(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 130 315 A1

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
08.02.2023 Bulletin 2023/06

(21) Application number: **21774412.7**

(22) Date of filing: **10.03.2021**

(51) International Patent Classification (IPC):
C22C 21/02 $^{(1968.09)}$ ***C22C 1/04*** $^{(1968.09)}$
C22F 1/00 $^{(1968.09)}$ ***C22F 1/043*** $^{(1985.01)}$
C25D 11/04 $^{(1974.07)}$ ***C25D 11/22*** $^{(1974.07)}$

(52) Cooperative Patent Classification (CPC):
C22C 1/04; C22C 21/02; C22F 1/00; C22F 1/043; C25D 11/04; C25D 11/22

(86) International application number:
PCT/JP2021/009517

(87) International publication number:
WO 2021/193064 (30.09.2021 Gazette 2021/39)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **27.03.2020 JP 2020057188**

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(54) ALUMINUM ALLOY MEMBER AND METHOD FOR MANUFACTURING SAME

(57) The present invention provides: an aluminum alloy member which can be manufactured at a relatively low cost and has a light weight, and which can have high dimensional accuracy under a high-temperature environment and is less likely to undergo the color-fading of a blackened surface even under a high-temperature environment, and has excellent heat resistance; and a method for manufacturing the aluminum alloy member with high efficiency. The aluminum alloy member according to the present invention comprises: a substrate which comprises an extruded material of an aluminum powder alloy having an Si content of 20 to 40% by mass and has an anodic oxide coating film formed on the surface thereof; and an electrolytically colored layer which is formed by precipitating a metal or a metal salt on voids in the anodic oxide coating film.

Description

TECHNICAL FIELD

[0001] The present invention relates to an aluminum alloy member which is required to have a blackened or darkened surface, and a method for manufacturing the same.

PRIOR ARTS

[0002] In recent years, there has been an increasing demand for optical members and electronic circuit members for automobiles, and inspection devices for these members. Aluminum alloys, which are light weight and easy to process, are widely used as these materials, but the temperature guarantee range of members for automobiles is wide, and the maximum temperature may be about 200 °C. Further, there is a demand for inspecting the members for automobiles at the maximum temperature.

[0003] Here, the surface of the aluminum alloy used for the optical member, the electronic circuit member, and the inspection device for these members is generally blackened with an organic dye after anodizing treatment such as anodizing with sulfuric acid in order to suppress light reflection.

[0004] However, there is a case that, in a high temperature environment for automobiles, the color of the aluminum alloy member blackened by the organic dye may be lost. In addition, where high dimensional accuracy is required for optical members, aluminum basically has a large linear expansion coefficient, and in an environment for automobiles where the durability temperature is high compared to the general environment, thermal expansion causes misalignment, which is a concern that it will affect the operation and inspection.

[0005] On the other hand, for example, in Patent Literature 1 (Japanese Unexamined Patent Publication No. 2010-237282), there is disclosed a method for manufacturing a support frame for a pellicle which is formed with an aluminum material including aluminum or an aluminum alloy and includes an optical thin film body for a pellicle, an anodic oxidation film is formed on a surface of the aluminum material by anodic oxidation processing using an alkaline aqueous solution containing tartaric acid, and the anodic oxidation film is subjected to dyeing processing using an organic dye and then is subjected to sealing processing by steam to obtain a support frame for the pellicle.

[0006] In the method for manufacturing a support frame for a pellicle described in Patent Literature 1, it is said that since the aluminum material is anodized with an alkaline aqueous solution containing tartaric acid without using sulfuric acid, which is the largest causative substance of haze, a support frame for pellicle that has excellent durability and corrosion resistance and reduces the occurrence of haze as much as possible.

[0007] Further, in Patent Literature 2 (Japanese Unexamined Patent Publication No. 2016-177120), there is disclosed a pellicle frame which is formed with a frame shape and consists of a sintered body with a Young's modulus of 150 GPa or more and a Vickers hardness of 800 or more, corner parts in the frame shape secure width which is larger than the width of a linear part and at least one width of the corner parts is wider than the width of the linear part, and the pellicle frame is made of ceramics, cemented carbide or cermet.

[0008] In the pellicle frame described in Patent Literature 2, it is said that since the sintered body having a high Young's modulus and Vickers hardness is used, it is possible to suppress the deformation of the pellicle frame caused by the film tension when the pellicle film is stretched on the pellicle frame. Moreover, since the width of at least one of the corner parts is wider than the width of the linear part, the strength of the corner part can be increased, and the deformation and breakage of the pellicle frame can further be suppressed.

CITATION LIST

Patent Literature

[0009]

Patent Literature 1: Japanese Patent Unexamined Publication No. 2010-237282
Patent Literature 2: Japanese Patent Unexamined Publication No. 2016-177120

Summary of the Invention

Technical Problem

[0010] The support frame for a pellicle described in Patent Literature 1 has excellent stability that does not form a reaction product (haze) such as ammonium sulfate even when energy is input from a high-output short-wavelength exposure light source, but, no consideration is given to color loss when the product is kept in a high temperature environment. Further, it has not been studied to suppress the misalignment caused by the large linear expansion coefficient of the aluminum material.

[0011] Further, although the pellicle frame described in Patent Literature 2 has high mechanical properties at room temperature, thermal expansion and blackening of the surface in a high temperature environment have not been studied. In addition, since ceramics having poor workability, cemented carbide and cermet having a large specific gravity are used, it is difficult to widely use them as optical members.

[0012] In view of the above problems in the prior art, an object of the present invention is to provide an aluminum alloy member which can be manufactured at a relatively low cost and has a light weight, and which can have high dimensional accuracy under a high temperature environment and is less likely to undergo the color fading of a blackened surface even under a high temperature environment, and has excellent heat resistance, and a method for manufacturing the same efficiently.

Solution to Problem

[0013] As a result of intensive studies on the composition of aluminum alloy members and the method of surface blackening in order to achieve the above object, the present inventors have found that it is effective to use an extruded material of aluminum alloy powder having a specific composition to make the linear expansion coefficient lower, and to form an electrolytically colored layer in which a metal or a metal salt is precipitated in the voids of the anodic oxide film, and reached the present invention.

[0014] Namely, the present invention provides an aluminum alloy member which comprises:

an extruded material of an aluminum powder alloy having an Si content of 20 to 40% by mass, and
includes a substrate having an anodic oxide coating film on the surface, and
an electrolytically colored layer which is formed by precipitating a metal or a metal salt on voids in the anodic oxide coating film.

[0015] Si has the effect of reducing the linear expansion coefficient and improving Young's modulus and wear resistance by crystallizing as the Si phase in the Al matrix. In the aluminum alloy member of the present invention, when setting the Si content to 20% by mass or more, a high Young's modulus, excellent abrasion resistance and a low linear expansion coefficient are realized, and when setting to 40% by mass or less, reduction of processing and the decrease in strength and toughness due to the coarsening of the Si phase are suppressed. The Si content is more preferably 24 to 28% by mass.

[0016] Further, the surface of the aluminum alloy member of the present invention is blackened by an electrolytically colored layer which is formed by precipitating a metal or a metal salt on the voids of the anodic oxide coating film, and the color fading in a high temperature environment is suppressed extremely effectively. That is, in the aluminum alloy member of the present invention, both the reduction of the linear expansion coefficient and the suppression of color fading in a high temperature environment are realized.

[0017] Further, the aluminum alloy member of the present invention has a smaller specific gravity than that of the cemented carbide or cermet, and the optical member can be made lighter. In addition, it is easy to handle because of excellent toughness compared to the ceramics and cemented carbide. Furthermore, since the workability is good, it is possible to impart high dimensional accuracy to the optical member, in addition to the reduction of the manufacturing cost.

[0018] In the aluminum alloy member of the present invention, it is preferable that the aluminum powder alloy contains Si: 20 to 40% by mass, Mg: 0.2 to 1.2% by mass, Cu: 2% by mass or less, Fe: 2% by mass or less, Cr: 0.4% by mass or less, and the balance being composed of Al and unavoidable impurities.

[0019] The aluminum alloy member can be endowed with excellent mechanical properties, corrosion resistance and heat resistance by precipitation strengthening by adding Mg and Cu, improving Young's modulus and corrosion resistance by adding Fe, and refining crystal particles by adding Cr.

[0020] Further, in the aluminum alloy member of the present invention, it is preferable that the metal and the metal salt contain at least one of Ni, Co, Cu, Sn, Mn, Fe, Pb, Ca, Zn and Mg. By including these elements, blackening of the surface can be efficiently and surely achieved.

[0021] Further, in the aluminum alloy member of the present invention, it is preferable that the linear expansion coefficient is 10×10^{-6} to 23×10^{-6} /K. By setting the linear expansion coefficient to 10×10^{-6} /K or more, it is possible to suppress the reduction of processability and decrease of strength and toughness due to the addition of various elements more than necessary, and in addition, the linear expansion coefficient of the optical material is close to that of a material made of ceramics or silicon or the like. Further, by setting the value to 23×10^{-6} /K or less, it is possible to suppress the displacement due to thermal expansion in a high temperature environment (for example, 200 °C). Here, the range of the linear expansion coefficient is more preferably 13×10^{-6} to 20×10^{-6} /K, and the most preferable range of the linear expansion coefficient is 15×10^{-6} to 19×10^{-6} /K.

[0022] Further, in the aluminum alloy member of the present invention, it is preferable that the difference between the L* value after the heat treatment and the L* value before the heat treatment held in an atmosphere of 200 °C for 100 hours is 3 or less. When the difference between the L* value after heating and the L* value before heating is 3 or less, there is almost no need to consider color fading in a high temperature environment where the optical member is used. Here, the difference between the L* value after heating and the L* value before heating is more preferably 2 or less, and most preferably 1 or less. Further, by setting the L* value of the aluminum alloy member to 60 or less, the light reflection of various optical components can be sufficiently suppressed. The L* value of the aluminum alloy member is more preferably 50 or less, and further preferably 45 or less.

[0023] Furthermore, it is preferable that the aluminum alloy member of the present invention is an optical member or a member for an optical member inspection device. Since the aluminum alloy member of the present invention is an aluminum alloy member which has high dimensional accuracy under a high temperature environment and is less likely to undergo the color fading of a blackened surface even under a high temperature environment, and has excellent heat resistance, it is possible to suitably use as the optical member or the member for an optical member inspection device. Here, as the optical member inspection device, an inspection light source device for a CCD ·C-MOS image sensor can be exemplified.

[0024] Further, the present invention provides a method for manufacturing an aluminum alloy member, which includes:

a first step of manufacturing a substrate by subjecting an aluminum alloy powder having a Si content of 20 to 40% by mass to pressure molding, sintering and extrusion processing,
a second step of forming an anodic oxide film on the surface of the substrate, and
a third step of electrolytically coloring the substrate in an electrolytic solution containing a metal or a metal salt to form an electrolytically colored layer on the surface of the substrate by precipitating a metal or a metal salt on voids in the anodic oxide coating film.

[0025] By extruding the sintered body of the aluminum alloy powder, a homogeneous aluminum alloy can be obtained even if the Si content is 20 to 40% by mass. Further, by electrolytically coloring the aluminum alloy material having the anodic oxide film in the electrolytic solution containing a metal or a metal salt, the metal or the metal salt is precipitated in the voids of the anodic oxide film, and then the blackening can be achieved.

Effects of the invention

[0026] According to the present invention, it is possible to provide an aluminum alloy member which can be manufactured at a relatively low cost and has a light weight, and which can have high dimensional accuracy under a high temperature environment and is less likely to undergo the color fading of a blackened surface even under a high temperature environment, and has excellent heat resistance, and a method for manufacturing the same efficiently.

Brief Explanation of the Drawings

[0027]

FIG. 1 is a schematic cross-sectional drawing of the aluminum alloy member of the embodiment.
FIG. 2 is a flow sheet of the manufacturing method of the aluminum alloy member of the embodiment.

Embodiments for achieving the invention

[0028] Hereinafter, representative embodiments of the aluminum alloy member and the efficient manufacturing method thereof according to the present invention will be described in detail with reference to the drawings, but the present invention is not limited to only these examples. Further, the elements in the embodiment can be optionally combined with a part or the whole. In the following description, the same or equivalent parts are denoted by the same numerals, and there is a case that redundant explanation may be omitted. In addition, since the drawings are for conceptually explaining the present invention, dimensions of the respective constituent elements expressed and ratios thereof may be different from actual ones.

1. Aluminum alloy member

[0029] FIG. 1 shows a schematic cross-sectional view of the aluminum alloy member of the present invention. The aluminum alloy member 1 has an anodic oxide film 4 formed on the surface of the aluminum alloy substrate 2, and includes an electrolytically colored layer 6 in which a metal or a metal salt is precipitated in the voids of the anodic oxide film 4.

[0030] The aluminum alloy substrate 2 is composed of an extruded material of an aluminum alloy powder sintered body which includes Si: 20 to 40% by mass, Mg: 0.2 to 1.2% by mass, Cu: more than 0 to 2% by mass or less, Fe: more than 0 to 2% by mass or less, Cr: more than 0 to 0.4% by mass or less, and the balance being composed of Al and unavoidable impurities, and has a low linear expansion coefficient and a high Young's modulus as compared with for example, the 7000 series (Al-Zn-Mg series) aluminum alloy, the 6000 series (Al-Mg-Si series) aluminum alloy and the 5000 series (Al-Mg series) aluminum alloy. Hereinafter, the reasons for limiting each additive element will be described.

(1) Si

[0031] Si has the effect of improving the wear resistance and lowering the thermal expansion coefficient in addition to contributing to the improvement of Young's modulus by crystallizing as the Si phase in the Al matrix. In the aluminum alloy substrate 2, when setting the Si content to 20% by mass or more, a high Young's modulus, excellent abrasion resistance and a low linear expansion coefficient are realized, and when setting to 40% by mass or less, reduction of processing and the decrease in strength and toughness due to the coarsening of the Si phase are suppressed. The Si content is more preferably 22 to 35% by mass, furthermore preferably 24 to 30% by mass, and particularly preferably 25 to 28% by mass.

(2) Mg

[0032] The content of Mg is 0.2 to 1.2% by mass. By setting the Mg content in this range, it is possible to improve the strength by precipitation strengthening. (Precipitation strengthening with Mg_2Si and Al_2CuMg). The Mg content is more preferably 0.55 to 0.90% by mass.

(3) Cu

[0033] The content of Cu is more than 0 and 2% by mass or less. By setting the Cu content in this range, it is possible to improve the strength by precipitation strengthening in the same manner as the above-mentioned Mg. (Precipitation strengthening with Mg_2Si and Al_2CuMg). It also contributes to improving Young's modulus and corrosion resistance. When the content is more than 2% by mass, the anodic oxide film property is lowered. The Cu content is more preferably 0.11 to 0.30% by mass.

(4) Fe

[0034] The content of Fe is more than 0 and 2% by mass or less. By setting the Fe content in this range, it contributes to the improvement of the Young's modulus and the improvement of the corrosion resistance. When more than 2% by mass, elongation, thermal conductivity and extrusion will decrease. The Fe content is more preferably 0.7% by mass or less.

(5) Cr

[0035] The content of Cr is more than 0 and 0.4% by mass or less. By setting the Cr content in this range, it contributes to make the crystal finer to improve the toughness. The Cr content is more preferably 0.03 to 0.26% by mass.

(6) Al

[0036] In addition to the components of (1) to (5), the balance is substantially composed of Al. Further, unavoidable impurities may be contained as other components.

[0037] The aluminum alloy substrate 2 is preferable that the linear expansion coefficient is 10×10^{-6} to 23×10^{-6} /K. By setting the linear expansion coefficient to 10×10^{-6} /K or more, it is possible to suppress the reduction of processability and decrease of strength and toughness due to the addition of various elements more than necessary, and in addition, the linear expansion coefficient of the optical material is close to that of a material made of ceramics or silicon or the like. Further, by setting the value to 23×10^{-6} /K or less, it is possible to suppress the displacement due to thermal expansion in a high temperature environment (for example, 200 °C). Here, the range of the linear expansion coefficient is more preferably 13×10^{-6} to 20×10^{-6} /K, and the most preferable range of the linear expansion coefficient is 15×10^{-6} to 19×10^{-6} /K.

[0038] The film quality and the like of the anodic oxide film 4 is not particularly limited as long as the effect of the present invention is not impaired, and various conventionally known anodic oxide films can be used. The anodic oxide film may be formed by anodizing treatment with a sulfuric acid bath, or by subjecting the aluminum alloy substrate 2 to anodizing treatment in an alkaline bath. For example, when the anodizing treatment is performed by using a sulfuric acid bath, there is a risk that inorganic acids such as sulfuric acid and phosphoric acid may remain on the anodic oxide film 4 on the surface of the aluminum alloy substrate 2 due to this. For example, when the aluminum alloy member 1 is a pellicle frame, the inorganic acid reacts with a basic substance such as ammonia present in the exposed atmosphere to produce a reaction product (haze) such as ammonium sulfate, and the reaction product (haze) causes cloudiness in the pellicle and affects the pattern transfer image. On the other hand, by using an alkaline bath for the anodizing treatment, it is possible to prevent the residual inorganic acid which forms the reaction product (haze) from remaining.

[0039] The film thickness of the anodic oxide film 4 is not particularly limited as long as the effect of the present invention is not impaired, and it is preferably 1 to 15 pm.
By setting the film thickness to 1 pm or more, a homogeneous anodic oxide film 4 can be formed, and by setting the film thickness to 15 pm or less, a decrease in strength of the anodic oxide film 4 can be suppressed.

[0040] With respect to the electrolytically colored layer 6, it is preferable that the metal or the metal salt precipitated in the voids of the anodic oxide film 4 contains at least one of Ni, Co, Cu, Sn, Mn, Fe, Pb, Ca, Zn and Mg. By containing these elements, the blackening of the surface can be efficiently and surely achieved. Further, the fading in a high temperature environment can be reliably reduced as compared with the case of blackening with an organic dye. Among these elements, Ni, Co, Cu and Sn are more preferable, and Ni is further preferable.

[0041] Further, in the aluminum alloy member 1, it is preferable that the difference between the L* value after heating and the L* value before heating is 3 or less. When the difference between the L* value after heating and the L* value before heating is 3 or less, there is almost no need to consider color fading in a high temperature environment where the optical member is used. Here, the difference between the L* value after heating and the L* value before heating is more preferably 2 or less, and most preferably 1 or less. Further, by setting the L* value of the aluminum alloy member 1 to 60 or less, the light reflection of various optical components can be sufficiently suppressed. The L* value of the aluminum alloy member 1 is more preferably 50 or less, and further preferably 45 or less.

[0042] Furthermore, it is preferable that the aluminum alloy member 1 is an optical member or a member for an optical member inspection device. Since the aluminum alloy member of the present invention is an aluminum alloy member which has high dimensional accuracy under a high temperature environment and is less likely to undergo the color fading of a blackened surface even under a high temperature environment, and has excellent heat resistance, it is possible to suitably use as the optical member or the member for an optical member inspection device. Here, as the optical member inspection device, an inspection light source device for a CCD ·C-MOS image sensor can be exemplified. Further, examples of the optical member include a pellicle frame, a lens holder, a barrel, a shade, a reflector and the like.

2. Method for manufacturing aluminum alloy member

[0043] As shown in FIG. 2, the method for manufacturing an aluminum alloy member according to the present embodiment includes a first step (S01) of manufacturing a substrate, a second step (S02) of forming an anodic oxide film on the surface of the substrate, and a third step (S03) of forming an electrolytically colored layer on the surface of the substrate. Hereinafter, each step and the like including optional step will be described in detail.

(1) Manufacturing substrate step (First step: S01)

[0044] The manufacturing substrate process (S01) is a step of manufacturing the aluminum alloy substrate 2 by using aluminum alloy powder having a Si content of 20 to 40% by mass as a raw material through pressure molding, sintering, and extrusion processing. It is preferable that the aluminum alloy powder contains Si: 20 to 40% by mass, Mg: 0.2 to 1.2% by mass, Cu: more than 0 to 2% by mass or less, Fe: more than 0 to 2% by mass or less, Cr: more than 0 to 0.4% by mass or less, and the balance is composed of Al and unavoidable impurities.

[0045] The method of pressure molding of the aluminum alloy powder is not particularly limited as long as the effect of the present invention is not impaired, and can be applied by various conventionally known methods, for example, a press method, a CIP method or the like can be used. The molding pressure for the pressure molding may be appropriately set according to the composition, shape, particle size and the like of the aluminum alloy powder.

[0046] Further, the conditions for sintering the pressure molded body are appropriately adjusted according to the composition, particle size and shape of the aluminum alloy powder, the density of the pressure molded body, and the like, and it may be employed the sintered conditions which gives a sintered body in the state where a good extruded material can be obtained by hot extrusion. As the sintering conditions, for example, the pressure molded body is held in a vacuum furnace having a vacuum degree of 1 Torr or less and the temperature inside the furnace controlled to 100 to 400 °C for 0.5 to 2 hours, and then while maintaining the vacuum degree at 1 Torr or less (preferably 0.1 Torr or less), the temperature inside the furnace is raised to 520 to 570 °C and held for 1 to 6 hours.

[0047] For the extrusion processing of the aluminum alloy powder sintered body, it is preferable to use the hot extrusion.

The method and conditions of the hot extrusion are not particularly limited as long as the effects of the present invention are not impaired, and conventionally known hot extrusion methods and conditions of aluminum alloy powder sintered bodies may be used, but the temperature of the hot extrusion may be set to around 400 to 500 °C.

[0048] Further, in the case of the hot extrusion, a metal plate (for example, pure aluminum, a 5000 series aluminum alloy, or the like) may be placed in front of the mold and in front of the sintered body which is the extrusion material in front of the mold. Thereby, a thin film having the composition of the metal plate can be formed on the surface of the extruded material, and as a result, it is possible to suppress aged pitting corrosion and total corrosion at the interface between Si and Al, which may occur when the Al-Si material is on the outermost surface.

[0049] If necessary, the hot-extruded molded product is subjected to forging or the like in order to give a desired shape. In this case, the heat treatment of the molded product may be performed prior to the forging or the like. For example, the forging property of the hot-extruded molded product can be improved by performing the heat treatment at 200 to 400 °C for about 0.5 to 2 hours.

(2) Anodic oxide film forming step (Second step: S02)

[0050] The anodic oxide film forming step (S02) is the step where the anodic oxide film 4 is formed on the surface of the aluminum alloy substrate 2 obtained by the manufacturing substrate step (S01). The conditions of the anodizing treatment are not particularly limited as long as the effects of the present invention are not impaired, and various conventionally known anodizing treatments can be used. The bath suitably used may be a sulfuric acid bath, or an inorganic alkaline bath containing one or more inorganic alkaline components selected from the group consisting of sodium hydroxide, potassium hydroxide, lithium hydroxide, calcium hydroxide, strontium hydroxide, and rubidium hydroxide, or an alkaline mixed bath containing one or more inorganic alkaline components selected from the group consisting of sodium hydroxide, potassium hydroxide, lithium hydroxide, calcium hydroxide, strontium hydroxide, and rubidium hydroxide and one or more organic acids selected from the group consisting of tartaric acid, citric acid, oxalic acid, and salicylic acid the like.

(3) Electrolytically colored layer forming step (Third step: S03)

[0051] The electrolytically colored layer forming step (S03) is the step where a metal or a metal salt is precipitated on the voids of the anodic oxide film 4 formed in the anodic oxide film forming step (S02) to form the electrolytically colored layer 6.

[0052] The aluminum alloy substrate 2 on which the anodic oxide film 4 is formed is subjected to a coloring pretreatment where the substrate is immersed in an electrolytic treatment liquid containing a soluble metal salt for constant current electrolysis using the aluminum alloy substrate 2 as an anode, and then the aluminum alloy substrate 2 is subjected to electrolytic coloring treatment as a cathode in the same electrolytic treatment liquid, or the coloring pretreatment may be omitted.

[0053] For the electrolytic coloring treatment, other than the direct current, there can be used a rectangular wave, a sine wave, a pulse wave, or an alternating current having a waveform obtained by combining these, which have a positive component. When performing the coloring pretreatment, it is preferable that the current density of the positive component is substantially equal to the current density at the time of the coloring pretreatment, and specifically, it is preferable to set in the range of 1 / 0.6 to 1 / 0.95 times of the cathode current density at the time of the electrolytic coloring. Further, when the alternating current having a negative component is supplied during the coloring pretreatment, the absolute value of the maximum current density of the negative component is maintained preferably in the range of 0.6 to 0.95 times the absolute value of the maximum current density of the positive component.

[0054] Furthermore, for the purpose of developing a uniform dark color tone, it is preferable that the potential difference in the electrolytic coloring treatment tank is kept at 4 V or less, and the absolute value of the current density at the time of the electrolytic coloring is maintained around 0.7 times the current density at the time of the coloring pretreatment.

[0055] When the current density of the cathode current flowing through the aluminum alloy substrate 2 during the electrolytic coloring is set to a value in the range of 0.6 to 0.95 times the anode current flowing through the aluminum alloy substrate 2 during the coloring pretreatment, the current distribution is the same and uniform between the case that the anode current flows and the case that the cathode current flows. As a result, a uniform electrolytic coloring reaction occurs over the entire surface of the aluminum alloy substrate 2, and a colored film having excellent color tone uniformity is formed. The anodized aluminum alloy substrate 2 is subjected to the coloring pretreatment by using the same treatment liquid as the electrolytic coloring treatment liquid used in the subsequent coloring step. Since the same treatment liquid is used for the coloring pretreatment and the coloring treatment, the non-uniformity of the current distribution during the coloring treatment is corrected by the coloring pretreatment. On the other hand, when the coloring pretreatment and the coloring treatment are carried out in different tanks, that is, in different electrolytic tank conditions and bath conditions, the optimum current density ratio Rd for uniformity of the color tone differs between the tanks, so that the uniformity of color tone is lowered as compared with the case of using the same tank.

[0056] The electrolytic coloring treatment bath is not particularly restricted by the component species, concentration, and the like, but a weakly acidic to neutral treatment bath is usually used. The metal salt includes an inorganic acid salt such as a nitrate, a sulfate, a phosphate or a chromate, or an organic acid salt such as an oxalate, an acetate or a tartrate, which contains at least one of Ni, Co, Cu, Sn, Mn, Fe, Pb, Ca, Zn and Mg, and may be added to the electrolytic coloring treatment bath alone or in combination. In the electrolytic coloring method, even if the same electrolytic treatment bath is used, different color tones are developed depending on the treatment conditions such as applied voltage, current, and time.

[0057] In the coloring pretreatment, in order to eliminate variations in the thickness of the barrier layer, the electrolytic conditions such as voltage, current, temperature, and time are set in these electrolytic coloring treatment liquids. It is preferable that the electrolytic conditions are appropriately selected within the range of a voltage of 20 to 70 V, a current of 10 to 50 A/m^2, a temperature of 10 to 30 °C, and a treatment time of 100 seconds or less, depending on the type of electrolytic coloring treatment liquid to be used. It is preferable that the electrolytic coloring treatment is preferably achieved under the conditions which are appropriately selected within the range of a voltage of 20 to 70 V, a current of 10 to 50 A/m^2, a temperature of 10 to 30 °C, and a treatment time of 600 seconds or less, on condition where the cathode electrolysis is performed at a current density of 0.6 to 0.95 times the current density at the time of the coloring pretreatment.

[0058] The waveform of the current used in the coloring pretreatment and the electrolytic coloring treatment is not particularly limited. For example, a direct current, a pulse wave, a rectangular wave, a sine wave, a waveform similar to these, a waveform obtained by combining them, or the like can be used.

[0059] When a current having a positive component such as a rectangular wave current is used for the electrolytic coloring treatment, in order to make each current distribution uniform, it is effective that the positive component (anode current) during the electrolytic coloring treatment is substantially equal to the anode current during the coloring pretreatment, or to set the anode current during the electrolytic coloring treatment to 1 / 0.6 to 1 / 0.95 of the cathode current during the electrolytic coloring pretreatment. In the aluminum alloy substrate 2 thus subjected to the electrolytic coloring treatment, since the electrolytic coloring reaction proceeds with a uniform current distribution over the entire surface, the electrolytic colored layer 6 having excellent color tone uniformity is formed. The electrolytically colored aluminum alloy substrate 2 can be sealed or the like according to a conventional method.

[0060] Hereinafter, the aluminum alloy member of the present invention and the method for manufacturing the same will be further described in example, but the present invention is not limited to these examples.

EXAMPLE

« Example 1 »

[0061] An aluminum alloy powder having a composition of Si: 27% by mass, Fe: 0.25% by mass, Cu: 0.25% by mass, Mg: 0.7% by mass, Cr: 0.15% by mass was CIP molded, and then sintered by holding in a vacuum atmosphere at 565 °C for 4 hours to obtain a sintered columnar body having a bulk density of 2.3 g/cm^3 and an outer diameter of 250 mm. 93% of the aluminum alloy powder used as a raw material has a particle size of less than 150 pm.

[0062] Next, the obtained sintered body was hot-extruded as a billet for hot extrusion. Specifically, the billet was heated at 450 °C, inserted into a container of a 10 inch extruder and extrusion-molded to obtain a plate-shaped extruder having a width of 100 mm and a thickness of 8 mm. The obtained extruded material was machined to produce a 50 × 50 × 10 mm aluminum alloy substrate.

[0063] The aluminum alloy substrate was subjected to the anodizing treatment by using a sulfuric acid bath having a concentration of 180 g/l under the conditions of a current density of 15 mA/cm^2 and a treatment time of 1333 seconds to form an anodic oxide film.

[0064] The aluminum alloy substrate after forming the anodic oxide film is used as the anode, SUS304 electrode is used as the counter electrode, and the coloring pretreatment was achieved in an electrolytic bath (pH 5, temperature 30 °C) having a composition of nickel sulfate hexahydrate: 140 g/l, boric acid: 40 g/l, and tartrate acid: 4 g/l by passing a DC current having an anode current density of 2.5 mA/cm^2 for an energization time of 5 seconds, and then, the aluminum alloy substrate after the coloring treatment was used as the cathode, the electrolytic coloring treatment was achieved by passing through a DC current which was superimposed with a pulsed voltage between the cathode and the counter electrode (SUS304), under the conditions of a frequency: 5 Hz, ta/tc ratio: 1/9, waveform: rectangular wave, cathode current density: 2.5 mA/cm^2, and electrolytic time: 360 seconds to form an electrolytically colored layer, and the aluminum alloy member of Example 1 was obtained.

« Comparative Example 1 »

[0065] An aluminum alloy substrate having a size of 50 × 50 × 10 mm was manufactured by cutting a JIS-A5052

aluminum alloy material.
An aluminum alloy member of Comparative Example 1 was obtained by using this aluminum alloy substrate, immersing into an aqueous solution containing an organic dye (TAC411 available from Okuno Pharmaceutical Co., Ltd.) in a concentration of 10 g/L, and subjected to a dyeing treatment at a temperature of 55 °C for 10 minutes.

« Comparative Example 2 »

[0066] An aluminum alloy substrate was manufactured in the same manner as in Example 1, and an anodic oxide film was formed on the aluminum alloy substrate in the same manner as in Example 1. After the formation of the anodic oxide film, the aluminum alloy substrate was dyed in the same manner as in Comparative Example 1 to obtain an aluminum alloy member of Comparative Example 2.

<Evaluation of L* value>

[0067] The brightness index L* value of each aluminum alloy member obtained in Example and Comparative Example was measured by using a brightness measuring device (NF777, available from Nippon Denshoku Kogyo Co., Ltd.). Next, the aluminum alloy member was heat-treated by holding in an atmosphere of 200 °C for 100 hours, and the brightness index L* of the aluminum alloy member after the heat treatment was measured. The L* value before the heat treatment, the L* value after the heat treatment, and the difference between the L* value after the heat treatment and the L* value before the heat treatment are shown in Table 1.

<Evaluation of linear expansion coefficient>

[0068] According to JIS Z2285: 2003, the linear expansion coefficient of each aluminum alloy member obtained in Example and Comparative Example was measured.
The obtained values are shown in Table 1.

[Table 1]

	L* value before heat treatment	L* value after heat treatment	Variation of L* value	Linear expansion coefficient
Ex. 1	40.79	41.62	0.86	18.0×10^{-6}
Com. Ex. 1	30.05	50.29	20.24	23.8×10^{-6}
Com. Ex. 2	35.90	46.20	8.56	18.0×10^{-6}

Explanation of symbols

[0069]

1	Aluminum alloy member,
2	Aluminum alloy substrate,
4	Anodic oxide film,
6	Electrolytically colored layer.

Claims

1. An aluminum alloy member which comprises:

an extruded material of an aluminum powder alloy having an Si content of 20 to 40% by mass, and includes a substrate having an anodic oxide coating film on the surface, and
an electrolytically colored layer which is formed by precipitating a metal or a metal salt on voids in the anodic oxide coating film.

2. The aluminum alloy member according to claim 1, wherein
the aluminum powder alloy contains Si: 20 to 40% by mass, Mg: 0.2 to 1.2% by mass, Cu: more than 0 to 2% by mass or less, Fe: more than 0 to 2% by mass or less, Cr: more than 0 to 0.4% by mass or less, and the balance is composed of Al and unavoidable impurities.

3. The aluminum alloy member according to claim 1or 2, wherein
the metal and the metal salt contain at least one of Ni, Co, Cu, Sn, Mn, Fe, Pb, Ca, Zn and Mg.

4. The aluminum alloy member according to any one of claims 1 to 3, wherein
the linear expansion coefficient is 10×10^{-6} to 23×10^{-6} /K.

5. The aluminum alloy member according to any one of claims 1 to 4, wherein the difference between the L* value after the heat treatment and the L* value before the heat treatment held in an atmosphere of 200 °C for 100 hours is 3 or less.

6. The aluminum alloy member according to any one of claims 1 to 5, wherein the member is an optical member or a member for an optical member inspection device.

7. A method for manufacturing an aluminum alloy member, which includes:

a first step of manufacturing a substrate by subjecting an aluminum alloy powder having a Si content of 20 to 40% by mass to pressure molding, sintering and extrusion processing,
a second step of forming an anodic oxide film on the surface of the substrate, and
a third step of electrolytically coloring the substrate in an electrolytic solution containing a metal or a metal salt to form an electrolytically colored layer on the surface of the substrate by precipitating a metal or a metal salt on voids in the anodic oxide coating film.

FIG. 1

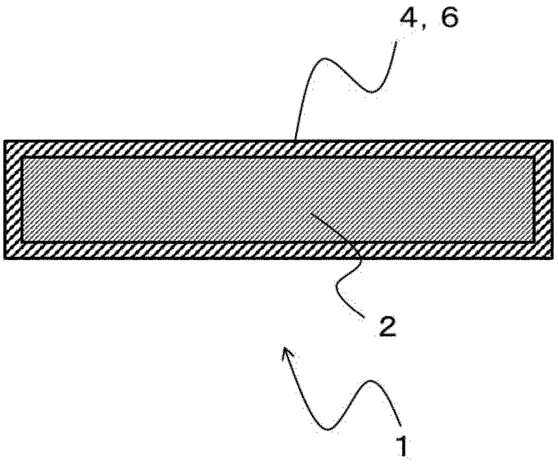
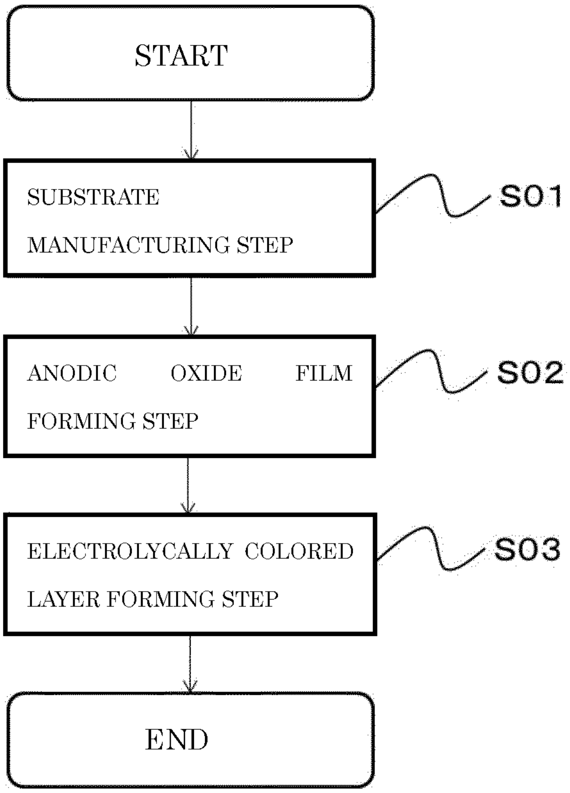

4, 6
2
1

FIG. 2


START
SUBSTRATE MANUFACTURING STEP
S01
ANODIC OXIDE FILM FORMING STEP
S02
ELECTROLYCALLY COLORED LAYER FORMING STEP
S03
END

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/009517

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. C22C21/02(2006.01)i, C22C1/04(2006.01)i, C22F1/00(2006.01)i, C22F1/043(2006.01)i, C25D11/04(2006.01)i, C25D11/22(2006.01)i
FI: C25D11/22 A, C22C1/04 C, C22C21/02, C22F1/00 612, C22F1/00 613, C22F1/00 671, C22F1/00 691B, C22F1/00 691C, C22F1/043, C25D11/04 308

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)
Int. Cl. C25D11/04-C25D11/24, C22C21/02-C22C21/04

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

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2021
Registered utility model specifications of Japan	1996-2021
Published registered utility model applications of Japan	1994-2021

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2019-105714 A (NIPPON LIGHT METAL CO., LTD.) 27 June 2019, paragraphs [0014]-[0016], [0046]-[0053], fig. 3	1-7
Y	WO 2018/012324 A1 (NIPPON LIGHT METAL CO., LTD.) 18 January 2018, paragraphs [0057]-[0062]	1-7
A	JP 2016-216763 A (TOYOTA CENTRAL RESEARCH AND DEVELOPMENT LABORATORIES, INC.) 22 December 2016, entire text, fig. 1	1-7
A	JP 60-110895 A (NIPPON ALUMINIUM MFG. CO., LTD.) 17 June 1985, entire text, fig. 1-4	1-7

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

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search
26.04.2021

Date of mailing of the international search report
11.05.2021

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Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/JP2021/009517

Patent Documents referred to in the Report	Publication Date	Patent Family	Publication Date
JP 2019-105714 A	27.06.2019	WO 2019/116755 A1 TW 201930607 A	
WO 2018/012324 A1	18.01.2018	US 2019/0302607 A1 paragraphs [0068]-[0073] EP 3486723 A1 CN 109416504 A KR 10-2019-0028471 A	
JP 2016-216763 A	22.12.2016	(Family: none)	
JP 60-110895 A	17.06.1985	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

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- JP 2016177120 A **[0007] [0009]**