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(54) **Method of removing dielectric material from metal surface**

(57) A method of removing a dielectric coating from a surface of a conductive element comprises immersing the coated element in a basic solution, applying a dc current to the solution, and reversing the polarity of the

dc current. Air is injected into the solution. Thereafter the conductive element is dipped into an acid bath. The basic solution is caustic and alkaline and in a stainless steel container and the conductive element is nickel and is carried by a copper rack.

EP 1 152 072 A1

Description

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention generally relates to a method of removing coatings from metal surfaces, and more particularly to a method of removing a dielectric material from a nickel surface.

Description of the Prior Art

[0002] Mirrors for use on orbiting satellites must operate under demanding environmental and mechanical conditions and meet extremely exacting specifications. Hence they are extremely costly to fabricate. For example, a small mosaic attenuating highly polished mirror segment, about 2 inches square costs about \$50,000 to produce. Typically there are multiples of these mirror segments on an orbiting satellite.

[0003] A portion of a segment of such a mirror is shown in FIG. 1 in a cross-section perspective view around the divot 15. The mirror, generally designated by the numeral 10, comprises a nickel substrate or element 12 having a highly polished mirror surface 14. Nickel has a conductivity of 0.14 Mmho/cm and is corrosion resistant. A layer of silicon dioxide 16 is vapor deposited on the surface 14 to seal it. The layer may be a polymeric version of silicon dioxide or another formation of SiO_x where $x \geq 2$. The surface 14 has an array of divots 15 formed therein. The divots 15 appear as sunken concave hemispherically-shaped surfaces. In the preferred embodiment, the array has 10 columns and 11 rows and ball bearings are used to form the divots. When coated, the divots have a reflectance of greater than 84% over the wavelength range from 350 nm to 2500 nm and the mirror surface 15 has an integrated reflectance of greater than 90%. Thereafter, a layer 18 of a mixture of silicon oxide and chromium oxide is vapor deposited on the layer 16. The layer 18 serves to harden, seal and produce the reflective mirror properties. In the preferred embodiment, the layer 18 is a mixture of 50% chromium oxide and 50% silicon dioxide and is manufactured by EM Industries and sold as its EM Black A™ brand. Next, another thin layer 20 of SiO_x is vapor deposited to further seal the mirror. Thereafter a layer of aluminum 22 is vapor deposited to improve reflectance and the scattering properties of the mirror. As is well known, aluminum oxidizes on contact with air so a layer 24 of silicon oxide, SiO_x , is vapor deposited to seal and harden the underlayers and prevent decay of the aluminum.

[0004] In the mirror 10 used on the satellites, the nickel substrate 12 is 0.080 inches thick, the layer 16 is 500Å thick, the layer 18 is 3000Å thick, the layer 20 is 500Å thick, the aluminum layer 22 is 2000Å thick and the outer sealing layer 24 is 1000Å thick.

[0005] Recently an entire batch of mirror segments

that were qualified to be implemented on a satellite were contaminated with an acrylic polymer resin used to protect the light-scattering divots from abrasion. These contaminated mirror segments were dispositioned as unusable for the next step in fabricating the mirrors. The next step required the application of a multilayer vacuum deposition coating of metallic and dielectric layers. Hence all the mirror segments were discarded as being contaminated with the failed coatings. There were no remaining mirrors to vacuum coat for scheduled flight processing and the time required to electroform, polish and clean new mirrors would have caused a delay in the schedule. Consequently, there was a need to salvage these qualified mirrors that had been improperly vacuum coated without damaging the highly polished nickel surface of the substrate material.

[0006] In the past, an electrocleaning process has been used in the metal plating industry to remove a metal plating, namely electroless nickel, copper or gold, from stainless steel or another metal substrate. In the electrocleaning process, the substrate was immersed in a caustic, alkaline solution for between 5 and 30 seconds with a voltage up to 8 volts applied across the electrodes until the metal plating was removed.

[0007] Such an electrocleaning process was known to be capable of removing metal plated on a ferrous metal substrate. It was also known that the electrocleaning process was unable to remove glass, a dielectric, from the substrate. Moreover, because the electrocleaning solution was caustic, it was believed that it would destroy the polished mirror surface of a nickel mirror.

[0008] What is needed, therefore, is a process for removing one or more dielectric coatings and a metal coating from the highly polished surface of a nickel substrate without destroying the polished surface. This would allow contaminated and expensive nickel mirror segments qualified for use on a satellite mirror to be reprocessed and reused on the satellite mirror. In turn this would avoid discarding the contaminated mirror, reduce satellite manufacturing costs and keep the satellite delivery on schedule.

SUMMARY OF THE INVENTION

[0009] A method of removing a dielectric coating from a surface of a conductive element comprises immersing the coated element in a basic solution, applying a dc current to the solution, and reversing the polarity of the dc current. Air is injected to agitate the solution. Thereafter, the conducting element is dipped into an acid bath to remove copper that plates from a copper rack onto the nickel substrate when current direction is reversed. The basic solution is caustic and alkaline and in a stainless steel container and the conductive element is nickel and is carried by the copper rack.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The foregoing and additional features and advantages of this invention will become apparent from the detailed description and accompanying drawing figures below. In the figures and the written description, numerals indicate the various elements of the invention, like numerals referring to like elements throughout both the drawing figures and the written description.

[0011] FIG. 1 is a cross section perspective of a mirror segment coated with multiple layers of metals and dielectrics that are to be removed in accordance with the present invention.

[0012] FIG 2 is a schematic perspective diagram of a mirror immersed in a solution illustrating the removal of the layers of metals and dielectrics from the polished mirror surface in accordance with the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0013] As illustrated in the cross section view of FIG. 1 and as previously described, the mirror 10 includes a nickel substrate 12 with a highly polished surface 14, a layer of silicon dioxide 16, a layer 18 of EM Black A™-- a mixture comprising silicon oxide and chromium oxide, a sealing layer 20 of silicon oxide, a layer of aluminum 22 for improving the scattering properties of the mirror, and a layer 24 of silicon dioxide to seal and harden the underlayers and prevent decay or corrosion of the aluminum.

[0014] With reference to FIG. 2 a process of removing the dielectric layers 16, 20 and 24 and the metal layers 18 and 22 from the polished surface 14 of the nickel substrate 12 without destroying the surface 14 is illustrated.

[0015] The process includes apparatus, generally illustrated by the numeral 50, including a source of dc current 52 and a container 54, or tank, formed from an electrically conducting material, preferably stainless steel. The dc source 52 includes conductors 56 and 58 and a reversing switch 60.

[0016] The container 54 comprises a conductive rack 64 having a mirror support 66 and is preferably fabricated from stainless steel. A non-conductive bar 68 is mounted across two side walls of the container and holds the rack within the container, but not touching its walls, with an end protruding upwardly therefrom serving as an anode for connection to the conductor 56. Hence, there is no electrical conductive path directly from the container to the rack. The conductor 58 is connected to a terminal on the container 54 that serves as a cathode. The container 54 is filled with a caustic solution 70, that is alkaline or basic in nature and has a pH greater than 7. In the preferred embodiment the solution 70 is Oakite 90, manufactured and sold by Oakite Products, Inc. As was described, the mirror 10 comprises a multiplicity of mirror segments such that the divots form a matrix of 10 columns and 11 rows. One mirror segment

is mounted on the mirror support 66 with multiple points of contact between the copper support 66 and the nickel substrate 12. This assures an electrical path from the conductor 56 to the mirror segment 10 which is electrically separated from the conductor 58 by the caustic solution 70.

[0017] An air supply 80 injects air bubbles into the solution 70. This agitates the solution and maintains it well mixed even after one or more of the metal or dielectric layers have been removed from the substrate as will be subsequently described. Alternatively, agitation could be achieved by relatively rotating the rack with respect to the container.

[0018] In operation with the solution 70 at 140° - 160° between a temperature the dc current source 52 and the air supply are energized. The level of dc voltage supplied is between 4 and 6 volts. Soon thereafter, the thickness of the layers of dielectrics and metals begin to diminish but are visibly not entirely removed. Initially, the solution 70 is seen to effervesce. The reason for this is unknown although it is believed to result due to a chemical reaction by the caustic solution and the dielectric layer 16. Partially through the process, the switch 60 is toggled, reversing polarity of the dc current through the solution. The current is periodically reversed one or more times. This has been found to remove and strip away all the layers 24, 22, 20, 18 and 16. As the EM Black A™ layer was removed a visual color change is observed, in that the Black A appeared green or purple that disappeared when the layer was removed.

[0019] It has been found that in some cases, a thin layer of copper that is dissolved in the solution from the rack is redeposited on the surface 14. To remove this, the rack 64 is lifted from the solution and the nickel substrate is removed. Then it is dipped in an acid bath with ammonium perfluorate, preferably Actane 97 manufactured by Enthone Inc., to remove the thin layer of redeposited copper material. Surprisingly, the polished nickel surface 15 was not visibly damaged by the harsh caustic solution.

[0020] By way of reference, the voltage level used in this invention is lower than the 8 volts used in the prior art electrocleaning process for removing metal layers from stainless steel or other ferrous metal substrates.

[0021] Upon removal from the acid bath, the nickel substrate 12 has all its coated metal and dielectric layers removed and actually its surface 15 is prepared for reworking. It can be immediately placed in a vacuum deposition chamber to deposit new layers of dielectrics and metals thereon. Hence the normal surface preparation plasma discharge step to clean and prepare the surface is avoided. This additionally reduces the manufacturing costs to rework or redo the nickel substrate.

[0022] It is believed that this invention can be used to remove dielectric and metal layers from other metal substrates that are at least as conductive as nickel. Although this invention has been described using nickel substrates, one skilled in the art should recognize that

the process may be utilized in removing dielectric and metal layers from other conductive materials. In addition, it should be recognized that this invention is directed toward a novel process for removing dielectric layers from a polished metal surface which includes reversing the polarity of a dc current through a caustic solution. The individual steps which make up this novel process are not in themselves new. However, their application in combination to totally remove a dielectric material from a nickel substrate without damaging its polished mirror surface is both new and novel.

[0023] While there has been described what is at present considered to be the preferred embodiment of the invention, it will be understood that various modifications may be made therein, and it is intended to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

[0024] What is claimed and desired to be secured by Letters Patent of the United States is:

Claims

1. A method of removing a dielectric coating from a surface of a conductive element comprising:
 - immersing the coated element in a basic solution;
 - applying a dc current to the solution; and
 - reversing the polarity of the dc current.
2. The method as set forth in claim 1 wherein the conductive element comprises nickel.
3. The method as set forth in claim 1 wherein the basic solution is alkaline.
4. The method as set forth in claim 1 wherein the basic solution is in an electrically conductive container and the conductive element is carried by an electrically conductive rack, said dc current being supplied by a dc voltage source having a first terminal connected to said rack and a second terminal connected to said container.
5. The method as set forth in claim 1 and further comprising dipping the conductive element in an acid bath.
6. The method as set forth in claim 1 and further comprising injecting air into the solution to agitate it and mix therein the removed dielectric coating.
7. The method of removing a dielectric coating and a metal layer from a metal substrate comprising:
 - immersing the coated metal substrate in a basic solution;

applying a dc current to the solution; and reversing the polarity of the dc current.

8. The method as set forth in claim 7 wherein the metal substrate comprises nickel and has a polished surface that is coated with the dielectric, said dielectric being removed without damaging the polished surface.
9. The method as set forth in claim 7 and further placing the metal substrate in electrical contact with an electrically conductive rack and containing the basic solution in an electrically conductive container.
10. The method as set forth in claim 9 and injecting air into the solution.
11. The method of claim 9 and further dipping the cleaned metal substrate in an acid solution to remove any electrically conductive material therefrom.

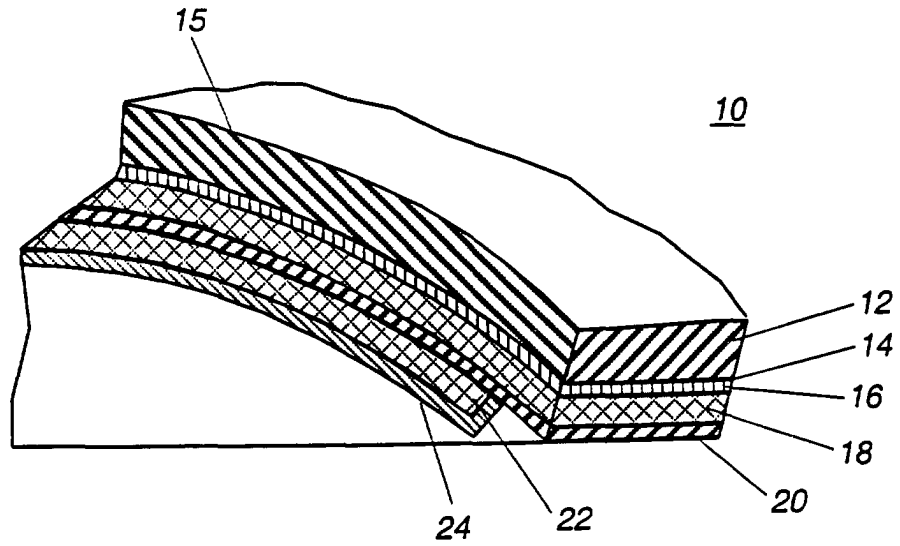


Fig. 1

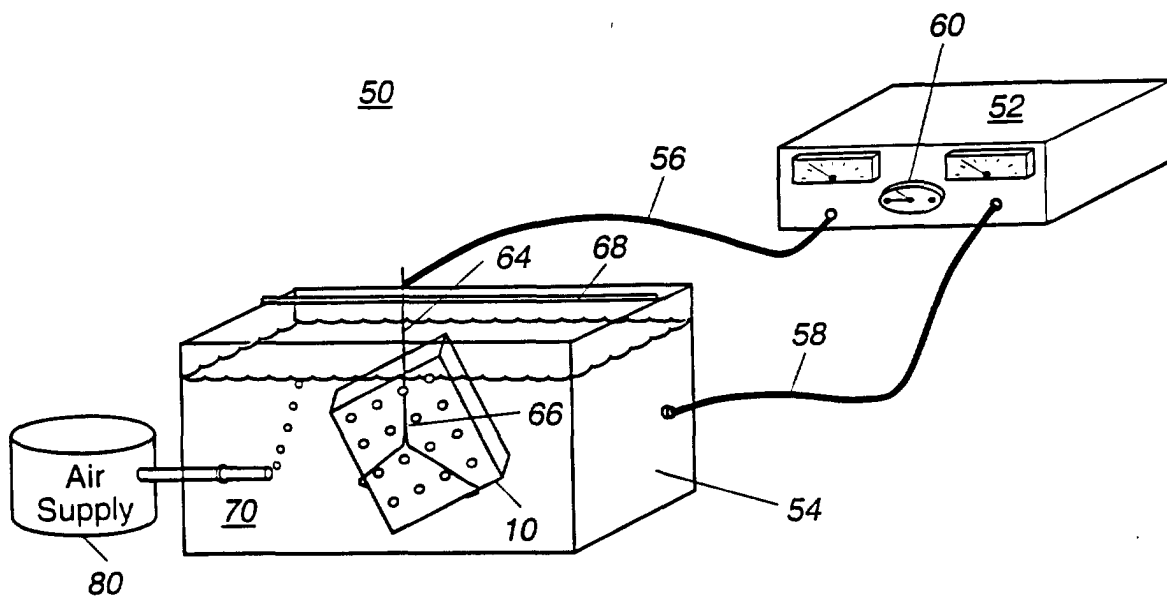


Fig. 2



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EUROPEAN SEARCH REPORT

Application Number
EP 01 11 0125

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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A	EP 0 291 161 A (METAL BOX P.L.C.) 17 November 1988 (1988-11-17) * column 3, line 54 - column 4, line 19 * * column 4, line 38 - line 51 *	1-5,7,11	
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The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 30 August 2001	Examiner Groseiller, P
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 01 11 0125

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82