, for example, as shown in Fig. 2, the rolled material of the aluminum alloy is manufactured by processes starting from a melting step S101 via an annealing step S600, and is examined for the distortion, thickness, surface flaws, and the like (see, for example, Japanese Unexamined Patent Publication No. 2006-281381). Thereafter, the rolled material has both sides thereof covered with a resin film made of vinyl chloride, polyethylene, or the like (for example, registered trademark: ALHIGHCE, described in KOBE STEEL ENGINEERNG REPORTS/Vol.52 No.2, Sep. 2002, or registered trademark: HIPLATE, manufactured by Furukawa-Sky Aluminum Corp, or the like, each of which is well known) (in steps S101 to S900).

[0004] The reason why a high-precision aluminum plate is treated in the form of a product with both rolled sides covered with a resin film is that the high-precision aluminum plates are more frequently used as components of precision equipment or the like and thus are traded in small size and number by cutlength sheet wholesalers. That is, in the cutlength sheet wholesaler, the aluminum plate is cut into dice in a small size with a saw in application to the components of the precision equipment, or the aluminum plate is partly subjected to end milling in application to the vacuum chamber. Thus, an unprocessed part of the aluminum alloy possibly becomes an outer jacket. For the purpose of preventing occurrence of flaws in the cutting process, the high-precision aluminum alloy plates are distributed in the form of a product with both rolled sides covered with the resin film.

[0005] The aluminum alloy rolled material is normally manufactured by hot-rolling an ingot to a given thickness. Such an aluminum alloy hot-rolled plate, however, has the thickness and flatness controlled only by a reduction roll, which makes it difficult to achieve good thickness precision and flatness (especially, flatness in the rolling direction). Further, in the hot-rolling process, a thick oxide film is formed on a rolled surface, which also makes it difficult to control the flatness. For this reason, a technique is disclosed which involves applying cold rolling to an aluminum plate at such a degree of rolling reduction of 5 % or less that does not accumulate distortion after the hot-rolling process,therebyimproving the thicknessprecision (see, for example, Patent Document 1).

[Patent Document 1] Japanese Unexamined Patent Publication No. 2006-316332 (phrases 0027 to 0028)

DISCLOSURE OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0006] The related art disclosed in Patent Document 1, however, is directed to convert an aluminum alloy plate into an aluminum thin plate having a thickness of about 1 mm.

[0007] The above-mentioned surface flaws become serious quality defects that impair not only the beauty of an external appearance of a product, but also the function of the product, which reduces the product field, while simultaneously interrupting the productivity because many man-hours are required for removing the defects. For example, suppose a customer purchases and uses an aluminum alloy pre-product in a small size like a dice to process the purchased pre-product into a product and to deliver the product to a final customer. In this case, flaws are possibly found on the final customer side in peeling off a coated resin film from the purchased product, which loses the opportunities for the products to be purchased by the final customers any more. For application to a vacuum chamber, minute flaws in the formofblowhole leads to functional defects, and cannot be distinguished from a damaged flaw. It takes much time to determine a cause of the flaw, which disadvantageously loses the opportunity to sell the product to the final customer.

[0008] In recent years, the requirements of an acceptable flaw level have been high. The flaw of 8 μm or more in depth and about 0.1 mm in diameter of a circle can be found visually, and thus become problematic. Further, in the conventional producing process, it is difficult to completely eliminate the flaws of the above level. Mainly for the application to the vacuum chamber, the aluminum material is hardly used with its bare surface, and subj ected to anodizing treatment orplatingprocess so as to enhance corrosion resistance and resistance to weather. Although there is no defect in the original plate, a black streaky surface defect of about 3 μm in length is disadvantageously generated in the rolling direction due to insoluble Ti-B to be described later after the above surface treatment. The need to improve the problem has become urgent. In order to satisfy the customer's demands on the surface defects, a high-precision aluminum alloy plate is desired from which the surface defects of this level or the surface defects generated by the surface treatment before coating of the resin film can be surely removed.

[0009] The invention has beenmade in view of the forgoing problems, and it is an object of the invention to provide an aluminum alloy plate with good thickness precision and flatness which can be used for manufacturing a device relating to a semiconductor, such as a chamber for a vacuum device, and which can suppress surface defects, including flaws or black streaks, and a process for producing the same.

MEANS FOR SOLVING THE PROBLEMS

[0010] In order to solve the above-mentioned problems, the aluminum alloy plate according to the invention is an aluminum alloy plate formed by smoothening the surface of an aluminum alloy hot-rolled plate. The aluminum alloy plate has a surface flatness of 0.2 mm or less per meter of the rolling direction length, and fluctuations in plate thickness within ± 0.5 % of a desired plate thickness.

[0011] In this way, by smoothening the surface (before coating of a resin film), the surface flatness and fluctuations in plate thickness of the surface are limited within respective predetermined ranges, which can provide the aluminum alloy material suitable for use in products requiring high precision of shape, such as devices relating to semiconductors, without a thinning process, such as cold rolling, or the like. Further, the aluminum alloy material can be prevented from having surface defects, such as flaws or black streaks.

[0012] Preferably, the aluminum alloy plate contains 1. 5 to 12.0 % by mass of Mg, and further one or more elements selected from the group consisting of 0.7 % by mass or less of Si, 0.8 % by mass or less of Fe, 0.6 % by mass or less of Cu, 1.0 % by mass or less of Mn, 0.5 % by mass or less of Cr, 0.4 % by mass or less of Zn, and 0.1 % by mass or less of Ti, with the balance being Al and inevitable impurities.

[0013] Such elements are contained within the predetermined range of concentration, which can provide an Al-Mg based alloy plate having excellent properties, including strength and the like, as well as thickness precision, and flatness. Further, in the aluminum alloy plate, the surface defects, such as flaws or black streaks, can be suppressed, and additionally the occurrence of color irregularity on its surface can also be suppressed.

[0014] Preferably, the aluminum alloy plate contains 0.3 to 1.6 % by mass of Mn, and further one or more elements selected from the group consisting of 0.7 % by mass or less of Si, 0.8 % by mass or less of Fe, 0.5 % by mass or less of Cu, 1.5 % by mass or less of Mg, 0.3 % by mass or less of Cr, 0.4 % by mass or less of Zn, and 0.1 % by mass or less of Ti, with the balance being Al and inevitable impurities.

[0015] Such elements are contained within the predetermined range of concentration, which can provide an Al-Mn based alloy plate having excellent properties, including strength and the like, as well as thickness precision, and flatness. Further, in the aluminum alloy plate, the surface defects, such as flaws or black streaks, can be suppressed, and additionally the occurrence of color irregularity on the surface can also be suppressed.

[0016] Preferably, the aluminum alloy plate contains 0. 3 to 1.5 % by mass of Mg, 0.2 to 1.6 % by mass of Si, and further one or more elements selected from the group consisting of 0.8 % by mass or less of Fe, 1.0 % by mass or less of Cu, 0.6 % by mass or less of Mn, 0.5 % by mass or less of Cr, 0.4 % by mass or less of Zn, and 0.1 % by mass or less of Ti, with the balance being Al and inevitable impurities.

[0017] Such elements are contained within the predetermined range of concentration, which can provide an Al-Mg-Si based alloy plate having excellent properties, including strength and the like, as well as thickness precision, and flatness. Thus, in the aluminum alloy plate, the surface defects, such as flaws or black streaks, can be suppressed, and additionally the occurrence of color irregularity of the surface can also be suppressed.

[0018] Preferably, the aluminum alloy plate contains 3.0 to 9.0 % by mass of Zn, 0.4 to 4.0 % by mass of Mg, and further one or more elements selected from the group consisting of 0.7 % by mass or less of Si, 0.8 % by mass or less of Fe, 3.0 % by mass or less of Cu, 0.8 % by mass or less of Mn, 0.5 % by mass or less of Cr, 0.1 % by mass or less of Ti, and 0.25 % by mass or less of Zr, with the balance being Al and inevitable impurities.

[0019] Such elements are contained within the predetermined range of concentration, which can provide an Al-Zn-Mg based alloy plate having excellent properties, including strength or the like, as well as thickness precision, and flatness. Thus, in the alloy plate, the surface defects, such as flaws or black streaks, can be suppressed, and additionally the occurrence of color irregularity of the surface can also be suppressed.

[0020] A process for producing an aluminum alloy plate according to the invention is a process for producing the aluminum alloy plate according to a first aspect of the invention, and includes the steps of melting an aluminum alloy to form a molten aluminum alloy, dehydrogenating the molten aluminum alloy to remove hydrogen gas therefrom, filtering inclusions from the molten aluminum alloy having the hydrogen gas removed therefrom, casting the molten aluminum alloy having the inclusions removed therefrom into an ingot, hot rolling the ingot to a predetermined thickness to produce a hot-rolled plate, cutting the hot-rolled plate into a predetermined rolling-direction length and width, and smoothening a surface of the cut hot-rolled plate. In the smoothening step, a thickness of the removed surface of the hot-rolled plate is in a range of 2 to 5 mm per side.

[0021] In this way, the smoothening process is applied to the surface of the hot-rolled plate up to a predetermined removal thickness, which can improve the thickness precision and flatness. Surface defects, including flaws, black streaks, and the like can be suppressed.

[0022] Preferably, in the process for producing the aluminumplate, a soaking step is performed on the ingot by a heat treatment for one or more hours at a temperature of 400 ˚C or more and less than a melting point of the aluminum alloy before the hot rolling step.

Thus, the ingot is subjected to the heat treatment before the hot rolling step, whereby the composition of the ingot can be made fine and homogenized.

[0023] Preferably, in the process for producing the aluminumplate, an annealing step is performed for annealing the cut hot-rolled plate before the smoothening step.

Thus, the properties of the hot-rolled plate can be improved by annealing the hot-rolled plate.

[0024] Preferably, in the process for producing the aluminumplate, the smoothening process is performed by any one of a cutting method, a grinding method, and a polishing method.

This method makes the thickness precision and flatness of the aluminum alloy plate better. The method can also suppress surface defects, including flaws, black streaks, and the like.

EFFECTS OF THE INVENTION

[0025] The aluminum alloy plate according to the invention with little plastic deformation also has the desired thickness and flatness, and hence can be suitable for use in producing a device relating to a semiconductor or the like requiring an accurate shape. Further, the surface defects, such as flaws or black streaks, are reduced to result in good surface texture of the alloy plate. Further, the use of the predetermined aluminum alloy improves the properties of the plate, including strength and the like, suppresses the occurrence of color irregularity of the surface, and further makes the surface texture of the plate better.

The process for producing the aluminum alloy plate according to the invention can produce the aluminum alloy plate having the above effects with high productivity.

BRIEF DESCRIPTION OF DRAWINGS

[0026]

Fig. 1 is a flowchart showing a process for producing an aluminum alloy plate according to the present invention; and
Fig. 2 is a flowchart showing an example of a process for producing a conventional aluminum alloy plate in the related art.

BEST MODE FOR CARRYING OUT THE INVENTION

[0027] The following will describe preferred embodiments for achieving an aluminum alloy plate according to the present invention.

[Aluminum Alloy Plate Structure]

[0028] The aluminum alloy plate according to the invention is an aluminum alloy hot-rolled plate (aluminum alloy hot stretched plate) whose surface is smoothened. The aluminum alloy plate has a surface flatness of 0.2 mm or less per meter of the rolling-direction length, and fluctuations in plate thickness within ±0.5 % of a desired plate thickness. The aluminum alloy plate in the invention has a thickness of 15 to 200 mm, but is not limited thereto. The thickness of the aluminum alloy plate can be appropriately changed according to the applications of the aluminum alloy plate. Each element forming the aluminum alloy plate in the invention will be described below.

(Surface Flatness: 0.2 mm or Less Per Meter of Rolling-Direction Length)

[0029] In using a member with poor flatness in a member relating to a semiconductor, specifically, an internal component of a chamber for a vacuum device, such as a plasma treatment device, absorption gas is discharged from the surface of the member when the pressure is reduced to high vacuum, which results in loss of vacuum. For this reason, it takes more time to reach a target degree of vacuum, leading to a reduced production efficiency. Thus, the aluminum alloy plate in the invention has a surface flatness equal to or less than 0.2 mm/m. The hot-rolled plate has the worst surface flatness in the direction of hot rolling. The surface flatness is measured per meter of rolling-direction length. Such flatness is adjusted by a smoothening step and a straightening step in a production method as will be described later.

(Fluctuations in Plate Thickness: Within ± 0.5 % of Desired Plate Thickness)

[0030] The aluminum alloy plate in the invention is required to have the high thickness precision because the alloy plate is used for products which needs high precision of shape, for example, members relating to semiconductors. In order to satisfy the requirement, fluctuations in plate thickness is within ± 0.5 % of a desired plate thickness. The plate thickness precision is adjusted by the smoothening step in the production process to be described later.

[0031] Additionally, the aluminum alloy plate in the invention preferably has a hydrogen gas content of 0.2 ml or less per 100 g of the alloy plate, and more preferably of 0.1 ml or less. The hydrogen gas is generated from hydrogen in fuel, moisture attached to a base metal or the like, other organic compounds, and the like. When the aluminum alloy plate contains much hydrogen gas, the hydrogen gas causes pin holes, or reduces the strength of the product. Further, hydrogen is accumulated, and incrassated in a gain boundary near the surface of an ingot, which causes blister of the ingot and peeling of the aluminum alloy plate due to the blister, while causing latent defects of the surface of the aluminum alloy plate which appears as the surface defect of the plate. Under the presence of such defects in the internal member of the chamber for the vacuumdevice, gas atoms solid-soluted in the member are discharged from the surface of the member when the pressure is reduced to high vacuum, which results in loss of vacuum. For this reason, it takes more time to reach a target degree of vacuum, leading to a reduced production efficiency. In order to reduce the amount of hydrogen gas in the aluminum alloy plate, hydrogen gas is removed from a molten aluminum alloy before casting, in a hydrogen gas removal step of the production process to be described later.

[0032] The concentration of hydrogen gas in the ingot can be determined, for example, by the inert gas fusion-thermal conductivity method (LIS(Light-Metal Industrial Standard) AO6-1993) using a sample which has been prepared by taking a part from the ingot (before a soaking step) and performing ultrasonic cleaning with alcohol and acetone. The concentration of hydrogen gas in the aluminum alloy plate can be determined, for example, a vacuum heating extraction capacity method (LIS A06-1993) using a sample which has been prepared by taking a part from an aluminum alloy plate, immersing the part in a NaOH solution, removing an oxide film on its surface with nitric acid, and then performing ultrasonic cleaning with alcohol and acetone.

[0033] The aluminum alloy plate in the invention may be made of any aluminum alloy, but can be made of material selected from any one of an Al-Mg based alloy, an Al-Mn based alloy, an Al-Mg-Si based alloy, and an Al-Zn-Mg based alloy according to the application. Now, the respective components of examples of aluminum alloys included in the aluminum alloy plate in the invention will be described below.

[Al-Mg Based Alloy Composition]

[0034] An Al-Mg based alloy according to the invention, that is, an aluminum alloy in conformance with 5000-series Al alloy contains 1.5 to 12.0 % by mass of Mg, and further one or more elements selected from the group consisting of 0.7 % by mass or less of Si, 0.8 % by mass or less of Fe, 0.6 % by mass or less of Cu, 1.0 % by mass or less of Mn, 0.5 % by mass or less of Cr, 0.4 % by mass or less of Zn, and 0.1 % by mass or less of Ti, with the balance being Al and inevitable impurities.

(Mg: 1.5 to 12.0 % by mass)

[0035] The Mg element has an effect of improving the strength of an Al-Mg based alloy. For the Mg content of less than 1.5 % by mass, the effect becomes small. In contrast, when the Mg content exceeds 12.0 % by mass, the casting-performance is greatly degraded, which makes it impossible to manufacture products using the alloy. Thus, the Mg content needs to be 12.0 % by mass or less in using the Al-Mg based alloy with the above element composition. Accordingly, the Mg content is in a range of 1.5 to 12.0 % by mass.

(Si: 0.7 % by mass or less)

[0036] The element Si is an element inevitably contained in the aluminum alloy as a base metal impurity. The Si has an effect of improving the strength of the aluminum alloy, but tends to be bonded to Mn and Fe in cashing or the like to generate an Al-(Fe)-(Mn)-Si based intermetallic compound. When the Si content exceeds 0.7 % by mass, a bulky intermetallic compound is formed in the ingot, which easily causes color irregularity of the surface appearance after an anodizing treatment. Thus, the Si content is 0.7 % by mass or less.

(Fe: 0.8 % by mass or less)

[0037] The element Fe is an element inevitably contained in the aluminum alloy as a base metal impurity. The Fe has effects of fining and stabilizing crystal grains of the aluminum alloy, while improving the strength thereof. In contrast, in the casting step, the Fe tends to be bonded to Mn and Si to generate anAl-Fe- (Mn) - (Si) based intermetallic compound. When the Fe content exceeds 0.8 % by mass, a bulky intermetallic compound is formed in the ingot, which easily causes color irregularity of the surface appearance after the anodizing treatment. Thus, the Fe content is 0.8 % by mass or less.

(Cu: 0.6 % by mass or less)

[0038] The element Cu has an effect of improving the strength of the aluminum alloy by being solid-solubilized into the aluminum alloy. The Cu content of 0.6 % by mass ensures the strength enough to enable the use of the Al-Mg based alloy plate. Even if the Cu content added to the alloy exceeds this level, the above effect will be kept saturated. Thus, the Cu content is 0.6 % by mass or less.

(Mn: 1.0 % by mass or less)

[0039] The element Mn has an effect of improving the strength of the aluminum alloy by being solid-solubilized into the aluminum alloy. In contrast, when the Mn content exceeds 1.0 % by mass, a bulky intermetallic compound is formed in the ingot, which easily causes color irregularity of the surface appearance after the anodizing treatment. Thus, the Mn content is 1.0 % by mass or less.

(Cr: 0.5 % by mass or less)

[0040] The element Cr has an effect of suppressing the grain growth by being precipitated as a fine compound in the casting or heat treatment. In contrast, when the Cr content exceeds 0.5 % by mass, a bulky Al-Cr based intermetallic compound is generated as primary crystal, which easily causes color irregularity of the surface appearance after the anodizing treatment. Thus, the Cr content is 0.5 % by mass or less.

(Zn: 0.4 % by mass or less)

[0041] The element Zn has an effect of improving the strength of the aluminum alloy. The Zn content of 0.4 % by mass ensures the strength enough to enable the use of the Al-Mg based alloy plate. Even if the Zn content added to the alloy exceeds this level, the above effect will be kept saturated. Thus, the Zn content is 0.4 % by mass or less.

(Ti: 0.1 % by mass or less)

[0042] The element Ti has an effect of making the crystal grains of the aluminum alloy fine. Even when the Ti content exceeds 0.1% by mass, the above effect will be kept saturated. Thus, the Ti content is 0.1 % by mass or less.

[Al-Mn Based Alloy Composition]

[0043] Next, the respective components of an Al-Mn based alloy will be described. The Al-Mn based alloy according to the invention, that is, an aluminum alloy in conformance with 3000-series Al alloy contains 0.3 to 1.6 % by mass of Mn, and further one or more elements selected from the group consisting of 0.7 % by mass or less of Si, 0.8 % by mass or less of Fe, 0.5 % by mass or less of Cu, 1.5 % by mass or less of Mg, 0.3 % by mass or less of Cr, 0.4 % by mass or less of Zn, and 0.1 % by mass or less of Ti, with the balance being Al and inevitable impurities.

(Mn: 0.3 to 1.6 % by mass)

[0044] The element Mn has an effect of improving the strength of the aluminum alloy by being solid-solubilized into the aluminum alloy. In contrast, for the Mn content of less than 0.3 % by mass, the above effect becomes small. In contrast, when the Mn content exceeds 1.6 % by mass, a bulky Al- (Fe)-Mn- (Si) based intermetallic compound is formed in the ingot, which easily causes color irregularity of the surface appearance after the anodizing treatment. Thus, the Mn content is in a range of 0.3 to 1.6 % by mass.

(Mg: 1.5 % by mass or less)

[0045] The element Mg has an effect of improving the strength of the aluminum alloy. The Mg content of 1.5 % by mass ensures the strength enough to enable the use of the Al-Mn based alloy plate. Even if the Mg content added to the alloy exceeds this level, the above effect will be saturated. Thus, the Mg content is 1.5 % by mass or less.

[0046] (Si: 0.7 % by mass or less, Fe: 0.8 % by mass or less, Cu: 0.5 % by mass or less, Cr: 0.3 % by mass or less, Zn: 0.4 % by mass or less, Ti: 0.1 % by mass or less)
The respective effects provided by the elements Si, Fe, Cu, Cr, Zn, and Ti are the same as those of the components of the Al-Mg based alloy, and hence the description of these effects will be omitted below.

[Al-Mg-Si Based Alloy Composition]

[0047] Next, the respective components of an Al-Mg-Si based alloy will be described. The Al-Mg-Si based alloy according to the invention, that is, an aluminum alloy in conformance with 6000-series Al alloy contains 0.3 to 1.5 % by mass of Mg, 0.2 to 1.6 % by mass of Si, and further one or more elements selected from the group consisting of 0.8 % by mass or less of Fe, 1.0 % by mass or less of Cu, 0. 6 % by mass or less of Mn, 0.5 % by mass or less of Cr, 0.4 % by mass or less of Zn, and 0.1 % by mass or less of Ti, with the balance being Al and inevitable impurities.

(Mg: 0.3 to 1.5 % by mass)

[0048] The element Mg has an effect of improving the strength of an aluminum alloy. The element Mg coexists with Si to form Mg_2Si, thereby improving the strength of the aluminum alloy. For the Mg content of less than 0.3 % by mass, the effects become small. In contrast, when the Mg content exceeds 1.5 % by mass, the aluminumalloyhas the properties of anAl-Mgbased (5000-series Al) alloy in some cases. Thus, the Mg content is in a range of 0.3 to 1.5 % by mass.

(Si: 0.2 to 1.6 % by mass)

[0049] The element Si has an effect of improving the strength of an aluminum alloy. The element Si coexists with Mg to form Mg_2Si, thereby improving the strength of the aluminum alloy. For the Si content of less than 0.2 % by mass, the effects become small. In contrast, when the Si content exceeds 1.6 % by mass, a bulky intermetallic compound is generated in the Al-Mg-Si based alloy, which easily causes color irregularity of the surface appearance after the anodizing treatment. Thus, the Si content is in a range of 0.2 to 1.6 % by mass.

(Cu: 1.0 % by mass or less)

[0050] The element Cu has an effect of improving the strength of the aluminum alloy by being solid-solubilized into the aluminum alloy. In contrast, when the Cu content exceeds 1.0 % by mass, the Al-Mg-Si based alloy has reduced corrosion resistance. Thus, the Cu content is 1.0 % by mass or less.

(Zn: 0.4 % by mass or less)

[0051] The element Zn has an effect of improving the strength of the aluminum alloy. In contrast, when the Zn content exceeds 0.4 % by mass, the corrosion resistance of the Al-Mg-Si based alloy is reduced. Thus, the Zn content is 0.4 % by mass or less.

(Fe: 0.8 % by mass or less, Mn: 0.6 % by mass or less, Cr: 0.5 % by mass or less, Ti: 0.1 % by mass or less)

[0052] The respective effects provided by the elements Fe, Mn, Cr, and Ti are the same as those of the components of the Al-Mg based alloy, and hence the description of these effects will be omitted below.

[Al-Zn-Mg Based Alloy Composition]

[0053] Next, the respective components of anAl-Zn-Mgbased alloy will be described. The Al-Zn-Mg based alloy according to the invention, that is, an aluminum alloy in conformance with 7000-series Al alloy contains 0.3 to 9.0 % by mass of Zn, 0.4 to 4.0 % by mass of Mg, and
further one or more elements selected from the group consisting of 0.7 % by mass or less of Si, 0.8 % by mass or less of Fe, 3.0 % by mass or less of Cu, 0.8 % by mass or less of Mn, 0.5 % by mass or less of Cr, 0.1 % by mass or less of Ti, and 0.25 % by mass or less of Zn, with the balance being Al and inevitable impurities.

(Zn: 3.0 to 9.0 % by mass)

[0054] The element Zn has an effect of improving the strength of the aluminum alloy. For the Zn content of less than 3.0 % by mass, the effect becomes small. In contrast, when the Zn content exceeds 9.0 % by mass, a bulky intermetallic compound is generated, which easily causes color irregularity of the surface appearance after the anodizing treatment, or results in reduced resistance to SCC (resistance to stress-corrosion cracking). Thus, the Zn content is in a range of 3.0 to 9.0 % by mass.

(Mg: 0.4 to 4.0 % by mass)

[0055] The element Mg has an effect of improving the strength of the aluminum alloy. For the Mg content of less than 0.4 % by mass, the effect becomes small. In contrast, when the Mg content exceeds 4.0 % by mass, a bulky intermetallic compound is generated, which easily causes color irregularity of the surface appearance after the anodizing treatment or results in reduced resistance to SCC (resistance to stress-corrosion cracking). Thus, the Mg content is in a range of 0.4 to 4.0 % by mass.

(Cu: 3.0 % by mass or less)

[0056] The element Cu has an effect of improving the strength of the aluminum alloy by being solid-solubilized into the aluminum alloy. In contrast, when the Cu content exceeds 3.0 % by mass, the Al-Zn-Mg based alloy has reduced corrosion resistance. Thus, the Cu content is 3.0 % by mass or less.

(Zr: 0.25 % by mass or less)

[0057] The element Zr has effects of making crystal grains of an aluminum alloy finer and stabilizing the aluminum alloy crystal grains. In contrast, when the Zr content exceeds 0.25 % by mass, a bulky intermetallic compound is generated, which easily causes color irregularity of the surface appearance after the anodizing treatment. Thus, the Zr content is 0.25 % by mass or less.

(Si: 0.7 % by mass or less, Fe: 0.8 % by mass or less, Mn: 0.8 % by mass or less, Cr: 0.5 % by mass or less, Ti: 0.1 % by mass or less)

[0058] The respective effects provided by the elements Si, Fe, Mn, Cr, and Ti are the same as those of the components of the Al-Mg based alloy, and hence the description of these effects will be omitted below.

[0059] In any one of the Al-Mg based alloy, Al-Mn based alloy, Al-Mg-Si based alloy, and Al-Zn-Mg based alloy, the content of inevitable impurities, such as V or B, should be 0.01 % by mass or less, which does not affect the properties of the aluminum alloy plate in the invention. Although a grain fining agent consisting of a master alloy containing B and Ti is often added in order to prevent an ingot cracking in casting of a slab, some bulky Ti-B particles often remain undissolved and as a result, cause black streaks after surface finishing, such as the anodizing treatment or plating, as described later. Thus, the use of an Al-Ti based grain fining agent or the like without adding the element B is preferable. Even when the addition of the B causes the black streaks, the appropriate smoothening step can be performed to remove the black streaks as will be described later.

[Process for Producing Aluminum Alloy Plate]

[0060] Next, a process for producing an aluminum alloy plate according to the invention will be described below with reference to the accompanying drawings. Fig. 1 is a flowchart showing the process for producing the aluminum alloy plate in the invention. In the process for producing the aluminum alloy plate in the invention, the aluminum alloy with the composition selected from any one of the compositions described above is melted to form a molten aluminum alloy (in a melting step S11), and then hydrogen gas and inclusions are respectively removed from the molten aluminum alloy (in a hydrogen gas removal step S12, and a filtration step S13). The molten aluminum alloy is cast into an ingot (in a casting step S14). The ingot is hot-rolled to a predetermined thickness to produce a hot-rolled plate (in a hot-rolling step S30). The hot-rolled plate is cut (in a cutting step S50) and finished by smoothening the surface of the plate (in a smoothening step S70). Additionally, before the hot-rolling step, the ingot may be homogenized by a heat treatment (in a soaking step S70). Further, the distortion of the hot-rolledplate maybe straightened (in a straightening step S40). Moreover, the hot-rolled plate may be annealed (in an annealing step S60). Then, the thus-obtained aluminum alloy plate is processed in an inspection step S80, and a resin film coating step S90 into a product with both sides covered with the resin film. In Fig. 1, for convenience, the production process is ended after the resin film coating step S90.

However, the aluminum alloy plate according to the invention means one obtained after the smoothening step S70. Now, the respective steps will be described below in detail.

(Melting Step)

[0061] In the melting step S11, the aluminum alloy with a predetermined composition is melted to form the molten aluminum alloy by the known equipment and method.

(Hydrogen Gas Removal Step)

[0062] In the hydrogen gas removal step S12, hydrogen gas is removed from the molten aluminum alloy. The molten aluminum alloy is subjected to fluxing, chlorine refining, or in-line refining, so that the hydrogen gas can be preferably removed therefrom. The use of a rotary hydrogen gas removal unit, such as SNIFF, or a porous plug (see Japanese Unexamined Patent Publication No. 2002-146447) as the hydrogen gas removal unit can more preferably remove the hydrogen gas.

(Filtration Step)

[0063] In the filtration step S13, oxides and non-metallic inclusions are removed mainly from the molten aluminum alloy by a filtration device. The filtration device is provided with a ceramic tube made of, for example, alumina particles having a grain size of about 1 mm. The molten aluminum alloy is passed through the filtration device, which can remove the above oxides and inclusions.

[0064] In the hydrogen gas removal step S12 and the filtration step S13, the high-quality aluminum alloy ingot with internal defects suppressed can be provided in the following casting step S14. Further, the depositions (dross) of the oxides can be prevented from being formed, which can save work for removal of the dross.

(Casting Step)

[0065] In the casting step S14, for example, in a casting unit containing a water cooling mold, the molten aluminum alloy is formed and coagulated in a predetermined shape, such as a rectangular parallelepiped shape, thereby to produce an aluminum alloy ingot. A semi-continuous casting method can be used as the casting method. The semi-continuous method involves charging a molten metal into a metallic water cooling mold with its button opened from the above, and continuously taking out the metal coagulated from the bottom of the semi-continuous mold to thereby obtain an ingot having a predetermined thickness. The semi-continuous casting method may be performed vertically or horizontally.

(Soaking Step - Process Temperature: of 400 ˚C or more and less than a melting point of the aluminum alloy, Process Time: 1 hour or more)

[0066] In the soaking step S20, by applying a heat treatment to the aluminumalloy ingot, an internal stress of the ingot is removed, solute elements segregated in the casting are homogenized, and the intermetallic compounds crystallized in the casting are diffused and solid-solubilized to thereby homogenize the composition. The heat treatment is applied to the aluminum alloy ingot by a normal method while keeping the temperature of the ingot at 400 ˚C or more and below a melting point of the aluminum alloy for one hour or more. At a soaking temperature of less than 400 ˚C, the effect is insufficient. At the process time of less than one hour, the intermetallic compounds are not solid-solubilized sufficiently and thus tend to be easily precipitated. In contrast, when the soaking temperature reaches the melting point of the aluminum alloy according to the invention, a phenomenon called "burning" occurs in which a part of the surface of the aluminum alloy ingot is melted. The phenomenon easily leads to the surface defect of the aluminum alloy plate. Thus, the soaking process is performed at a soaking temperature of 400 ˚C or more and less than the melting point of the aluminum alloy for one hour or more.

(Hot-Rolling Step)

[0067] In the hot-rolling step S30, the aluminum alloy ingot is hot-rolled into a plate (aluminum alloy hot-rolled plate) having a predetermined thickness. The hot-rolling method can employ a reverse (reversible) type hot rolling device. Specifically, the aluminum alloy hot-rolled plate having the predetermined thickness is produced by increasing the temperature of the aluminum alloy ingot up to a prescribed temperature, and rolling the aluminum alloy ingot by the reverse (reversible) type hot rolling device. The thickness (thickness of the aluminum alloy hot-rolled plate) in this step is a value provided by adding a decrease in thickness of the aluminum alloy plate in the following smoothening step S70 to a desired thickness of the aluminum alloy plate, and is preferably in a range of about 15 to 200 mm.

(Straightening Step)

[0068] In the straightening step S40, distortion of the aluminum alloyhot-rolledplate occurring in the hot rolling is straightened to planarize the surface by the known equipment, such as a stretcher or a tension leveler, and the known method.

(Cutting Step)

[0069] In the cutting step S50, the aluminum alloy hot-rolled plate is cut into a desired length (and width).

(Annealing Step)

[0070] In the annealing step S60, the aluminum alloy plate is subjected to the heat treatment thereby to remove the internal stress, while homogenizing the internal composition. Thermal refining may be applied to the alloy plate by a solution treatment and an aging treatment. Such treatments may be performed after the smoothening step S70. As disclosed in, for example, Japanese Unexamined Patent Publication No. 63-115617, the surface flatness can be improved by the heat treatment.

(Smoothening Step)

[0071] In the smoothening step S70, the surface (rolled surface) of the aluminum alloy hot-rolled plate is smoothened with the thickness thereof adjusted.
The thickness of the removed surface of the hot-rolled plate is set to 2 to 5 mm per side. Setting of the thickness of the removed part to 2 mm or more can adjust fluctuations in surface flatness and in plate thickness to desired levels, and can suppress the surface defects due to flaws.
[0072] As mentioned above, although no defects are formed in the original plate, surface defects with black streaks of about 3μ m in length may be disadvantageously generated in the direction parallel to the rolling direction after the surface treatment, such as the anodizing treatment or plating. The inventors have been dedicated themselves to studying the causes for this and, as a result, have found that the Ti-B particles added as an ingot fining agent (crystal grain fining agent) in casting or for preventing the ingot cracking remain insoluble at a rapid-solidified part near the mold in casting of a slab, thus causing the surface defect. By setting the thickness of the removed part to 2 mm or more, even the insoluble Ti-B particles as the ingot fining agent can be removed. Further, even the anodizing treatment or plating does not generate the surface defects with black streaks. The thickness of the removed part is 5 mm or less from the viewpoint of yield and cost performance.
[0073] The smootheningmethods inuse can include a cuttingmethod, such as end mill cutting or diamond bite cutting, a grinding method for grinding the surface of interest by a grindstone or the like, andapolishingmethod, such as buffing polishing, but the invention is not limited thereto.
[0074] In the smoothening step S70, a hair line process may be performed after suppressing fluctuations in surface flatness and plate thickness, and surface defects, including flaws or black streaks. The hair line process can be performed to apply a rolled pattern onto the surface of the plate. As the hair line process, a belt or wheel type polishing method is known. Both polishing methods may be used. The known polishing non-woven fabric used in the hair line process of the belt or wheel type includes an elemental substance, such as alumina, silicone carbide, or zirconia, as an abrasive grain or amixture thererof, andanadhesive, such as resin or glue. The grain abrasives include the commercially-available grains of grades #120 to #220 which are relatively coarse. When using the polished non-woven fabric having a rotary outer diameter of the belt or wheel of ϕ400 mm, the hair line process can be preferably performed at the number of revolutions of 1500 rpm or less by use of the fabric containing grease for preventing burning. However, the invention is not limited thereto.
[0075] As to the surface defects due to the flaws, the size of the flaw that can be visually identified by a man is 8 μm or more in depth, and the depth of the flaw that is difficult to detect in inspection is 20 μm or less. The flaw of 8 to 20 μm in depth is an indentation caused by foreign matter or roll marks. Such defects are not inherently functional defects. Thus, the indentations can be effectively distinguished easily from the functional defects by the hair line process (in which the amount processed is 2 to 3 μm) which can smoothen a boundary between the flaw and the smooth part on the plate surface. Only the hair line process which involves cutting of each side in a depth of 2 mm or more can also obtain the effects of the invention in the present application without taking into account economic factors.
[0076] Thereafter, the thus-produced aluminum alloy plate is inspected for distortion, plate thickness, surface flaws, and the like in the inspection step S80, and then both sides of the aluminum alloy plate are covered with the resin film

in the resin film coating step S90.

[Examples]

[0077] The preferred embodiments for carrying out the invention have been described above. Now, examples for confirming the effects of the invention will be described specifically by comparison with comparative examples not satisfying the requirements of the invention. It is understood that the invention is not limited to the examples.

[Example 1: Production of Samples]

(Al-Mg Based Alloy)

[0078] Aluminum alloys having alloy compositions No. 5a to 5v shown in Table 1 (5k: JIS5052 alloy, 51: JIS5083 alloy, 5v: Ti and B not added) were melted, subjected to the hydrogen gas removal process, filtered, and then cast into ingots having a thickness of 500 mm. Each ingot was subjected to the soaking process by heating at 500 ˚C for 4 hours. Then, the ingot was hot-rolled into an aluminum alloy hot-rolled plate of about 25 mm in thickness and another aluminum alloy hot-rolled plate of about 20 mm in thickness. The aluminum alloy hot-rolled was cut into pieces each having 2000 mm in rolling-direction length ×1000 mm in width, whose rolled surfaces (both sides) were subjected to the smoothening process to form an aluminum alloy plate (cut plate) having a thickness of 20 mm. As the alloy containing Ti, a Ti-B master alloy was added so as to prevent the ingot cracking. The smoothening processes using three kinds of methods, namely, the end mill process, the end mill process + hair line process (using a belt type polishing non-woven fabric), and the hair line process, were compared with each other in terms of their effects. It is noted that the plate to which the end mill process was applied was the aluminum alloy hot-rolledplate of about 25 mm in thickness, and that the plate to which only the single hair line process was applied was the aluminum alloy hot-rolled plate of about 20 mm in thickness.

[0079] The end mill process was performed using a processing machine created by remodeling an end mill machine (milling attachment) manufactured by WASSER GmbH (which is a German machinery manufacturer, and in which GmbH means company limited).
A rough tip was made of cemented carbide, and a finishing tip was made of diamond. The amount of a part to be processed by the end mill machine was the amount of pressing of a disk from a zero point. The end mill process was processed such that the amount of the processed part was adjusted to about 2.5 mm per side in total.
Specifically, 30 rough tips and 2 finishing tips were attached near the circumferential part of the lower surface of the disk. The disk was descended toward an object to be processed. The disk was fed in the plate longitudinal direction while being rotated, whereby the cutting process was performed. The finishing tips were attached in such a manner that the amount of protruding of the finishing tip was slightly larger than that of the rough tip. As a result, the surface cut by the rough tip was further cut by the following finishing tip.

[0080] The hair line process was performed using a polishing machine created by rebuilding an aluminum plate buffing machine manufactured by Nomizu Machine Mfg.Co., Ltd such that a polishing non-woven fabric wheel can be attached to a buff polishing roll. The wheel was POLITEX (trademark) manufactured by KOYO-SHACo., Ltd. The KF wheel was made of MA (grade (#150)). The outer diameter ϕ was 400 mm. The wheel was impregnated with grease. A brown molten alumina was used as the kind of abrasive grain. A resin bond was used as an adhesive.

[0081] The polishing was performed on conditions where an amount of the part processed was about 3. 0 μm per side (with oscillation (reciprocating twice)). The polishing amount was measured and confirmed by performing geometry measurement of a stepped portion of a polished part of the sample by "WYKO NT330 (profilometer system)" manufactured by Vecoo instruments Inc (USA) to measure the depth of pits and projections.

(Al-Mn Based Alloy)

[0082] Aluminum alloys having alloy compositions No. 3a to 3e shown in Table 1 (3e: Ti and B not added) were melted, subjected to the hydrogen gas removal process, filtered, and then cast into ingots having a thickness of 500 mm. Then, each ingot was hot-rolled into an aluminum alloy hot-rolled plate of about 25 mm in thickness and another aluminum alloy hot-rolled plate of about 20 mm in thickness. The aluminum alloy hot-rolled was cut into pieces, each having 2000 mm in rolling-direction length × 1000 mm in width, whose rolled surfaces (both sides) were subjected to the smoothening process to form an aluminum alloy plate (cut plate) having a thickness of 20 mm. As the alloy containing Ti, a Ti-B master alloy was added so as to prevent the ingot cracking. The smoothening processes using three kinds of methods, namely, the end mill process, the end mill process + hair line process (using a belt type polishing non-woven fabric), and the hair line process, were compared with each other in terms of their effects. It is noted that the plate to which the end mill process was applied was the aluminum alloy hot-rolled plate of about 25 mm in thickness, and that the plate to which only the single hair line process was applied was the aluminum alloy hot-rolled plate of about 20 mm in thickness. The end mill process and the hair line process were the same as those applied to the above Al-Mg based alloy.

[0083]

[Table 1].

Alloy No.	Aluminum alloy element composition (% by mass)								
	Mg	Si	Fe	Cu	Mn	Cr	Zn	Ti	Al**
5a	2.6	0.1	0.4	-	-	-	-	0.01	Balance
5b	2.6	0.1	0.4	-	0.3	-	-	0.01	Balance
5c	4.4	0.1	0.4	-	-	-	-	0.01	Balance
5d	7.0	0.1	0.4	-	-	-	-	0.01	Balance
5e	10.5	0.1	0.4	-	-	-	-	0.01	Balance
5f	4.4	0.3	0.5	0.3	-	-	-	0.01	Balance
5g	4.4	0.1	0.3	-	0.05	-	-	0.01	Balance
5h	4.4	0.1	0.3	-	-	0.05	-	0.01	Balance
5i	4.4	0.1	0.3	-	0.7	0.3	-	0.01	Balance
5j	4.4	0.1	0.3	-	0.05	-	0.3	0.01	Balance
5k	2.5	0.1	0.3	-	-	0.15	-	0.01	Balance
5l	4.4	0.1	0.2	-	0.6	-	-	0.01	Balances
5m*	1.4*	0.1	0.4	-	-	-	-	0.01	Balance
5n *	13.0*	0.1	0.4	-	-	-	-	0.01	Balance
5o *	4.4	0.8*	0.4	-	-	-	-	0.01	Balance
5p *	4.4	0.1		1.0*	-	-	-	0.01	Balance
5q *	4.4	0.1	0.4	0.7*	-	-	-	0.01	Balance
5r *	4.4	0.1	0.4	-	1.1 *	-	-	0.01	Balance
5s *	4.4	0.1	0.4	-	-	0.6 *	-	0.01	Balance
5t *	4.4	0.1	0.4	-	-	-	0.5 *	0.01	Balance
5u *	4.4	0.1	0.4	-	-	-	-	0.15	Balance
5v	2.6	0.1	0.4	-	-	-	-	-	Balance
3a	-	0.1	0.3	-	0.5	-	-	0.01	Balance
3b	-	0.1	0.4	-	0.9	-	-	0.01	Balance
3c *	-	0.1	0.4	-	0.2 *	-	-	0.01	Balance
3d *	-	0.1	0.3	-	1.7 *	-	-	0.01	Balance
3e	-	0.1	0.3	-	0.5	-	-	-	Balance
*: Outside appropriate range **: Including inevitable impurities									

[Example 1: Evaluation]

[0084] The thus-obtained aluminum alloy plates were evaluated for the following properties, and the evaluation results were shown in Tables 2 and 3. Further, an aluminum alloy hot-rolled plate (of 20 mm in thickness) not subjected to the smoothening process was produced and evaluated as a comparative example. Since the alloy No. 5n was not able to produce an aluminum alloyhot-rolled plate as described later, the following processes and evaluation were not performed on the alloy No. 5n, whose results were represented by a mark "-" in Tables 2 and 3.

(Flatness)

[0085] The flatness of the aluminum alloy plates was evaluated by measuring an amount of warpage per meter (flatness) of each sample in the rolling-direction. An acceptability criterion of flatness was the flatness of 0.2 mm/m or less.

(Thickness Precision)

[0086] The thicknesses of six points in total of each sample were measured by a micrometer. Specifically, the six points were four corners of the sample and two points each located at 20 mm inward in the width direction from a position halfway of the rolling-direction side of the sample. The sample having the thickness of each of the six points within 20.0 ± 0. 06 mm (within a range of 19.94 to 20.06 mm) was determined to have excellent thickness precision and thus was represented by a mark "◎". The sample having the thickness within 20.0 ± 0.10 mm (20. 0 mm ± 0. 5 %, that is, 19.90 to 20.10 mm) was determined to have good thickness precision and thus was represented by a mark "○".

(Strength)

[0087] A tensile specimen compliant with JIS No.5 was cut out of each sample. The specimen was subjected to a tensile test according to JISZ2241 to measure a tensile strength and an offset yield strength (0.2 % offset yield strength) thereof. Acceptability criteria of strength were a tensile strength of 180 N/mm^2 or more for the alloys No. 5a to 5u (Al-Mg based alloys), and a tensile strength of 90 N/mm^2 or more for the alloys No. 3a to 3d (Al-Mn based alloys).

(Surface Texture)

[0088] In order to evaluate the effect of the smoothening process on a surface texture of each sample, the samples (40 pieces made of each aluminum alloy plate) were subjected to the anodizing treatment. Then, the appearance of the treated surface of each sample was observed.
Specifically, the sample was subjected to a sulfuric acid anodizing treatment (using 15 % sulfuric acid at 20 ˚C at a current density of $2A/dm^2$) to form an alumite coating of 10 μm in thickness. The surface texture in terms of flaws and black streaks on the surface of each sample was examined.

<Evaluation of Surface Texture in Terms of Flaw After Anodizing Treatment>

[0089] The appearance of the surface subjected to the anodizing treatment was observed. The sample in which none of 40 cut pieces had a flaw visually identified was evaluated to have very good surface texture in terms of flaws and represented by a mark " ◎". The sample in which one to four pieces of 40 cut pieces had flaws visually identified was evaluated to have good surface texture in terms of flaws, and represented by a mark "○". The sample in which five pieces or more of 40 cut pieces had flaws visually identified was evaluated to have bad surface texture in terms of flaws, and represented by a mark "x".

<Evaluation of Surface Texture in Terms of Black Streak After Anodizing Treatment>

[0090] Whether or not the surface subjected to the anodizing treatment had a black streak (which was not a functional defect) was determined by observing the surface. The sample in which no black streak was visually identified was determined to have good surface texture in terms of black streak, and represented by a mark "○". The sample in which a black streak was visually identified was determined to have bad surface texture in terms of black streak, and represented by a mark "x".

[0091] Further, each sample was also evaluated for the surface texture in terms of color irregularity of the surface. This surface texture was a simple criterion of the surface texture desired by the invention. However, even the sample which satisfies the good surface texture in terms of the flaw and black streak without satisfying the adequate surface texture in terms of color irregularity is determined to achieve the minimum obj ect regarding the surface texture of the invention.

< Evaluation of Surface Texture in Terms of Color Irregularity After Anodizing Treatment>

[0092] The appearance of the surface subjected to the anodizing treatment was observed. The sample in which no color irregularity was observed was determined to have good surface texture in terms of color irregularity, and represented by a mark "○". The sample in which color irregularity was observed was determined to have bad surface texture in terms of color irregularity, and represented by a mark "x".

[0093] The strength levels of the samples after the end mill process + hair line process, and only after the hair line process were the same as that only after the end mill process, and thus the description of such strength levels will be omitted in Tables.

[0094]

[Table 2]

Alloy No.	Aluminum alloy plate											
	Smoothening treatment using end mill process							Smoothening treatment using end mill process + hair line process				
	Flatness (mm/m)	Thickness precision	Strength (N/mm²)		After alumite treatment			Flatness (mm/m)	Thickness precision	After alumite treatment		
			Tensile strength	Offset yield strength	Surface texture in terms of flaws	Surface texture in terms of black streak	Surface texture in terms of color irregularity			Surface texture in terms of flaws	Surface texture in terms of black streak	Surface texture in terms of color irregularity
5a	0.15	◎	217	102	◎	○	○	0.14	◎	◎	○	○
5b	0.15	◎	228	110	◎	○	○	0.15	◎	◎	○	○
5c	0.16	◎	294	143	◎	○	○	0.16	◎	◎	○	○
5d	0.18	◎	331	170	◎	○	○	0.17	◎	◎	○	○
5e	0.19	◎	385	186	◎	○	○	0.18	◎	◎	○	○
5f	0.18	◎	309	139	◎	○	○	0.18	◎	◎	○	○
5g	0.16	◎	305	146	◎	○	○	0.16	◎	◎	○	○
5h	0.16	◎	314	145	◎	○	○	0.15	◎	◎	○	○
5i	0.17	◎	318	155	◎	○	○	0.17	◎	◎	○	○
5j	0.18	◎	305	144	◎	○	○	0.18	◎	◎	○	○
5k	0.16	◎	222	108	◎	○	○	0.15	◎	◎	○	○
5l	0.18	◎	307	145	◎	○	○	0.18	◎	◎	○	○
5m*	0.15	◎	171	69	◎	○	○	0.15	◎	◎	○	○
5n*	–	–	–	–	–	–	–	–	–	–	–	–
5o*	0.17	◎	322	160	◎	○	×	0.17	◎	◎	○	×
5p*	0.17	◎	306	150	◎	○	×	0.16	◎	◎	○	×
5q*	0.18	◎	320	163	◎	○	○	0.18	◎	◎	○	○
5r*	0.17	◎	324	162	◎	○	×	0.17	◎	◎	○	×
5s*	0.18	◎	322	158	◎	○	×	0.17	◎	◎	○	×
5t*	0.17	◎	305	146	◎	○	○	0.17	◎	◎	○	○
5u*	0.18	◎	310	147	◎	○	○	0.18	◎	◎	○	○
5v	0.15	◎	215	101	◎	○	○	0.14	◎	◎	○	○
3a	0.15	◎	94	38	◎	○	○	0.15	◎	◎	○	○
3b	0.16	◎	103	41	◎	○	○	0.15	◎	◎	○	○
3c*	0.16	◎	84	37	◎	○	○	0.16	◎	◎	○	○
3d*	0.17	◎	117	49	◎	○	×	0.16	◎	◎	○	×
3e	0.15	◎	92	37	◎	○	○	0.14	◎	◎	○	○

*: Outside appropriate range

[0095]

[Table 3]

Alloy No.	Aluminum alloy plate: Smoothening treatment using hair line process: Flatness (mm/m)	Thickness precision	After alumite treatment: Surface texture in terms of flaws	Surface texture in terms of black streak	Surface texture in terms of color irregularity	Aluminum alloy hot-rolled plate: Flatness (mm/m)	Thickness precision	Strength (N/mm^2): Tensile strength	Offset yield strength	After alumite treatment: Surface texture in terms of flaws	Surface texture in terms of black streak	Surface texture in terms of color irregularity
5a	0.41	◎	○	×	○	0.41	◎	212	102	×	×	○
5b	0.41	◎	○	×	○	0.42	◎	222	108	×	×	○
5c	0.50	○	○	×	○	0.50	○	292	136	×	×	○
5d	0.61	○	○	×	○	0.62	○	310	160	×	×	○
5e	0.68	○	○	×	○	0.69	○	368	195	×	×	○
5f	0.47	◎	○	×	○	0.47	◎	298	152	×	×	○
5g	0.48	○	○	×	○	0.48	○	291	146	×	×	○
5h	0.47	○	○	×	○	0.47	○	293	149	×	×	○
5i	0.49	○	○	×	○	0.50	○	307	154	×	×	○
5j	0.48	○	○	×	○	0.48	○	297	142	×	×	○
5k	0.43	◎	○	×	○	0.43	◎	219	122	×	×	○
5l	0.48	○	○	×	○	0.49	○	300	157	×	×	○
5m*	0.42	◎	○	×	○	0.42	◎	175	92	×	×	○
5n *	–	–	–	–	–	–	–	–	–	–	–	–
5o *	0.48	◎	○	×	×	0.48	◎	292	136	×	×	×
5p *	0.50	○	○	×	×	0.50	○	290	137	×	×	×
5q *	0.48	○	○	×	○	0.49	○	298	150	×	×	○
5r *	0.48	◎	○	×	×	0.48	◎	305	152	×	×	×
5s *	0.47	○	○	×	×	0.48	○	302	148	×	×	×
5t *	0.50	○	○	×	○	0.50	○	288	137	×	×	○
5u *	0.49	○	○	×	○	0.50	○	293	140	×	×	○
5v	0.40	◎	○	○	○	0.40	◎	211	102	×	○	○
3a	0.41	◎	○	×	○	0.41	◎	113	55	×	×	○
3b	0.41	○	○	×	○	0.42	○	118	58	×	×	○
3c *	0.41	◎	○	×	○	0.41	◎	96	48	×	×	○
3d *	0.43	○	○	×	×	0.44	○	140	72	×	×	×
3e	0.41	◎	○	○	○	0.41	◎	112	55	×	○	○

*: Outside appropriate range

[0096] Each of aluminum alloy plates made of the alloys No. 5a to 5l and 5v had the additional element content in an appropriate range, and has its surface subj ected to the appropriate smoothening treatment. As a result, these aluminum alloy plates had good strength, flatness, thickness precision, and surface texture. Further, such aluminum alloy plates had the sufficient strength and good surface texture as compared to an aluminum alloy hot-rolled plate not subjected to the smoothening treatment. On the other hand, an aluminum alloy plate made of the alloy No. 5m had an insufficient Mg content, and thus was not able to have enough strength. In contrast, an aluminum alloy plate made of the alloy No.5n had an excessive Mg content, and thus ingot cracking was caused therein. As a result, a sample of the alloy No.5n was not able to be fabricated. Aluminum alloy plates made of the alloys No.5o, 5p, 5r, and 5s had excessive Si, Fe, Mn, and Cr contents, respectively, and thus bulky intermetallic compounds were formed therein to cause color irregularity on the outer appearance of the surface after the anodizing process. Aluminum alloy plates made of the alloys No.5q, 5t, and 5u had Cu, Zn, Ti contents exceeding the respective appropriate ranges, and thus did not exhibit the effect of improving the strength and surface texture as compared to those of the aluminum alloy plates made of the alloys 5f, 5j, and 5c having the contents of these elements controlled in the appropriate ranges.

[0097] Differences between the surface smoothening processes were confirmed as follows. A combination of the end mill process and the hair line process, by which the amount of removal of the plate was appropriate, or only the end mill process was confirmed to improve the surface texture in terms of flaws as compared to the case of using only the hair line process by which the amount of removal of the plate was small. The flaws found in a cut plate of the conventional hot-rolled plate included fine flaws in such a size that were able to be visually identified with difficulty and which did not affect the function. In contrast, the flaws found in the cut plate subjected to only the hair line process were only those that were able to be visually identified clearly. Accordingly, it has been found that even only the hair line process can also effectively facilitate the identification of functional defects.

[0098] Further, it has been found that the use of only the hair line process results in the small amount of the removed plate, and cannot prevent the occurrence of black streaks, but that the use of only the end mill process, or of the combination of the end mill process and hair line process result in the appropriate amount of the removed plate, and thus can prevent the occurrence of black streaks. The aluminum alloy plate made of the alloy No.5v did not use Ti-B as the ingot grain fining agent in casting the slab. It has been found that the aluminum alloy plate of the alloy No.5v can prevent the occurrence of the black steaks even by any one of the surface smoothening processes without being influenced by the difference between the surface smoothening processes.

[0099] Each of aluminum alloy plates made of the alloys No. 3a, 3b, and 3e had the additional element content in an appropriate range, and had its surface subj ected to the appropriate smoothening treatment. As a result, these aluminum alloy plates had good strength, flatness, thickness precision, and surface texture. Further, such aluminum alloy plates had the sufficient strength and good surface texture as compared to an aluminum alloy hot-rolled plate not subjected to the smoothening treatment. On the other hand, an aluminum alloy plate made of the alloy No. 3c had an insufficientMn content, and was not able to obtain enough strength. In contrast, an aluminum alloy plate made of the alloy No. 3d had an excessive Mn content, and the bulky intermetallic compound was formed therein, which caused the color irregularity in the outer appearance of the surface subjected to the anodizing process.

[0100] Differences between the surface smoothening processes were confirmed as follows. The combination of the endmill process and the hair line process, by which the amount of removal of the plate was appropriate, or only the end mill process was confirmed to improve the surface texture in terms of flaws as compared to the case of using only the hair line process by which the amount of removal of the plate was small. The flaws found in the cut plate of the conventional hot-rolled plate included fine flaws in such a size that were able to be visually identified with difficulty and which did not affect the function. In contrast, the flaws found in the cut plate subjected to only the hair line process were only those that were able to be visually identified clearly. Accordingly, it has been found that even only the hair line process can also effectively facilitate the identification of functional defects.

[0101] Further, the use of only the hair line process resulted in the small amount of removal of the plate, and was not able to prevent the occurrence of black streaks. In contrast, the use of only the end mill process, or of the combination of the end mill process and hair line process resulted in the appropriate amount of removal of the plate, and was able to prevent the occurrence of black streaks. The aluminum alloy plate made of the alloy No.3e did not use Ti-B as the ingot grain fining agent in casting the slab. It has been found that the aluminum alloy plate of the alloy No.3e can prevent the occurrence of the black steaks even by any one of the surface smoothening processes without being influenced by the difference between the surface smoothening processes.

[0102] The aluminum alloy hot-rolled plate not subjected to the smoothening process had accumulated process distortion, and as a result, had the bad flatness due to the large warpage in the rolling direction. Most of the aluminum alloy hot-rolled plates not subjected to the smoothening process were slightly inferior in thickness precision to an aluminum alloy plate with the same composition. The hot-rolledplate hadbad surface texture in terms of flaws and black streaks. Also, the flatness of the aluminum alloy hot-rolled plate only after the hair line process, and the thickness precision of the cut plate of the hot-rolled plate were evaluated to be substantially the same as the flatness of the aluminum hot-rolled plate (without the smoothening process) and the thickness precision of the cut plate thereof (note that the amount of the processed part of 2 to 3 μm did not reduce the accumulated process distortion, which leads to large warpage in the rolling direction, resulting in poor flatness).

[Example 2: Production of Samples]

(Al-Mg-Si Based Alloy)

[0103] Aluminum alloys having alloy compositions No. 6a to 6g shown in Table 4 were melted, subj ected to the hydrogen gas removal process, filtered, and then cast into ingots having a thickness of 500 mm. Then, each ingot was hot-rolled into an aluminum alloy hot-rolled plate of about 25 mm in thickness and another aluminum alloy hot-rolled plate of about 20 mm in thickness. The aluminum alloy hot-rolled plate was cut into pieces, each having 2000 mm in rolling-direction length x1000 mm in width, whose rolled surfaces (both sides) were subjected to the smoothening process to form an aluminum alloy plate (cut plate) having a thickness of 20 mm. As the alloy containing Ti, a Ti-B master alloy was added so as to prevent the ingot cracking. The smoothening processes using three kinds of methods, namely, the endmill process, the endmill process + hair line process (using a belt type polishing non-woven fabric), and the hair line process, were compared with each other in terms of their effects. It is noted that the aluminum alloy plate to which the end mill process was applied was the aluminum alloy hot-rolled plate of about 25 mm in thickness, and that the aluminum alloy plate to which only the single hair line process was applied was the aluminum alloy hot-rolled plate of about 20 mm in thickness. The end mill process and the hair line process were the same as those applied to the above Al-Mg based alloy. The thus-obtained aluminum alloy plates were subjected to solution treatment at 520 ˚C, and then to aging treatment at 175 ˚C for 8 hours.

(Al-Zn-Mg Based Alloy)

[0104] Aluminum alloys having alloy compositions No. 7a to 7g shown in Table 4 were melted, subjected to the hydrogen gas removal process, filtered, and then cast into ingots having a thickness of 500 mm. Then, each ingot was hot-rolled into an aluminum alloy hot-rolled plate of about 25 mm in thickness and another aluminum alloy hot-rolled plate of about 20 mm in thickness. The aluminum alloy hot-rolled plate was cut into pieces, each having 2000 mm in rolling-direction length x1000 mm in width, whose rolled surfaces (both sides) were subjected to the smoothening process to form an aluminum alloy plate (cut plate) having a thickness of 20 mm. As the alloy containing Ti, a Ti-B master alloy was added so as to prevent the ingot cracking. The smoothening processes using three kinds of methods, namely, the endmill process, the endmill process + hair line process (using a belt type polishing non-woven fabric), and the hair line process, were compared with each other in terms of their effects. It is noted that the aluminum alloy plate to which the end mill process was applied was the aluminum alloy hot-rolled plate of about 25 mm in thickness, and that the aluminum alloy plate to which only the single hair line process was applied was the aluminum alloy hot-rolled plate of about 20 mm in thickness. The end mill process and the hair line process were the same as those applied to the above Al-Mg based alloy. The thus-obtained aluminum alloy plates were subjected to solution treatment at 470 ˚C, and then to aging treatment at 120 ˚C for 48 hours.

[0105]

[Table 4]

Alloy No.	Aluminum alloy element composition (% by mass)									
	Mg	Si	Fe	Cu	Mn	Cr	Zn	Ti	Zr	Al**
6a	0.9	0.5	0.5	0.3	0.1	0.2	0.2	0.02	-	Balance
6b	0.5	0.9	0.2	-	0.1	-	-	0.02	-	Balance
6c *	0.9	0.1*	0.5	-	0.1	-	-	0.02	-	Balance
6d *	0.9	1.8*	0.4	-	0.1	-	-	0.02	-	Balance
6e *	0.2*	0.5	0.5	-	0.1	-	-	0.02	-	Balance
6f *	1.7*	0.5	0.4	-	0.1	-	-	0.02	-	Balance
6g	0.9	0.5	0.5	0.3	0.1	0.2	0.2	-	-	Balance
7a	2.5	0.1	0.2	1.8	-	0.2	4.0	0.02	-	Balance
7b	3.5	0.2	0.2	2.0	-	-	8.0	0.02	0.2	Balance
7c *	0.3*	0.1	0.2	2.2	-	0.1	4.0	0.02	-	Balance
7d *	5.0*	0.2	0.2	2.0	-	0.1	5.0	0.02	-	Balance

(continued)

Alloy No.	Aluminum alloy element composition (% by mass)									
	Mg	Si	Fe	Cu	Mn	Cr	Zn	Ti	Zr	Al**
7e *	2.5	0.1	0.2	2.2	-	0.1	2.4*	0.02	-	Balance
7f *	3.0	0.2	0.2	2.0	-	0.1	9.5*	0.02	-	Balance
7g	2.5	0.1	0.2	1.8	-	0.2	4.0*	-	-	Balance
*: Outside appropriate range ** : Including inevitable impurities										

[Example 2: Evaluation]

[0106] The thus-obtained aluminum alloy plates were evaluated for the strength and surface texture in the same way as Example 1. The evaluation results were shown in Tables 5 and 6. An aluminum alloy hot-rolled plate (of 20 mm in thickness) not subjected to the smoothening process was also produced, and then subjected to the solution treatment and the aging treatment on the same conditions. The aluminum alloy hot-rolled plate was also evaluated as a comparative example. Acceptability criteria of strength were a tensile strength of 200 N/mm^2 or more for the alloys No. 6a to 6g (Al-Mg-Si based alloys), and a tensile strength of 250N/mm^2 or more for the alloys No. 7a to 7g (Al-Zn-Mg based alloys). The strength levels of the samples after the end mill process + hair line process, and only after the hair line process were the same as that only after the end mill process, and thus the description of such strength levels will be omitted in Tables.

[0107]

[Table 5]

Alloy No.	Aluminum alloy plate							
	Smoothening treatment using end mill process					Smoothening treatment using end mill process +hair line process		
	Strength (N/mm^2)		Atter alumite treatment			After alumite treatment		
	Tensile strength.	Offset yield strength	Surface texture in lems of flaws	Surface texture in terms of black streak	Surface texture in terms of color	Surface texture in terms of flaws	Surface texture in terms of black streak	Surface texture in terms of color irregularity
6a	323	274	◎	○	○	◎	○	○
6b	292	249	◎	○	○	◎	○	○
6c *	115	67	◎	○	○	◎	○	○
6d *	336	298	◎	○	×	◎	○	×
6e *	174	121	◎	○	○	◎	○	○
6f *	210	124	◎	○	○	◎	○	○
6g	321	273	◎	○	○	◎	○	○
7a	424	364	◎	○	○	◎	○	○
7b	511	450	◎	○	○	◎	○	○
7c *	195	168	◎	○	○	◎	○	○
7d *	289	190	◎	○	×	◎	○	×
7e *	212	132	◎	○	○	◎	○	○
7f *	610	530	◎	○	×	◎	○	×

(continued)

Alloy No.	Aluminum alloy plate							
	Smoothening treatment using end mill process					Smoothening treatment using end mill process +hair line process		
	Strength (N/mm²)		Atter alumite treatment			After alumite treatment		
	Tensile strength.	Offset yield strength	Surface texture in lems of flaws	Surface texture in terms of black streak	Surface texture in terms of color	Surface texture in terms of flaws	Surface texture in terms of black streak	Surface texture in terms of color irregularity
7g	423	363	◎	○	×	◎	○	×
*: ; Outside appropriate range								

[0108]

[Table 6]

Alloy No.	Aluminum alloy plate			Aluminum alloy hot-rolled plate				
	Smoothening treatment using hair line process							
	After alumite treatment			Strength (N/mm²)		After alumite treatment		
	Surface texture in terms of flaws	Surface texture in terms of black streak	Surface texture in terms of color irregularily	Tensile strength	Offset yield strength	Surface texture in terms of flaws	Surface texture in terms of black streak	Surface texture in terms of color irregularity
6a	○	×	○	342	269	×	×	○
6b	○	×	○	315	271	×	×	○
6c *	○	×	○	137	88	×	×	○
6d *	○	×	×	364	324	×	×	×
6e *	○	×	○	198	142	×	×	○
6f *	○	×	○	234	145	×	×	○
6g	○	○	○	340	268	×	○	○
7a	○	×	○	439	378	×	×	○
7b	○	×	○	531	471	×	×	○
7c *	○	×	○	208	171	×	×	○
7d *	○	×	×	301	200	×	×	×
7e *	○	×	○	222	144	×	×	○
7f *	○	×	×	612	531	×	×	×
7g	○	○	×	437	376	×	○	×
*: Outside appropriate range								

[0109] Each of aluminum alloy plates made of the alloys No. 6a, 6b and 6g had the additional element content in an appropriate range, and had its surface subj ected to the appropriate smoothening treatment. As a result, these aluminum alloy plates had good strength and surface texture. Further, such aluminum alloy plates had the sufficient strength and good surface texture as compared to the aluminum alloy hot-rolled plate not subjected to the smoothening treatment. On the other hand, aluminum alloy plates made of the alloys No. 6c and 6e had insufficient Si and Mg contents, respectively, and thus were not able to have enough strength. In contrast, an aluminum alloy plate made of the alloy No.6d had an excessive Si content, and bulky intermetallic compounds were formed therein to cause color irregularity on the outer appearance of the surface after the anodizing process. An aluminum alloy plate made of the alloy No. 6f had an excessive Mg content only to have the properties of the Al-Mg based (5000-series Al) alloy, and did not exhibit the effect of improving the strength by a solution treatment and an aging treatment. Thus, the aluminum alloy plate of the alloy No 6f had a reduced strength as compared to the alloys No. 6a and 6b having the Mg content in the appropriate range.

[0110] Differences between the surface smoothening processes were confirmed as follows. The combination of the endmill process and the hair line process, by which the amount of removal of the plate was appropriate, or only the end mill process was confirmed to improve the surface texture in terms of flaws as compared to the case of using only the hair line process by which the amount of removal of the plate was small. The flaws found in the cut plate of the conventional hot-rolled plate included fine flaws in such a size that were able to be visually identified with difficulty and which did not affect the function. In contrast, the flaws found in the cut plate subjected to only the hair line process were only those that can be visually identified clearly. Accordingly, it has been found that even only the hair line process can also effectively facilitate the identification of functional defects.

[0111] Further, it has been found that the use of only the hair line process results in the small amount of removal of the plate, and cannot prevent the occurrence of black streaks, but that the use of only the end mill process, or of the end mill process and hair line process result in the appropriate amount of removal of the plate, and thus can prevent the occurrence of black streaks. The aluminum alloy plate made of the alloy No. 6g did not use Ti-B as the ingot grain fining agent in casting the slab. It has been found that the aluminum alloy plate of the alloy No. 6g can prevent the occurrence of the black steaks even by any one of the surface smoothening processes without being influenced by the difference between the surface smoothening processes.

[0112] Each of aluminum alloy plates made of the alloys No. 7a, 7b and 7g had the additional element content in an appropriate range, and had its surface subj ected to the appropriate smoothening treatment. As a result, these aluminum alloy plates had good strength and surface texture. Further, such aluminum alloy plates had the sufficient strength and good surface texture as compared to the aluminum alloy hot-rolled plate not subjected to the smoothening treatment. On the other hand, aluminum alloy plates made of the alloys No. 7c and 7e had insufficient Mg and Zn contents, respectively, and thus were not able to have enough strength. In contrast, aluminum alloy plates made of the alloys No. 7d and 7f had excessive Mg and Zn contents, respectively, and bulky intermetallic compounds were formed therein to cause color irregularity on the outer appearance of the surface after the anodizing process.

[0113] Differences between the surface smoothening processes were confirmed as follows. The combination of the endmill process and the hair line process, by which the amount of removal of the plate was appropriate, or only the end mill process was confirmed to improve the surface texture in terms of flaws as compared to the case of using only the hair line process by which the amount of removal of the plate was small. The flaws found in the cut plate of the conventional hot-rolled plate included fine flaws in such a size that were able to be visually identified with difficulty and which did not affect the function. In contrast, the flaws found in the cut plate subjected to only the hair line process were only those that were able to be visually identified clearly. Accordingly, it has been found that even only the hair line process can also effectively facilitate the identification of functional defects.

[0114] Further, it has been found that the use of only the hair line process results in the small amount of removal of the plate, and cannot prevent the occurrence of black streaks, but that the use of only the end mill process, or of the combination of the end mill process and hair line process result in the appropriate amount of removal of the plate, and thus can prevent the occurrence of black streaks. The aluminum alloy plate made of the alloy No.7g did not use Ti-B as the ingot grain fining agent in casting the slab. It has been found that the aluminum alloy plate of the alloy No.7g can prevent the occurrence of the black steaks even by any one of the surface smoothening processes without being influenced by the difference between the surface smoothening processes.

[0115] As mentioned above, it is understood that the aluminum alloy plate according to the present invention has good flatness and thickness precision, and is also prevented from having surface defects, such as flaw or black streaks, thereby to have a good surface texture. Further, it is understood that by appropriately setting the element composition of each of various alloys, the aluminum alloy plate can improve its properties, such as strength, and has the better surface texture with suppressed color irregularity.

Claims

1. An aluminum alloy plate, comprising an aluminum alloy hot-rolled plate whose surface is smoothened,
wherein said aluminum alloy plate has a surface flatness of 0.2 mm or less per meter of a rolling-direction length, and has fluctuations in plate thickness within ± 0.5 % of a desired plate thickness.

2. The aluminum alloy plate according to claim 1, comprising an aluminum alloy, wherein said aluminum alloy contains 1.5 to 12.0 % by mass of Mg, and further one or more elements selected from the group consisting of 0.7 % by mass or less of Si, 0.8 % by mass or less of Fe, 0.6 % by mass or less of Cu, 1.0 % by mass or less of Mn, 0.5 % by mass or less of Cr, 0.4 % by mass or less of Zn, and 0.1 % by mass or less of Ti, with the balance being Al and inevitable impurities.

3. The aluminum alloy plate according to claim 1, comprising an aluminum alloy, wherein said aluminum alloy contains 0.3 to 1.6 % by mass of Mn, and further one or more elements selected from the group consisting of 0.7 % by mass or less of Si, 0.8 % by mass or less of Fe, 0.5 % by mass or less of Cu, 1.5 % by mass or less of Mg, 0.3 % by mass or less of Cr, 0.4 % by mass or less of Zn, and 0.1% by mass or less of Ti, with the balance being Al and inevitable impurities.

4. The aluminum alloy plate according to claim 1, comprising an aluminum alloy, wherein said aluminum alloy contains 0.3 to 1.5 % by mass of Mg, 0.2 to 1.6 % by mass of Si, and further one or more elements selected from the group consisting of 0.8 % by mass or less of Fe, 1.0 % by mass or less of Cu, 0.6 % by mass or less of Mn, 0.5 % by mass or less of Cr, 0.4 % by mass or less of Zn, and 0.1 % by mass or less of Ti, with the balance being Al and inevitable impurities.

5. The aluminum alloy plate according to claim 1, comprising an aluminum alloy,
wherein said aluminum alloy contains 3.0 to 9.0 % by mass of Zn, 0.4 to 4.0 % by mass of Mg, and further one or more elements selected from the group consisting of 0.7 % by mass or less of Si, 0.8 % by mass or less of Fe, 3.0 % by mass or less of Cu, 0.8 % by mass or less of Mn, 0.5 % by mass or less of Cr, 0.1 % by mass or less of Ti, and 0.25 % by mass or less of Zr, with the balance being Al and inevitable impurities.

6. A process for producing the aluminum alloy plate according to claim 1, said process comprising the steps of:

melting an aluminum alloy to form a molten aluminum alloy;
dehydrogenating the molten aluminum alloy to remove hydrogen gas therefrom;
filtering inclusions from the molten aluminum alloy with the hydrogen gas removed therefrom;
casting the molten aluminum alloy having the inclusions removed therefrom into an ingot;
hot rolling the ingot to a predetermined thickness to produce a hot-rolled plate;
cutting the hot-rolled plate into a predetermined rolling-direction length and width; and
smoothening a surface of the cut hot-rolled plate,
wherein in the smoothening step, a thickness of the removed surface of the hot-rolled plate is in a range of 2 to 5 mm per side.

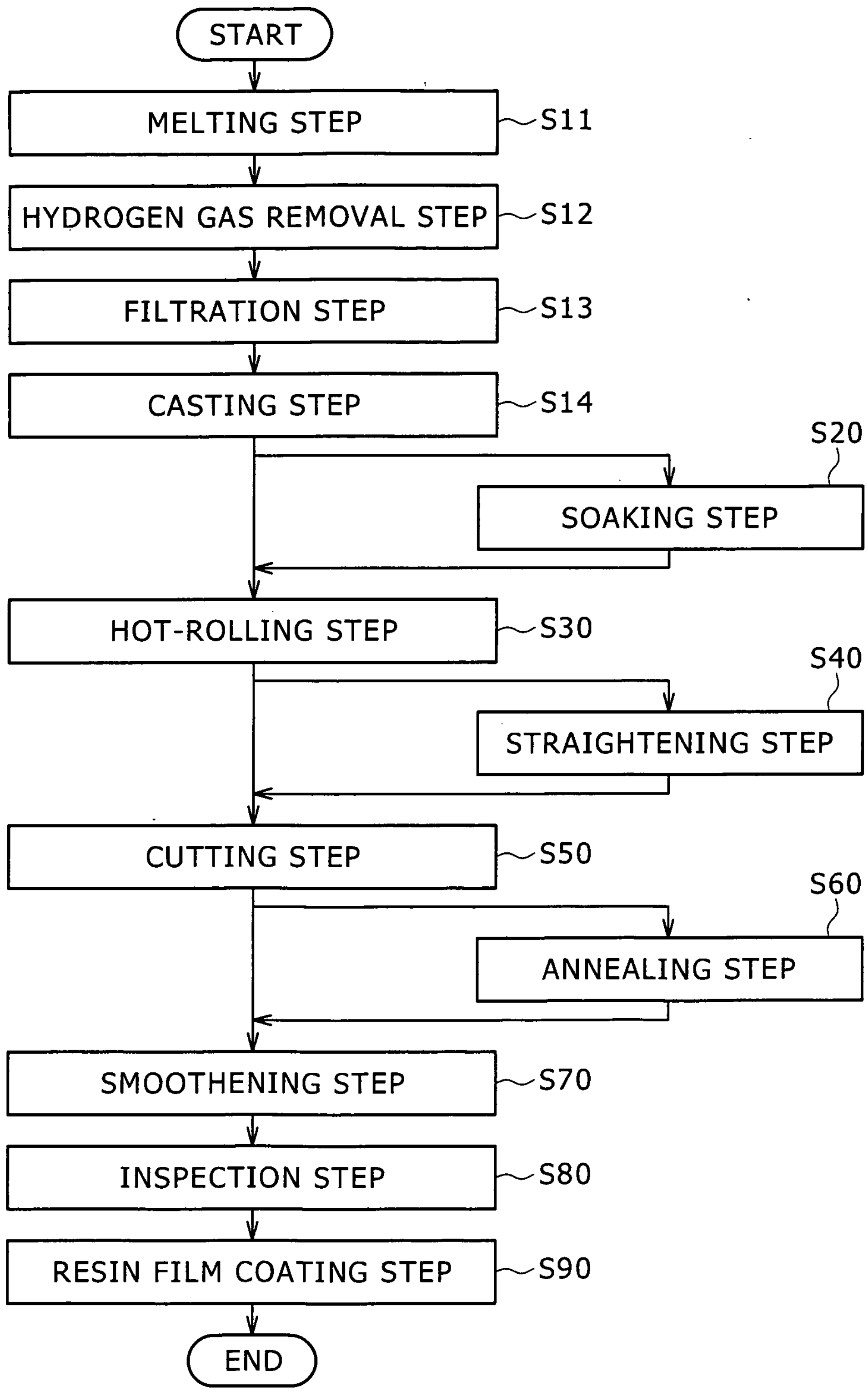
7. The process for producing the aluminum alloy plate according to claim 6, wherein a soaking step is performed on the ingot by a heat treatment for one or more hours at a temperature of 400 °C or more and less than a melting point of the aluminum alloy before the hot rolling step.

8. The process for producing the aluminum alloy plate according to claim 6, wherein an annealing step is performed for annealing the cut hot-rolled plate before the smoothening step.

9. The process for producing the aluminum alloy plate according to claim 6, wherein the smoothening step is performed by any one of a cutting method, a grinding method, and a polishing method.

10. The process for producing the aluminum alloy plate according to claim 6, wherein the aluminum alloy is the aluminum alloy according to any one of claims 2 to 5.

FIG. 1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HYDROGEN GAS REMOVAL STEP
S12
FILTRATION STEP
S13
CASTING STEP
S14
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SOAKING STEP
HOT-ROLLING STEP
S30
S40
STRAIGHTENING STEP
CUTTING STEP
S50
S60
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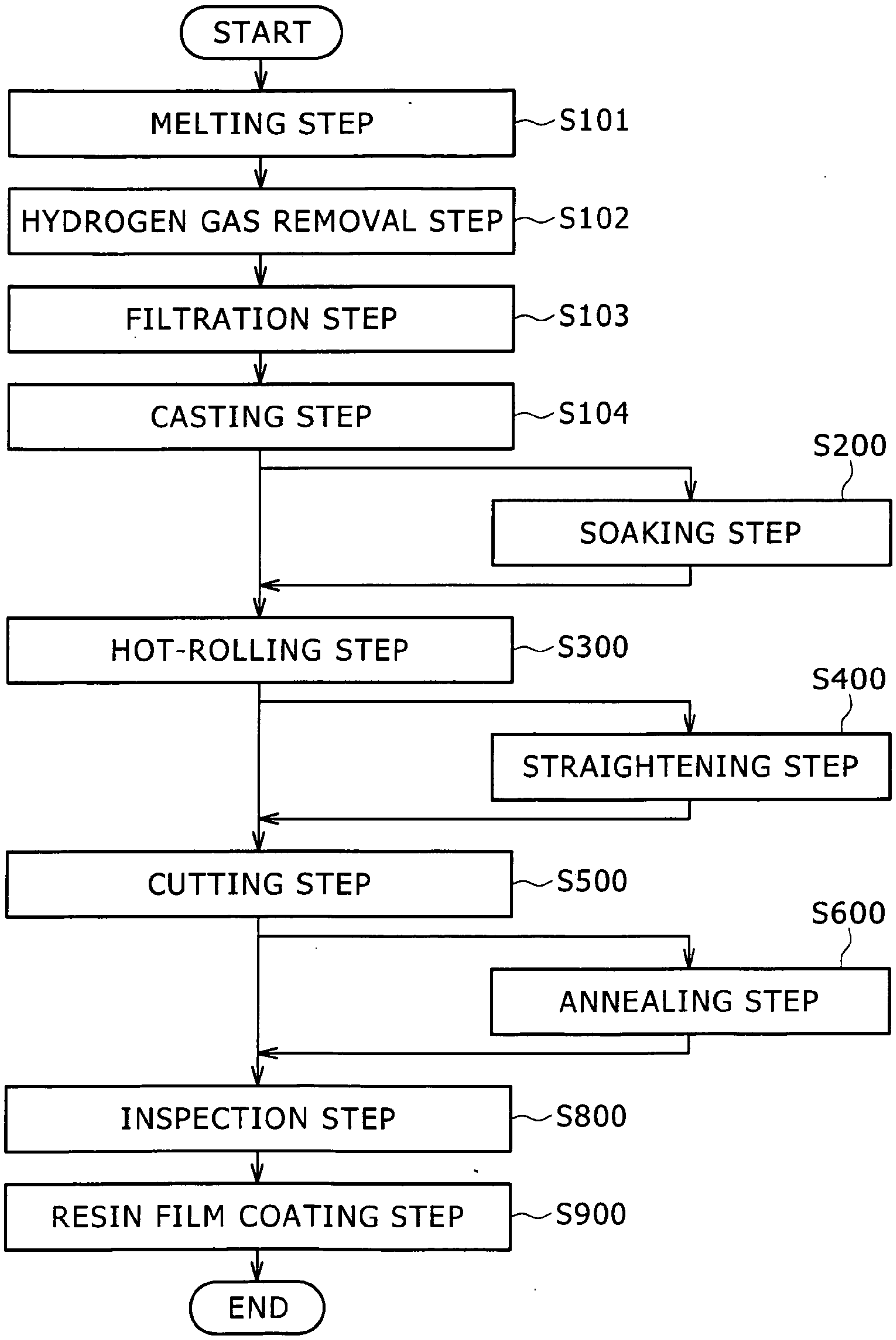
SMOOTHENING STEP
S70
INSPECTION STEP
S80
RESIN FILM COATING STEP
S90
END

FIG. 2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S101
HYDROGEN GAS REMOVAL STEP
S102
FILTRATION STEP
S103
CASTING STEP
S104
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SOAKING STEP
HOT-ROLLING STEP
S300
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S500
S600
ANNEALING STEP
INSPECTION STEP
S800
RESIN FILM COATING STEP
S900
END

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/056089

A. CLASSIFICATION OF SUBJECT MATTER
B21B45/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B21B45/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2009
Kokai Jitsuyo Shinan Koho	1971-2009	Toroku Jitsuyo Shinan Koho	1994-2009

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2005-74453 A (Nippon Light Metal Co., Ltd.), 24 March, 2005 (24.03.05), Claims (Family: none)	1-10
Y	JP 10-52740 A (Fuji Photo Film Co., Ltd.), 24 February, 1998 (24.02.98), Claims (Family: none)	1-10
Y	JP 10-137814 A (Kawasaki Steel Corp.), 26 May, 1998 (26.05.98), Full text (Family: none)	1-10

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
09 June, 2009 (09.06.09)	16 June, 2009 (16.06.09)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2009/056089

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2000-219996 A (Kobe Steel, Ltd.), 08 August, 2000 (08.08.00), Full text (Family: none)	1-10
Y	JP 2001-335812 A (Senju Metal Industry Co., Ltd.), 04 December, 2001 (04.12.01), Full text & US 2001/0055695 A1 & FR 2806765 A1	1-10

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REFERENCES CITED IN THE DESCRIPTION

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