

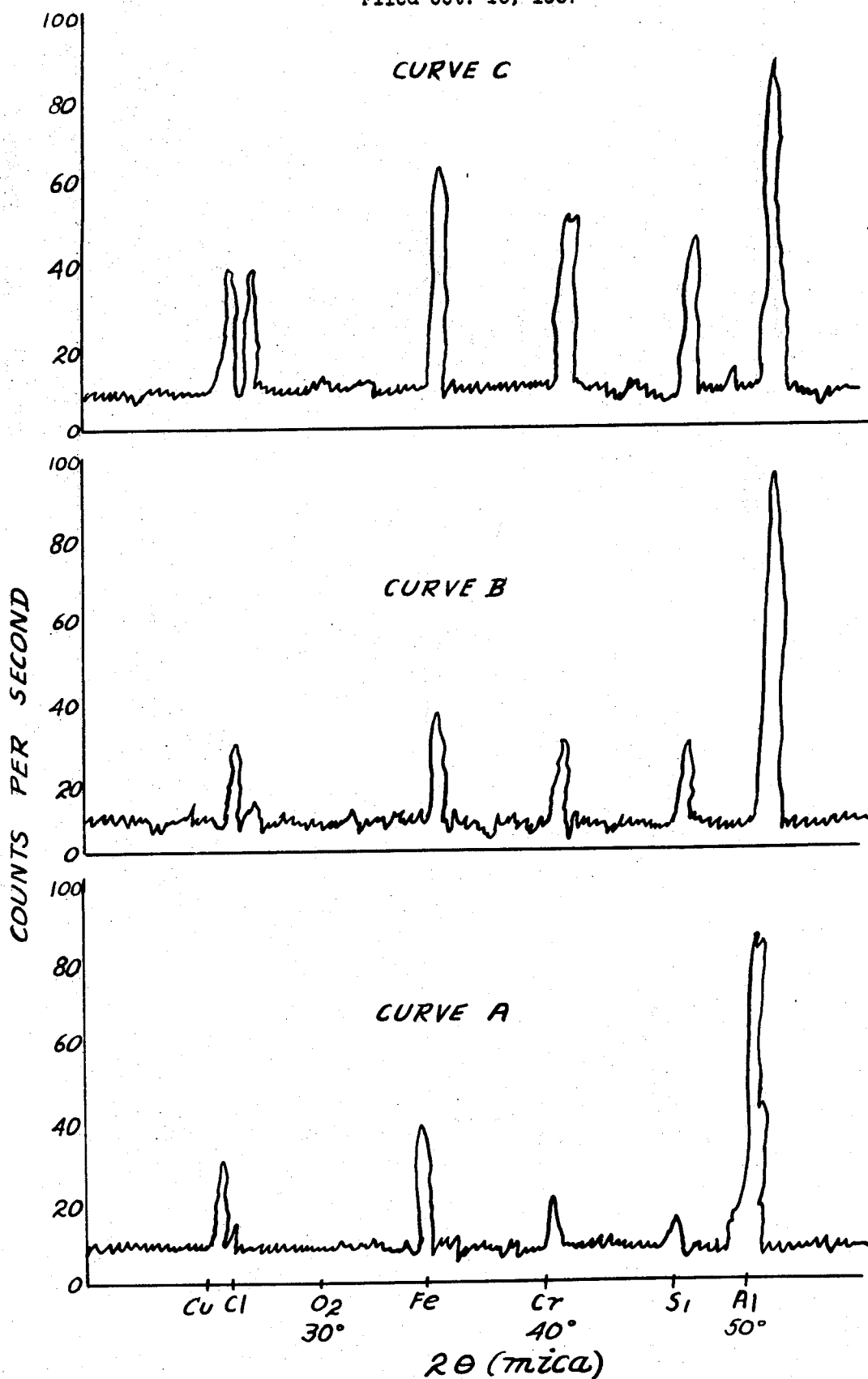
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M. GULLA

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ETCHING AND METAL PLATING SILICON CONTAINING ALUMINUM ALLOYS

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ETCHING AND METAL PLATING SILICON CONTAINING ALUMINUM ALLOYS

Michael Gulla, Framingham, Mass., assignor to Shipley Company, Inc., Newton, Mass., a corporation of Massachusetts

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ABSTRACT OF THE DISCLOSURE

A process for preparing an aluminum alloy containing at least about 0.1 percent silicon for finishing. The process is characterized by a treatment that dissolves aluminum out of the surface of the alloy leaving silicon and other insoluble alloying metals behind as a visible, adherent coating resistant to oxidation and highly receptive to finishing operations such as electroless and electrolytic metal deposition.

INTRODUCTION

This invention relates to preparing aluminum alloys containing at least 0.1 percent silicon for finishing and has for its principal object, the treatment of an aluminum alloy surface to form a coating aluminum substantially enriched in silicon and other alloying metals that is resistant to oxidation and receptive to metal deposition.

BACKGROUND OF THE INVENTION

The decoration and protection of aluminum and its alloys by the application of metal coatings results in aluminum parts having highly desirable properties. The prior art has experienced considerable difficulty in its attempts to deposit adherent metal coatings on aluminum because of the position of aluminum in the electrochemical series together with the high affinity of the metal for oxygen. The persistence of a tenacious oxide film present on the surface of aluminum prevents adequate adhesion between substrate and coating. Removal of the oxide, followed by short exposure to the atmosphere or an aqueous environment results in the rapid formation of a fresh oxide film. Consequently, it has been found necessary in the prior art to metal plate over aluminum immediately following removal of the oxide film.

Numerous attempts have been made to increase adhesion between an aluminum substrate and metal coating and to overcome the above-noted difficulties. One procedure, known as the zincate process, involves the application of zinc undercoatings to an aluminum surface prior to coating with desired surface metal. This procedure is cumbersome and requires some 12 to 21 process steps. Because of its position in the electrochemical series, the zinc coating aggravates the corrosion of aluminum and aluminum alloys during use of the plated material. Upon exposure to elevated temperatures, zinc diffuses into aluminum resulting in a loss of bond between an aluminum substrate and a subsequently applied metal coating.

Chemical etching of aluminum and its alloys to remove oxide films followed immediately by deposition of

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a thin coating of metal by immersion in a metallic salt solution is an additional method previously used to deposit metal coatings on aluminum. The etching step involves immersion of the aluminum part in a chemical etchant such as caustic soda, caustic soda plus sodium chloride, hydrochloric acid plus nitric acid, hydrofluoric acid, hydrofluoric acid plus nitric acid, etc., for a brief period of time sufficient only to dissolve the oxide coating. Conditions are critical. Should the aluminum part be over-etched, the prior art has found it necessary to treat the part with nitric acid or a mixture of nitric and hydrofluoric acid to remove all surface layers formed during the etching step to thereby provide a bright, shiny surface for metal plating. This surface must be immediately plated or maintained in a non-oxidizing atmosphere to prevent formation of fresh oxide film.

A similar process involves an etch solution containing heavy metallic salts such as salts of iron, copper, nickel, or manganese to give an immersion deposit of metal during the etching process. The deposit acts as a base upon which a desired metal may be deposited. At the present time, the process has not been found to give satisfactory coatings.

STATEMENT OF THE INVENTION

The present invention provides a facile procedure for preparing aluminum alloys containing at least about 0.1 percent silicon for finishing, preferably by metal plating or painting. The invention is predicated upon the discovery that a visible, adherent coating, resistant to oxidation and receptive to finishing operations is formed on the surface of an aluminum part by selectively dissolving aluminum out of the surface of the alloy leaving behind a coating of silicon and other insoluble alloying ingredients. This coating, hereinafter referred to as a "conversion coating," is composed of aluminum substantially enriched in silicon and other alloying constituents. Because the conversion coating is oxidation resistant, an aluminum part may be prepared in accordance with the invention, and thereafter stored or transported in air without formation of a damaging oxide film that would act to prevent adhesion between a metal coating and the aluminum substrate. Metal plated directly over the conversion coating is extremely adherent to the aluminum substrate and possesses good surface appearance.

In order to obtain the benefits of oxidation resistance, adhesion and appearance, the conversion coating must be characterized by uniform displacement over the entire surface of the aluminum surface to be plated and adherence between it and the aluminum substrate. The conversion coating appears on the aluminum surface normally as a visible, white to dark grey layer, dependent upon alloying constituents.

The conversion coating is formed by immersion of the aluminum part in a solution capable of selectively dissolving aluminum from the surface of the part leaving silicon and other alloying metals behind as a uniform and adherent coating. This can be accomplished with an acid solution containing hydrogen ions and halide ions other than fluoride ions; the latter being unsuitable because of its attack on silicon. The solution can be formed from hydrochloric acid, hydrobromic acid or hydriodic acid and mixtures thereof, or from metal salts of these acids,

where the metal cation of the salt does not deposit to form an immersion coating on the aluminum substrate, and a source of hydrogen ions such as sulfuric acid, phosphoric acid, etc. These solutions should be at least 0.1 N and preferably between 0.5 and 8 N in halide ion concentration with a maximum pH of about 2.5. Selective dissolution of aluminum can also be accomplished with a basic solution containing hydroxyl ions and chlorite, bromite or iodite ions. Bases such as sodium hydroxide, potassium hydroxide, etc. can be used as the source of the hydroxide ion and salts such as sodium bromite, sodium chlorite, potassium chlorite, calcium chlorite, etc., can be used as the source of the oxyhalide ions. The metal cation of the base and salt should not form an immersion deposit on the aluminum substrate. These solutions should be at least 0.1 N and preferably between 0.5 and 8 N in oxyhalide ion concentration with a pH of at least about 10. For a pH below about 9, a solution composed of an oxidant such as a persulphate, chlorate, bromate, peroxide, and the like and a halide ion other than a fluoride ion may be used. A ferric chloride solution having a pH below about 5 has also been found effective.

All of the above solutions may be used at temperatures ranging between room temperature and the boiling point of the solution dependent upon solution strength. Temperatures below about 120° F. are preferred.

The time of treatment in solution varies widely dependent upon alloy composition, solution temperature and the ability of the solution to dissolve aluminum. In general, an aluminum part is immersed in solution for a time in excess of that necessary to remove all oxide present on the surface of the part and sufficient to form a conversion coating that is adherently bonded to the aluminum substrate and uniformly displaced over the entire surface of the part to be plated. For most alloys, treatment is terminated when, by visual inspection, a conversion coating of this description is obtained. For alloys having a low concentration of alloying constituents the conversion coating may not be visible.

The time of immersion in the solution is critical. If the time is inadequate, the conversion coating will not form on the aluminum surface or will not be uniform over its entire surface. This results in poor adhesion between the aluminum substrate and a subsequently deposited metal coating. When a part is immersed in solution for an excessive period of time, a nonadherent smut forms which results in poor adhesion and appearance of a subsequently deposited metal coating.

Should a nonadherent smut form due to excessive treatment time, the part may be reconditioned by treatment with a desmutter such as a mixture of one part by volume hydrofluoric acid with three parts nitric acid at a temperature of from 75 to 85° F. for a period of time sufficient to remove the loose nonadherent smut and insufficient to remove the adherent conversion coating. Following treatment with the desmutter, the part should exhibit a clean, white to dark grey appearance with no areas of shiny metal showing through.

To insure the formation of a conversion coating that is both uniform and adherent and to prevent insufficient or excessive treatment, it is desirable to regulate reaction conditions to provide a relatively slow rate of aluminum dissolution from the surface of the part to be plated. In general, the reaction conditions should be regulated so that the time to form the conversion coating exceeds at least 3 minutes. This can be accomplished using reaction temperatures below 120° F. and a relatively low concentration of reactive ingredients in solution. Additionally, an organic liquid that inhibits ionization may be substituted, in part, for water, to decrease reactivity. The requirements for the organic liquid include partial solubility in water and non-reactivity with both the aluminum part to be treated and the solution components. Typical of such liquids include, by way of example, methyl carbitol, butyl crabitol, ethyl alcohol, methyl alcohol, ethylene

glycol, acetone, butyl alcohol, diethylene glycol, monobutyl ether, ethyl ether, isopropyl alcohol, etc.

The overall procedure for finishing aluminum in accordance with this invention requires a minimum of steps.

If excessively soiled, the surface of the aluminum part is degreased and cleaned using standard procedures. Following a cold water rinse, it is preferred, though not mandatory, to desmut the surface following conventional procedures such as immersion in nitric acid solution. The part is then cold water rinsed and a uniform, adherent conversion coating is formed using procedures defined above, preferably with bath agitation. If a nonadherent smut forms over the conversion coating, it may be removed with a desmutter such as a mixture of nitric and hydrofluoric acid taking precautions to remove the aluminum part from the desmutter before it attacks the conversion coating, thereby exposing the aluminum substrate. The part is then rinsed and may be finished or it may be dried and stored or transported prior to finishing without formation of a damaging oxide film. Finishing of the aluminum part may be accomplished using standard procedures such as electroless or electrolytic metal plating, painting, etc.

The aluminum alloys within the scope of this invention are those containing at least 0.1 percent, and preferably, 0.5 percent silicon as one alloying ingredient. Other alloying metals such as copper, iron, etc. may be present and do not interfere with the formation of the conversion coating.

Though not wishing to be bound by theory, it is believed that the presence of silicon in the alloy is responsible for formation of a conversion coating resistant to oxidation and receptive to metal deposition. The dissolution of aluminum from the surface of the alloy leaves a layer enriched in silicon, possibly in the form of a silicon-aluminum intermetallic compound, along with other alloying metals insoluble in the treatment solution. This theory is substantiated by three factors. First, it is known in the art that silicon-aluminum intermetallic compounds are oxidation resistant. Secondly, it has been found that the process is inoperable in the presence of the fluoride ion. It is known that fluoride ions attack and dissolve silicon whereas the attack of the other halide ions on silicon is minimal. Thirdly, it has been found that the process of the invention is only operable with aluminum alloys containing at least about 0.1 percent silicon.

The remainder of the disclosure will be directed to examples illustrating specific embodiments of the invention, but should not be construed as limiting the invention thereto.

In the examples, all metal plating was conducted using either electroless or electrolytic nickel. It should be understood, however, that any of the known electroless or electrolytic formulations that do not etch aluminum are suitable for plating over aluminum prepared for finishing in accordance with this invention.

The electroless procedure chosen for purposes of illustration involved immersion of the aluminum part in an electroless nickel bath of the following composition:

nickel sulfate—40 grams
citric acid—30 grams
sodium hypophosphite—40 grams
acetic acid—10 ml.
ammonium hydroxide—to pH 4.8
distilled water—to total volume of 1 liter

Bath temperature is maintained at about 200 degrees F. The aluminum part is immersed in the nickel bath for a total of two hours to form a nickel coating having a thickness of approximately 1 ml.

Electrolytic plating is performed by immersing the aluminum part in a conventional nickel electrolytic bath known as a "Watts Nickel-Plating Electrolytic Bath." The bath used in the examples is maintained at a pH of between 4.0 to 5.0 and operated at a temperature of about

130° F. Current density is maintained at 40 a.s.f. for a period of time sufficient to deposit a coating of approximately one mil thickness.

The aluminum alloys used in the examples have the following compositions:

	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Other
Alloy:									
Electrolytic									0.01
1100	0.50	0.50	0.20	0.05			0.10		0.15
3003	0.60	0.70	0.20	1.20			0.10		0.15
2024	0.50	0.50	14.0	0.60	1.10	0.10	0.25		0.15
5052	0.20	0.25	0.10	0.10	2.60	0.25	0.10		0.15
6061	0.60	0.70	0.30	0.10	11.00	0.30	0.25	0.15	0.15
7075	0.50	0.70	1.80	0.30	12.80	0.30	6.00	0.20	0.15
380	12.00	3.80							

¹ Approximate.

A plated surface may be evaluated in any of three ways. First, the part is inspected visually for blisters and voids. Secondly, the sample is heated at 300° C. for one half hour followed immediately by quenching in cold water and inspection for blister formation. The third method, called the bend test, involves breaking a sample by folding it back and forth upon itself and inspecting the break for peeling of the metal coating from the aluminum substrate.

Example 1

Test bars of a No. 1100 aluminum alloy measuring 3" x 1" x 1/32 were prepared and degreased in trichloroethylene vapor. Each bar was then immersed in a 3.5 N hydrochloric acid solution maintained between 75° F. and 80° F. for a period of time varying between 1/2 and 15 minutes, removed, rinsed, inspected visually, metal plated with nickel using electroless procedures, and evaluated. It was found that uniform, adherent, very light grey coatings were formed on bars immersed in solution for periods of time ranging between 4 and 7 1/2 minutes. Nickel coatings on these bars possessed excellent appearance, were free of blisters and voids following quenching, and did not peel from the substrate upon breaking of the bar.

Test bars pretreated for a period of less than 4 minutes either possessed a non-uniform conversion coating with shiny aluminum streaks appearing on the surface of the test bars or retained a residual oxide coating. Nickel coatings deposited on these bars blistered or failed to adhere to the aluminum substrate. With treatment times in excess of 7 1/2 minutes, the conversion coatings formed were nonadherent and the nickel coatings deposited thereon were rough, blistered and peeled from the aluminum substrate.

Example 2

Repetition of the procedure of Example 1 substituting electrolytic nickel for electroless nickel yields comparable results, though the time to form an initial, complete deposit was substantially increased.

Example 3

The procedure of Example 1 was repeated with time of treatment maintained constant at 6 minutes and normality of the hydrochloric acid solution ranging between 0.1 and 12.0. It was found that light grey, adherent, conversion coatings were formed on bars immersed in hydrochloric acid solutions having a normality ranging between about 3.0 and 5.0. A nickel coating deposited on these test bars were adherent, did not peel and did not show blistering when quenched. Nickel coatings deposited on test bars treated with hydrochloric acid solutions having a normality below 3.0 or above 5.0 were blistered or nonadherent.

Example 4

The procedure of Example 1 was repeated with a hydrochloric acid solution maintained at 90° F., all other conditions remaining the same. The treatment time required to obtain optimum results varied between 3 1/2 and 5 1/2 minutes.

Example 5

A test bar of a No. 1100 aluminum alloy was prepared according to the procedure of Example 1. It was immersed in a 3.5 N hydrochloric acid solution at room tempera-

ture for a period of 5 minutes, rinsed and dried. It was then allowed to stand in air for a period in excess of 48 hours and then plated using an electroless nickel solution. The nickel coating was found to have excellent appearance, was free of blisters and voids following quenching and did not peel from the aluminum substrate upon breaking of the test bar.

Example 6

The procedure of Example 5 was repeated, but the surface of the test bar following treatment in hydrochloric acid solution and exposure to the atmosphere for a period of time in excess of 48 hours was subjected to electron beam microanalyses as follows:

A beam of electrons is accelerated with a high potential and focused by means of an electro-magnetic lense to a diameter of about 1 micron at the surface of the specimen. The specimen acts as a primary source of X-rays. A continuous or white spectrum is produced as well as fluorescent X-rays characteristic of the elements excited by the electron beam. A chemical analysis of the excited areas is afforded by analysis of the characteristic X-ray line by means of a single crystal X-ray spectrometer. Two curved mica crystal focusing spectrometers employing flow-proportional counters were set up to record the characteristic X-ray spectrum in the 0.5 to 10 A. wavelength range (U through Mg). In addition, one of the mica crystals was lead stearate coated to extend the analytical capability through boron.

A portion of each surface was scraped in order to expose the substrate. The sample was then inserted into the microanalyzer.

With the spectrometer aligned to record wavelengths characteristic of chlorine, the electron beam was positioned on the treated surface and exposed substrate with the available X-ray intensities being recorded. Chlorine was not detectable within the detectability limit of about 0.05 w./o.

The spectrometer was then aligned to record wavelength characteristics for oxygen. Analysis failed to detect a layer of oxide film on the surface of the aluminum.

Example 7

The procedure of Example 6 was repeated with a test bar prepared from a No. 6061 aluminum alloy. The results obtained are illustrated in the drawing wherein curve A is a representation of spectral pattern for the aluminum substrate scraped clean of the conversion coating; curve B is a representation of the spectral analysis of the conversion coating; and curve C is a representation of the spectral analysis of the conversion coating, in powder form, scraped from the test bar.

The curves indicate that the conversion coating is richer in alloying elements than the aluminum substrate and a comparison of curve A with curve C for silicon indicates that there is a substantial increase in the quantity of silicon in the conversion coating.

Example 8

The procedure of Example 6 was repeated with the substitution of a 3.0 N solution of hydrobromic acid for

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hydrochloric acid. Spectral analysis failed to detect the presence of oxygen in the conversion coating while showing a substantial increase in silicon content.

Example 9

Test bars of various aluminum alloys were prepared following the procedures of Example 1 and were immersed in 3.5 N hydrochloric acid solution. Plating was accomplished using an electroless nickel solution. The alloys treated and the treatment times are set forth in the following tables:

Alloy:	Pretreatment time (min.) at 80° F.
3003 -----	2.5
2024 -----	4.5
5052 -----	9.0
6061 -----	2.5
7075 -----	3.5
380 -----	4.5

All nickel coatings were smooth, did not blister when quenched and did not peel from the aluminum substrate.

Example 10

Repetition of Example 9 with the substitution of an electrolytic aluminum having less than 0.01 percent impurities failed to produce a conversion coating. An oxide film formed on the aluminum surface within one hour of treatment with hydrochloric acid and an electroless nickel coating failed to bond to the aluminum substrate.

Example 11

Substitution of a 3.5 N hydrobromic acid or hydriodic acid solution for hydrochloric acid in Example 9 yields comparable results, though time to form an acceptable conversion coating is slightly increased.

Example 12

A solution was prepared having the following composition:

potassium iodide—50 gms.
sulfuric acid—50 mls.
water—to 1 liter

A test bar of a No. 1100 aluminum alloy was prepared according to the procedure of Example 1 and immersed in the above solution maintained at 200° F. for 15 minutes. An adherent, uniform, very white coating formed. An electroless deposit of nickel formed that was blister free, would not peel and possessed excellent surface appearance.

Example 13

The procedure of Example 12 may be repeated with substitution of any of the following salts for potassium iodide with comparable results, though treatment time and/or bath temperature may require modification:

potassium chloride	magnesium chloride
potassium bromide	calcium chloride
sodium iodide	calcium bromide
sodium bromide	calcium iodide
magnesium iodide	cesium chloride
ammonium chloride	

Example 14

The procedure of Examples 12 and 13 may be repeated with any of the following aluminum alloys with comparable results though pretreatment time and/or bath temperature may require modification:

No. 3003	No. 6061
No. 2024	No. 7075
No. 5052	No. 380

Example 15

A solution was prepared by mixing 300 mls. of concentrated hydrochloric acid with 700 mls. of butyl carbitol. A No. 1100 alloy was prepared in accordance with the

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procedure of Example 1 and immersed in solution maintained at 150° F. for 7 minutes. A uniform, adherent conversion coating formed. The test bar was rinsed in water, dried and allowed to stand in air for 48 hours. It was then nickel coated using an electrolytic nickel solution. The coating was free of blisters following breaking of the test bar.

Example 16

The procedure of Example 15 may be repeated, with minor changes in conditions and substitution of the following materials for butyl carbitol:

Methyl carbitol
glycolmonoethyl ether
methoxyacetaldehyde
ethyl alcohol
formamide
acetone
butyl alcohol
diethyleneglycolmonomethyl ether
diethyleneglycolethyl ether
dimethylformamide
butyl cellosolve

Example 17

Three test bars of a No. 3003 aluminum alloy were prepared. Each was immersed in a 3.5 N hydrochloric acid solution maintained at 80° F. for 10 minutes. A non-adherent, grey coating formed on the surfaces of the test bars. One test bar was immediately plated with electroless nickel. The coating was rough and peeled from the aluminum substrate. The second bar was immersed in a solution of three parts nitric acid and 1 part hydrofluoric acid at 80° F. for 1 minute and rinsed in cold water. The bar had a clean white surface. The bar was plated with electroless nickel with formation of a smooth coating that did not peel from the aluminum substrate. The third bar was immersed in the same solution of nitric and hydrofluoric acid for 3 minutes. All of the nonadherent smut as well as the conversion coating was removed. An electroless nickel deposit did not adhere to the aluminum substrate.

Example 18

A solution was prepared by dissolving 50 grams of ferric chloride in one liter of water. A No. 1100 alloy prepared in accordance with Example 1 was immersed in the solution maintained at 80° F. for 5 minutes to form a uniform, adherent conversion coating on the alloy. Deposition of electroless nickel resulted in a coating that did not peel from a broken bar and did not blister when quenched from 300° F.

Example 19

The procedure of Example 18 was repeated with ferric chloride solutions containing from 50 to 500 grams per liter of ferric chloride. All solutions produced acceptable conversion coatings, though time for forming the coating decreased with increasing concentration of ferric chloride.

Example 20

A solution having a pH of about 7.0 was prepared from 50 grams of ammonium persulphate, 20 grams of sodium chloride and 1 liter of water. Immersion of a No. 1100 aluminum alloy in the solution maintained at 120° F. for 5 minutes produced an acceptable conversion coating. An electroless nickel deposit applied over the conversion coating was smooth, adherent and blister free.

Example 21

A solution having a pH of about 11.0 was prepared from 50 grams of sodium bromite, 10 grams of sodium hydroxide and 1 liter of water. At 80° F., acceptable conversion coatings were formed on test bars of a No. 1100 aluminum alloy immersed for periods of time ranging between 4 and 7 minutes. Electroless nickel deposits on samples immersed for 4 to 7 minutes were adherent and free from blisters and voids.

Repetition of Example 21 with the substitution of 800 ml. of butyl cellosolve for 800 ml. of water gives comparable results with somewhat extended immersion time.

All of the aluminum parts successfully treated in the above examples to give adherent metal coatings are characterized by aluminum substrate of the aluminum alloy, an intermediate conversion coating having the composition of the aluminum alloy substantially enriched in silicon and other alloying elements less soluble than silicon and a surface metal disposed directly over the conversion coating.

The process of the present invention provides numerous advantages over prior art procedures for metal plating over aluminum including the following:

(1) Improved adhesion between deposited metal and substrate. Adhesion between a metal deposit and the aluminum substrate is not degraded upon exposure to elevated temperatures, and in some cases, adhesion is improved. By comparison, upon exposure to elevated temperatures for extended periods of time, adhesion is lost between a metal deposited using the zincate process and an aluminum substrate due to the diffusion of zinc into aluminum.

(2) Ease of process and low cost of materials. Zincating requires from 12 to 21 process steps using expensive and dangerous materials. The present invention requires less than 12 procedural steps and can use readily available inexpensive reagents.

(3) Oxidation resistance of the conversion coating permitting storage and/or transportation prior to metal coating without formation of oxygen films that would prevent adhesion between an aluminum substrate and a metal coating.

(4) Ability to basket or barrel plate small aluminum parts. This is not possible with zincating because the coating cannot be disturbed until plated. The use of the process of the present invention eliminates racking of small parts.

While the invention has been described with respect to certain specific embodiments, it should be understood that it is susceptible to modification within the scope of the appended claims. For example, in the examples, all plating was conducted using either electroless or electrolytic nickel solutions. The plating step is not critical and the specific procedures used to plate and the plating compositions are not a part of the invention. Any metal heretofore used to plate over aluminum may be used to plate over aluminum pretreated in accordance with this invention. These metals include, for example, iron and mild steels, tin, brass, copper, silver, stainless steel, gold, etc. Typical electroless and electrolytic solutions for plating over aluminum are known in the art and described in many publications including Edwards et al., *The Aluminum Industry*, McGraw Hill Book Company, Inc., New York, 1930, pp. 492 to 499; Wernick et al., *Finishing of Aluminum*, Robert Draper Ltd., Teddington, England, 1959, Chapters 12 and 15; *Metal Finishing Guidebook*, Metals and Plastics Publications, Inc., Westwood, N.J., 1967, pp. 228 to 371; all included herein by reference.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A process for metal plating over an aluminum substrate containing at least 0.1% silicon comprising the steps of:

(1) etching said aluminum alloy by immersion of the alloy in an acid or alkaline etchant, selected from the group consisting of:

(a) an acid solution having maximum pH of 2.5 that is at least 0.1 N in a member selected from the group of chloride ions, bromide ions and iodide ions;

(b) an alkaline solution having a minimum pH of about 10.0 that is at least 0.1 N in an oxyhalide

selected from the group of chlorite, bromite, and iodite ions;

(c) a solution of ferric chloride having a pH below about 5; and,

(d) a solution formed from an oxidant of a member selected from the group of persulfate, chlorate, bromate and peroxide, and a halide salt, other than a fluoride salt, where the metal cation of said halide salt does not deposit on the aluminum substrate as an immersion coating; said solution having a pH below about 9; and etching for a time in excess of that necessary to remove any oxide coating on the surface of said alloy and at least sufficient to preferentially remove aluminum from the surface area of said alloy to thereby leave behind silicon and other alloying metals less soluble than silicon as a uniform coating of said aluminum alloy substantially enriched in silicon and adherently bonded to the aluminum substrate, said coating being oxidation resistant and receptive to metal deposition, and

(2) metal plating directly over said uniform metal coating by a deposition method selected from the group consisting of:

(a) depositing metal electrolessly from a non-etching electroless solution, and

(b) depositing metal electrolytically from a non-etching electrolytic solution.

2. The process of claim 1 where the aluminum alloy is allowed to dry and stand exposed to air for an extended period of time sufficient to form an oxide film on a clean aluminum surface.

3. The process of claim 1, where the pH of said acid solution is less than 1.0, and the concentration of the halide ion varies between 0.5 and 8.0 N.

4. The process of claim 1 where said acid solution is an aqueous solution of an acid selected from the group consisting of hydrochloric acid, hydrobromic acid and hydriodic acid.

5. The process of claim 1 where said acid solution is an aqueous acid solution and a metal halide salt other than a fluoride salt where the metal cation of said halide salt does not deposit on the aluminum substrate as an immersion coating.

6. The process of claim 1 where the concentration of the oxyhalide ion varies between 0.5 and 8 N.

7. The process of claim 1 including the initial steps of cleaning the alloy and treating with a desmutter prior to the step of dissolving aluminum from the surface of the alloy.

8. The process of claim 1 including the step of removing non-adherent smut residue present on the coating prior to metal plating by contact with a desmutter for a time sufficient to remove said residue and insufficient to remove the adherently bonded coating.

9. The process of claim 1 where the deposited metal is selected from the group consisting of nickel and nickel alloys.

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DANIEL E. WYMAN, Primary Examiner

P. E. KONOPKA, Assistant Examiner

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