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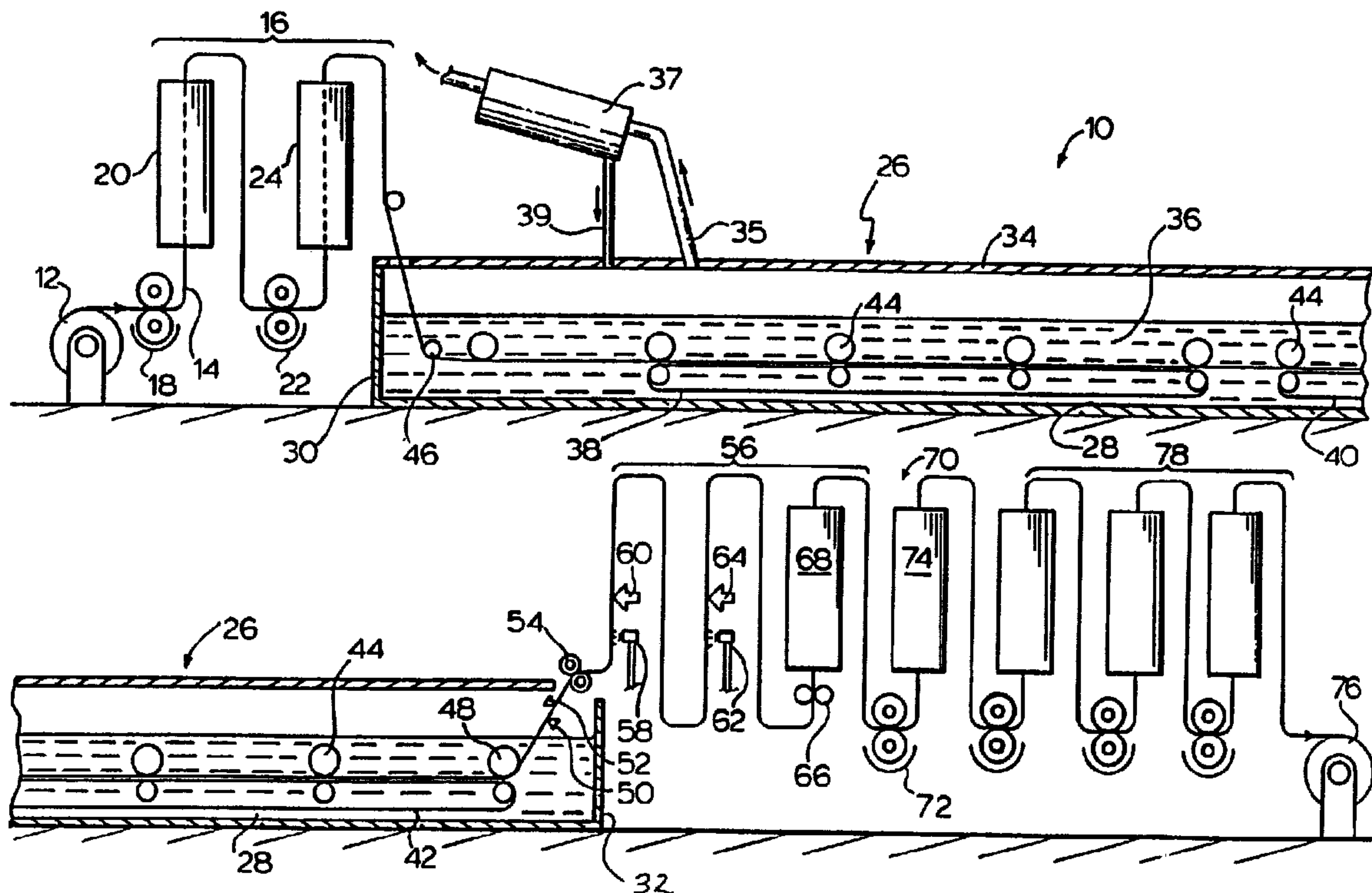
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(54) Title: NOVEL DEMETALLIZING APPARATUS



(57) Abrégé/Abstract:

Selective demetallization of an etchable metal layer supported on a polymeric material or other microwave transparent material, or a self-supporting etchable metal layer, particularly aluminium of thickness at least about 1 micron adhesively joined to a flexible polymeric material substrate, is described. A web of polymeric material bearing the etchable metal layer, or an unsupported etchable metal layer, has a pattern of etchant-resistant material first applied and then the web is immersed in and passed through a bath of aqueous etchant, particularly hot aqueous sodium hydroxide solution, for a time at least sufficient to completely remove the etchable metal from non-protected areas of the web. The demetallized web is washed and dried. Specific structure incorporating the selectively demetallized etchable metal layer also are described.

NOVEL DEMETALLIZING APPARATUS**Abstract**

Selective demetallization of an etchable metal layer supported on a polymeric material or other microwave transparent material, or a self-supporting etchable metal layer, particularly aluminium of thickness at least about 1 micron adhesively joined to a flexible polymeric material substrate, is described. A web of polymeric material bearing the etchable metal layer, or an unsupported etchable metal layer, has a pattern of etchant-resistant material first applied and then the web is immersed in and passed through a bath of aqueous etchant, particularly hot aqueous sodium hydroxide solution, for a time at least sufficient to completely remove the etchable metal from non-protected areas of the web. The demetallized web is washed and dried. Specific structure incorporating the selectively demetallized etchable metal layer also are described.

NOVEL DEMETALLIZING APPARATUS

The present invention is directed towards the selective demetallization of etchable metal, particularly supported on a web of microwave transparent material.

5 In U.S. Patent No. 4,398,994, assigned to the assignee hereof

there is described a continuous method of forming decorative patterns of aluminized plastic film and the use of such patterned
10 film in packaging.

As described therein, a web of aluminized polymer film is printed with a pattern of etchant-resistant material, corresponding to the pattern desired to be retained on the aluminized surface. Aqueous sodium
15 hydroxide solution is applied to the patterned film to etch away the exposed aluminum while the aluminum covered by etchant-resistant material is untouched.

In U.S. Patent No. 4,552,614, assigned to the applicant hereof, there is described an improved
20 procedure to effect such selective demetallization by employing spray application of the aqueous etchant to the patterned aluminized surface.

More recently, in U.S. Patent No. 4,869,778, it has been proposed to form a micropattern on the aluminized
25 surface by first contacting the patterned aluminized polymeric film with a warm, essentially saturated caustic solution followed by contact with an acidic solution and washing.

The procedures described in the aforementioned prior
30 art are very effective in achieving selective demetallization of relatively thin aluminum layers (generally less than about 1000 Å in thickness) supported on a polymeric web to completely remove aluminum from selected areas of the surface of the polymeric web for a
35 variety of purposes, such as in decorative packaging and

in microwave susceptor applications. The procedures, however, are less effective with relatively thick aluminum layers supported on a polymeric material web or unsupported because of rapid depletion of the etchant in
5 contact with the web by the etched material.

In accordance with one aspect of the present invention, there is provided a method of effecting selective demetallization of an etchable metal layer, which may be supported on a microwave transparent
10 material substrate, generally a polymeric film substrate, or unsupported, which comprises applying a pattern of etchant-resistant material to the etchable metal layer corresponding to a desired pattern of non-etched metal, repeatedly contacting the etchable metal with an aqueous
15 etchant material for a time at least sufficient to effect complete removal of the etchable metal from areas of the etchable metal layer not covered and protected by the pattern of etchant-resistant material, and washing spent etchant solution from the resulting etched polymeric film
20 substrate.

By providing prolonged exposure of the etchable metal layer to aqueous etchant by way of such repeated contact, relatively thick layers of etchable metals, such as aluminum, can be processed by the procedure of

the present invention to effect selective demetallization.

5 The prolonged exposure and repeated contact preferably is carried out by immersing the patterned metallized polymeric film substrate or patterned unsupported metal layer in a bath of etchant and maintaining it immersed until complete removal of etchable metal from the non-protected areas is effected.

10 For reasons of economy, it is preferred to operate the process in a continuous manner, with the layer of etchable metal being processed continuously through the steps of pattern application, demetallization and washing.

15 The invention is particularly applicable to etchable metal of a thickness of at least about 1 micron, preferably aluminum, although the method is equally applicable to other etchable metals of differing thicknesses.

20 Where the etchable metal layer is of self-supporting thickness, the metal layer may be processed unsupported, provided that the etched pattern desired comprises a continuous metal layer with apertures, such as elongate slots, therethrough. In such an operation, the same pattern of etchant-resistant material is
25 required to be applied in register to both faces of the etchable metal layer. Following selective demetallization, the etched metal layer may be adhered, such as by laminating adhesive, to a dielectric substrate layer, such as a polymeric film layer or a
30 paperboard layer. Alternatively, etched metal layers may be adhered, such as by laminating adhesive, to both sides of a dielectric substrate. In a further alternative, the etched metal layer may be sandwiched between outer layers of dielectric material, with such
35 outer layers of the resulting laminate being the same or different materials.

The selectively demetallized self-supporting metal layer resulting from such selective demetallization constitutes one aspect of the present invention. According to this aspect, there is provided a novel
5 element, comprising a self-supporting layer of flexible etchable metal having a thickness of at least about 1 micron and having a plurality of apertures formed therethrough, and a layer of etchant-resistant material on each face of said layer of flexible etchable metal in
10 a pattern completely overlying the metal layer and defining the periphery of the plurality of apertures.

The plurality of apertures in this novel element or in the polymeric film supported structures described below may be elongate and sized and arranged so as to
15 generate thermal energy from incident microwave radiation when the element is employed in a food packaging structure and located adjacent a foodstuff to be cooked by microwave radiation, as described in U.S. Patent No. 5,117,078, assigned to the applicant hereof.

20 More usually, the etchable metal is supported on a microwave transparent substrate, generally a polymeric film substrate, either by direct engagement, such as is achieved by vapor depositing the metal on the polymeric substrate, or by adhesive bonding of the metal to the
25 polymeric film substrate. The latter structure is more usual with the thicknesses of metal with which the present invention is particularly concerned. However, the present invention may be employed with metallized polymeric films bearing metal in a thickness opaque to
30 light.

In a preferred embodiment of the invention, there is provided a continuous method of effecting selective demetallization of a layer of aluminum having a

thickness of at least about 1 micron supported on a web of flexible polymeric material, which comprises continuously applying a pattern of sodium hydroxide-resistant material to the aluminum corresponding to a
5 desired pattern of non-etched aluminum, continuously passing the patterned web in an immersed condition through a bath of aqueous sodium hydroxide solution having a temperature of about 10° to about 98°C and a strength of about 0.1 to about 10 normal for a time of
10 at least 0.5 secs. per micron thickness of the aluminum layer to effect complete removal of aluminum from areas of the web not covered and protected by the pattern, continuously washing the web free from spent sodium hydroxide solution, and drying the washed web.

15 Following drying of the web, it is preferred to apply a detackifying material to the exposed laminating adhesive in the etched areas of the web to avoid overlying layers of web adhering to one another when the web is reeled up. This preferred operation results in a
20 novel laminate structure, which constitutes a further aspect of the invention. The detackifying material may be provided by laminating the etched face of the patterned metal layer to a layer of dielectric material, such as a further polymeric film layer, a paperboard
25 layer or a paper layer.

In accordance with this aspect of the present invention, there is provided a novel laminate structure comprising a flexible polymeric substrate layer, a layer of adhesive coextensive with the substrate, a layer of
30 an etchable metal having a thickness of at least about 1 micron overlying the substrate layer and adhered to the adhesive layer in a pattern, a layer of etchant resistant material overlying the etchable metal layer in the same pattern, and a layer of detackifying material
35 overlying the adhesive layer at least in regions thereof not overlaid by the etchable metal layer.

The present invention provides, in another aspect, an apparatus for effecting the preferred method of the present invention as described above, comprising an elongate tank adapted to hold a bath of aqueous etchant material and having an upstream end and a downstream end, means enclosing the elongate tank to provide an enclosure open only at the upstream end and downstream end to permit the etchable metal layer to enter and leave the tank, and guide means located within the tank and arranged to guide the web through the elongate tank from the upstream end to the downstream end below the intended level of the bath of etchant material. In one embodiment of this aspect of the invention, the web is guided horizontally through the bath while, in another embodiment, the web is guided sinusoidally through the bath. The guide means further are adapted to engage the etchable metal layer in driving relation to drive the etchable metal layer through the tank.

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SUMMARY OF THE INVENTION

Thus, in one embodiment, the present invention provides: An apparatus for effecting selective demetallization of a continuous web having a layer of etchable metal, comprising:

5 an elongate tank adapted to hold a bath of aqueous etchant material and having an upstream end and a downstream end,

means enclosing the elongate tank to provide an enclosure open only at the upstream end and downstream end to permit the continuous web to enter and leave the tank, and

10 guide means located within the tank and comprising a first lower set of guide roller elements and a second upper set of guide roller elements for receiving the continuous web, whereby the web is driven and guided in sinusoidal manner through the elongate tank from the upstream end to the downstream end below the intended level of the bath of etchant material,

15 the first and second sets of guide roller elements being mounted on carriage means located in the elongate tank and the carriage means is mounted to guide rails vertically extending from the elongate tank to permit the carriage to ride upon the rails for raising and lowering the carriage out of and into the tank.

In another embodiment, the invention provides a novel laminate structure, comprising:

a flexible polymeric substrate layer resistant to aqueous sodium hydroxide solution etchant,

20 a layer of adhesive coextensive with the substrate resistant to aqueous sodium hydroxide solution etchant,

a layer of an etchable metal comprising aluminum having a thickness of 1 to 15 microns overlying the adhesive layer in a pattern,

25 a layer of aqueous sodium hydroxide solution etchant-resistant material overlying the etchable metal layer in the same pattern as the etchable metal layer, and

a layer of detackifying material overlying the adhesive layer in regions thereof not overlaid by the etchable metal layer.

In yet another embodiment, the invention provides a continuous method of effecting selective demetallization of a layer of aluminum having a thickness of at least 1 micron

30 supported on a web of flexible polymeric material, which comprises:

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continuously applying a pattern of sodium hydroxide-resistant material to the aluminum corresponding to a desired pattern of non-etched aluminum,

5 continuously passing the patterned web in an immersed condition through a bath of aqueous sodium hydroxide solution having a temperature of 10° to 98° C.

and a strength of 0.1 to 1 normal for a time of at least 0.5 secs. per micron thickness of the aluminum layer to effect complete removal of aluminum from areas of the web not covered and protected by the pattern,

10 continuously washing the web free from spent sodium hydroxide solution, and drying the washed web.

In a further embodiment, the present invention, provides a continuous method of effecting selective demetallization of a layer of aluminum having a thickness of 1 to 15 microns supported on a microwave transparent web of flexible polymeric material, which comprises:

15 providing the microwave transparent web as a continuous web and conveying the continuous web from a reel thereof successively through an etchant solution-applying zone, a washing zone and a drying zone,

providing the microwave transparent web with a pattern of etchant-resistant material on the aluminum layer corresponding to a desired pattern of non-etched aluminum prior to the continuous web entering the etchant solution-applying zone,

20 continuously driving the microwave transparent web with the pattern of etchant-resistant material thereon in an immersed condition through a bath of aqueous etchant material which is aqueous sodium hydroxide having a temperature of 10° to 90° C. and a strength of 0.1 to 10 normal and conveying the microwave transparent web through the etchant solution-applying zone for a period of time of at least 0.5 seconds per micron thickness of the aluminum layer and at least sufficient to effect complete removal of the aluminum layer not covered and protected by the pattern of etchant-resistant material,

25 wiping the aqueous etchant solution from the surfaces of the web before the web leaves the etchant solution-applying zone,

30 contacting the web with wash water in the washing zone to remove residual etchant solution therefrom,

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wiping wash water from the surfaces of the web before the web leaves the washing zone,
and
drying the web in the drying zone.

5 In yet a further embodiment, the invention provides a method of effecting selective demetallization of a self-supporting aluminum web having a thickness of 1 to 15 microns and first and second sides to form an element having a plurality of apertures through the aluminum, which comprises:

10 applying a pattern of etchant-resistant material to both the first and second sides of the aluminum web in register and corresponding to a desired pattern of non-etched aluminum in the element and comprising a continuous aluminum web having a plurality of apertures therethrough,

15 repeatedly contacting the aluminum web with an aqueous etchant material comprising an aqueous solution of sodium hydroxide by immersing the aluminum web in and passing the aluminum web through a bath of the aqueous etchant material having a temperature of 10° to 98° C. and a strength of sodium hydroxide of 0.1 to 10 normal for a period of time of at least 0.5 seconds per micron thickness of the aluminum web and at least sufficient to effect complete removal of the aluminum from areas of the aluminum web not covered and protected by the pattern of etchant-resistant material and to form apertures through the
20 aluminum web,

removing the aluminum web from the bath,

washing spent etchant solution from the removed aluminum web, and
drying the washed aluminum web to provide the element comprising a self-supporting aluminum having a plurality of apertures therethrough.

25

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is described further, by way of illustration, with reference to the accompanying drawings, in which:

30 Figure 1 is a schematic representation of one embodiment of apparatus which may be employed to effect the method of the invention; and

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Figure 2 is a schematic representation of another embodiment of apparatus which may be
5 employed to effect the method of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to Figure 1 of the drawings, a selective demetallizing machine 10
comprises a plurality of stations to effect selective demetallizing of flexible polymeric film
10 bearing a metal layer thereon. A roll 12 of such film generally comprises aluminum of thickness
of at least 1 micron, usually up to 15 microns, preferably 3 to 10 microns, typically, aluminum
foil of thickness 7 to 8 microns, adhesively bonded to one face of the polymeric film.

A web 14 of the flexible polymeric film substrate supporting the aluminum layer is drawn from the roll 12 and passed to a protective lacquer applying station 16, wherein a pattern of etchant-resistant material is applied to the aluminum layer by a first applicator 18 before the pattern is dried by a first drier 20. The pattern of etchant-resistant material is applied to areas of the aluminum surface which it is desired to retain in the subsequent selective demetallization procedure. In view of the prolonged exposure of the web 14 to the etchant, it is usually desirable to apply the pattern of etchant-resistant material a second time to ensure a sufficient thickness of lacquer on the aluminum surface to resist the etchant. Accordingly, the web 14 passes, after the first drier 20, through a second etchant-resistant material applicator 22 and a second drier 24, before passing to an etching station 26.

The etching station 26 comprises an elongate horizontal tank 28 through which the patterned web 14 passes from an upstream end 30 to a downstream end 32. The tank 28 is provided with an upper closure 34 to prevent significant evaporative losses from the tank 28 into the ambient atmosphere. The interior of the tank 28 may be maintained under a slightly subatmospheric pressure to avoid loss of moisture through the end gaps between the upper closure 34 and the tank end walls through which the web is required to pass to enter and exit the tank 28. For this purpose, a conduit 35 to which a subatmospheric pressure is applied may communicate with the atmosphere above the liquid level in the tank, with an associated scrubber 37 to remove moisture for return to the tank 28 through line 39.

The tank 28 holds a bath 36 of aqueous etchant material, usually aqueous sodium hydroxide solution for aluminum as the etchable metal. Although the temperature of the aqueous sodium hydroxide solution may

vary widely, from about 10° to about 98°C, the aqueous sodium hydroxide solution generally is maintained hot to enhance rapid etching of the exposed aluminum metal, usually in the range of about 50° to about 90°C, preferably about 70° to about 75°C. The strength of the sodium hydroxide solution may vary widely, usually from about 0.1 to about 10 normal, with the stronger solutions in the range of about 2 to about 3 normal, being preferred to enhance rapid etching of the exposed aluminum.

Three endless driven belts 38, 40 and 42 (only parts of belts 40 and 42 are shown) are provided immersed in the bath 36 of aqueous sodium hydroxide solution and formed of a suitable etchant-resistant material, for example, stainless steel mesh. The driven belts 38, 40 and 42 each has a series of roller elements 44 located in close proximity to the upper surface of the respective belt, so that the web 14 passing between the roller elements 44 and the adjacent upper belt surface is engaged by both, to ensure driven engagement of the web 14 by the respective belt. Although three endless belts 38, 40 and 42 are illustrated, any convenient number of such belts may be provided. Any other convenient drive mechanism may be employed to drive the web 14 through the tank 28.

The web 14 enters the tank 28 at its upstream end 30 and is immersed in the bath 36 by passing over a guide roller 46. The web 14 then passes in a generally horizontal path through the tank 28 immersed in the bath 36 to a guide roller 48 and out of the tank 28 at the downstream end 32. During passage through the tank 28, the web 14 is driven by the conveyer belts 38, 40 and 42.

In the prior art of U.S. Patent No. 4,552,614 referred to above, the web is driven through the apparatus by a drive roller located at the downstream

end of the demetallizing tank. However, the additional dwell time required for the generally thicker aluminum layers with which the present invention is concerned necessitates that the web be positively driven through
5 the tank 28 rather than drawn, to avoid inordinate stretching and distortion of the web.

As the web 14 passes through the tank, the hot aqueous alkali etches the exposed aluminum and removes it from areas of the web not protected by the etchant-
10 resistant material. Since the web 14 remains submerged during its passage through the tank 28, the web is continuously in contact with fresh hot sodium hydroxide solution, which enhances the etching of the exposed aluminum.

15 The speed of movement of the web 14 through the tank 28, the length of tank 28 and the temperature and strength of the aqueous sodium hydroxide solution are coordinated to provide a dwell time of the web 14 in contact with the hot aqueous sodium hydroxide solution
20 of at least about 0.5 secs. per micron of thickness of metal layer, preferably in the range of about 5 to about 50 secs per micron of thickness of metal, so as to ensure that the metal is completely etched from the exposed areas of the web not protected by the pattern of
25 etchant-resistant material.

The rate of movement of the web 14 through the tank may vary widely, but generally higher speed operations are preferred in the interests of economy, generally up to about 350 meters/min, preferably about 150 to about
30 250 meters/min, although lower speeds down to 10 meters/min may be employed.

As etching of the web 14 continues in the tank 28, etched aluminum becomes dissolved in the aqueous sodium hydroxide solution and tends to build up in the
35 solution. The bath may be intermittently, or more preferably, continuously rejuvenated by appropriate

processing of the solution to remove the dissolved aluminum and regenerate the alkali. The process may be operated with a dissolved aluminum concentration in the bath 36 which may vary widely, generally from about 5 to
5 about 95% of the saturation value, preferably towards the lower end of this range, from about 15 to about 30%.

The dissolved aluminum may be removed from the aqueous etchant solution and the alkali regenerated in
10 any convenient manner to maintain a closed-loop for the alkali, with make-up quantities of sodium hydroxide being required only on a periodic basis. One particular procedure which can be adopted involves removal of dissolved aluminum by crystallization of aluminum
15 trihydrate, described in more detail below with respect to the embodiment of Figure 2. During reaction in the tank 28, the caustic soda combines with etched aluminum and forms sodium aluminate, which then is converted to aluminum hydroxide and sodium hydroxide by hydrolysis in
20 a regeneration operation outside the tank 28. This procedure is described in an article by Dejat entitled "Aluminum Anodizer Regenerates Caustic Etch Solution" published in Plating and Surface Finishing, April 1984.

After the etched web leaves the bath 36 at the
25 downstream end of the tank 28 but before the web leaves the tank 28, the web 14 engages a first doctor blade 50 and then a second doctor blade 52 to wipe off liquid etchant from the surfaces of the web, and retain such liquid in the tank 28, before passing between rollers 54.

30 The demetallized web then passes to a washing and drying station 56. The demetallized web has wash water sprayed on by first wash water sprayers 58 followed by wiping of the washed surface by a first wiper blade 60,

and then has wash water sprayed on again by second wash water sprayers 62 followed by wiping of the washed surface by a second wiper blade 64. The washed demetallized web is passed between a pair of rolls 66, which comprise a rubber pinch roll to squeeze the web into engagement with a metal surfaced drive roll to ensure a positive pulling drive is effected on the web 14 through the washing operation. The pair of rollers 66 also serve to remove surface water from the web.

Spent wash water from the washing operations may be recycled to the tank 28 to make up for evaporative losses, as required. Following washing of the etched web in this way, the washed, clean patterned web is dried by passing through a drier 68, which removes residual surface moisture from the web. The washing and drying operations effected in the washing and drying station 56 also may be effected in the manner described below with respect to such operations in the embodiment of Figure 2.

Where the web 14 comprises an aluminum layer adhesively bonded to the polymeric film layer, the selective demetallization exposes the adhesive in the regions of the web which are demetallized. This adhesive tends to be somewhat tacky and hence the dried demetallized web next is passed to a detackifying station 70, where the web first is contacted with a detackifier of suitable composition by an applicator 72 and then is dried by passing through a drier 74. In place of or in addition to applying a liquid detackifying material to the web, a further web of dielectric material, such as a polymeric film web, may be laminated to the etched face of the web.

Optionally, prior to winding up the web into a reel 76, the web may be passed through an in-line print station 78, where one or more colors, for example, three

as illustrated, may be applied to the web in a desired pattern, such as a decorative pattern.

5 The reel 76 of processed web is formed on a wind-up roll which is drivingly rotated to draw the web through the drying, detackifying and optional coloring operations. Other drive procedures may be adapted.

10 Turning now to Figure 2, there is illustrated schematically therein a further embodiment of selective demetallizing machine 110, which operates similarly to the demetallizing machine 10 described above, and represents the current best mode of putting the invention into effect known to the applicant. A roll 112 of flexible polymeric film bearing a metal layer thereon, generally comprises aluminum of thickness of at 15 least about 1 micron, usually up to about 15 microns, preferably about 3 to about 10 microns, typically aluminum foil of thickness about 7 to 8 microns, adhesively bonded to one face of the polymeric film.

20 A web 114 of the flexible polymeric film substrate supporting the aluminum layer, which is drawn from the roll 112, has a pattern of etchant-resistant material pre-applied to the aluminum layer in areas of the aluminum surface which it is desired to retain such metal in the subsequent demetallization operation.

25 The web 114 passes to an etching station 116 which comprises a tank 118 through which the patterned web 114 passes from an upstream end 120 to a downstream end 122. The tank 118 is provided with an upper closure (not shown) to prevent significant evaporative losses from 30 the tank 118 into the ambient atmosphere. The interior of the tank 118 may be maintained under a slight subatmospheric pressure to avoid loss of moisture through the end gaps between the upper closure and the tank end walls through which the web is required to pass 35 to enter and exit the tank 118. As illustrated in Figure 1, a conduit, or series of conduits, may be

employed to apply the subatmospheric pressure to the interior of the tank, with an associated scrubber to remove moisture for return to the tank 118.

5 In contrast to the structure shown in Figure 1, the tank 118 is relatively deep and the web 114 is guided through the tank in a sinusoidal path by sets of upper rollers 124 and lower rollers 126. This arrangement permits efficient demetallizing to be effected in the tank 118, while significantly simplifying the structure and significantly decreasing the physical length of the
10 tank 118.

The upper and lower sets of rollers 124, 126 are mounted to a carriage structure 128, which itself is mounted by rollers 129 to vertical rails 130 of a frame
15 structure 132, which permits the carriage 128 to be raised from the tank 118 and lowered into the tank 118. This arrangement is particularly beneficial in permitting threading or rethreading of the web without having to empty the tank 118 of aqueous etchant
20 material.

The tank 118 holds a bath 134 of aqueous etchant material, usually aqueous sodium hydroxide solution for aluminum as the etchable metal. The aqueous sodium hydroxide solution generally is maintained hot to
25 enhance rapid etching of the exposed aluminum metal, usually in the range of about 50° to about 90°C, preferably about 70° to about 75°C. The strength of the sodium hydroxide solution may vary widely, usually from about 0.1 to about 10 normal, with the stronger
30 solutions in the range of about 2 to about 3 normal, being preferred to enhance rapid etching of the exposed aluminum.

The web 114 enters the tank at the upstream end 120 with the assistance of a guide roller 136 and passes
35 alternatively about one of the lower and upper sets of rollers 124, 126 immersed in the bath 134 of aqueous

etchant material. As the web 114 passes through the tank 118, the hot aqueous alkali etches the exposed aluminum and removes it from areas of the web 114 not protected by the etchant-resistant material. Since the
5 web 114 remains submerged during its passage through the tank 118, the web is continuously in contact with fresh hot sodium hydroxide solution, which enhances etching of the exposed aluminum.

The speed of movement of the web 114 through the
10 tank 118, the length of tank 118 and the temperature and strength of the aqueous sodium hydroxide solution are coordinated to provide a dwell time of the web 114 in contact with the hot aqueous sodium hydroxide solution of at least about 0.5 secs. per micron of thickness of
15 metal layer, preferably in the range of about 5 to about 50 secs per micron of thickness of metal layer, so as to ensure that the metal is completely etched from the exposed areas of the web not protected by the pattern of etchant-resistant material.

The rate of movement of the web 114 through the
20 tank may vary widely, but generally higher speed operations are preferred in the interests of economy, generally up to about 350 meters/min, preferably about 150 to about 250 meters/min, although lower speeds down
25 to 10 meters/min may be used. The web 114 is driven through the tank 134 by providing driven power to at least some of the lower and upper sets of rollers 124, 126.

As etching of the web 114 continues in the tank
30 118 etched aluminum becomes dissolved in the aqueous sodium hydroxide solution and tends to build up in the solution. The bath may be intermittently, or more preferably, continuously rejuvenated by appropriate processing of the solution to remove the dissolved
35 aluminum and regenerate the alkali, as described in more detail below. The process may be operated with a

dissolved aluminum concentration in the bath 134 which may vary widely, generally from about 5 to about 95% of the saturation value, preferably towards the lower end of this range, from about 15 to about 30%.

5 As the etched web leaves the bath 134 at the downstream end 122 of the tank 118, the web 114 is engaged by a first doctor blade 137 as it wraps around a guide roller 138, in order to wipe liquid etchant from one surface of the web 114. The guide roller 138 has a
10 doctor blade 140 associated with its surface to remove liquid etchant transferred thereto by engagement with the guide roller 138. The etched web 114 then is engaged by a second doctor blade 141 as it wraps around roller 128 in order to wipe liquid etchant from the
15 opposite side of the web 114.

The demetallized web 114 then passes in a sinusoidal path through a wash tank 142 having a bath 144 of wash water therein, which serves to wash both faces of the web free from residual etchant material.
20 The web 114 is guided in its passage through the wash tank 142 by sets of upper rollers 146 and lower rollers 148, at least some of which may be driven. The web 114 passes through the nip between a pair of rollers 150 before exiting the wash tank 142, which serves to remove
25 moisture from the surface of the web. The web 114 next passes between a pair of doctor blades 151 which serve to remove further moisture from the washed web surfaces.

The washed demetallized web 114 next passes to a drying station 152 to remove residual moisture from the
30 web. The web is subjected to jets of hot air against the same from nozzles 153 to dry the same as it is trained through the drying station.

Where the web 114 comprises an aluminum layer adhesively bonded to the polymeric film layer, the
35 selective demetallization exposes the adhesive in the regions of the web which are demetallized. This

adhesive tends to be somewhat tacky and the dry web 114 is passed in contact with a bath 154 of detackifying material of suitable composition. The detackifying material then is dried by jets of hot air from nozzles 155.

A web of dielectric material, such as polymeric film or paperboard, may be adhered to the web to overlies the exposed adhesive by a suitable laminating operation which is employed as an alternative to or in combination with the application of a liquid detackifying material.

A roll 156 of processed web is formed on a wind up reel which is drivingly rotated to draw the web 114 through the drying and detackifying operations. Additional drives may be provided to the drying station and the detackifying station, if required. Optionally, prior to winding the web 114 onto the roll 156, the web 114 may be passed through an in-line print station, where one or more colors may be applied to the web 114 in a desired pattern, such as a decorative pattern.

To regenerate the etchant solution in bath 134, etchant is continuously removed from tank 120 by line 158 and passed to a series of parallel-fed tanks 160, 162 and 164. The hot sodium hydroxide in pipe 158 is cooled during its passage to the tanks, such as by a cooling jacket 166, to induce formation of crystallize aluminum trihydrate (aluminum hydroxide), which serves to remove aluminum from the sodium hydroxide solution. The tanks 160, 162 and 164 are filled successively, with one tank being filled before a next one. In the tanks, the liquid is stirred gently to promote the growth of crystals of aluminum trihydrate in the liquid therein.

When the liquid has been held for the desired period of time, generally long enough for a second tank to fill up, the liquid is discharged from the first tank filled to the inlet 167 of a precipitating tank 168 through which the liquor passes in a sinusoidal path

below and over baffles 169 to an outlet 170. This sinusoidal passage of liquid encourages settlement of the aluminum trihydrate crystals in the precipitation tank 168, so that a successively lesser concentration of crystals is present in the sodium hydroxide solution as it passes through the precipitation tank 168.

The aluminum trihydrate crystals settle from the aqueous phase into sumps 172 in the precipitation tank 168 and form a sludge-like mass in the sumps 172. From time to time, as required, the sludge may be discharged from the sumps 172 by line 174 to filtration separation.

The sodium hydroxide solution exiting the precipitation tank 168 by outlet 170 is passed by pipe 176 to the etch tank 134. The sodium hydroxide solution is heated during its return from the precipitation tank 168 to the etching tank 120, such as by heating jacket 178, to redissolve aluminum trihydrate crystals in the sodium hydroxide solution for the etching process. Make-up quantities of sodium hydroxide may be added from time to time, as required.

The demetallizing machines 10 and 110 may be used to effect selective demetallization of aluminum and other etchable metals generally in relatively thick layers supported by the polymeric web over a wide range of speeds of operation, as mentioned above.

The embodiments of Figures 1 and 2 have described the selected demetallization of an aluminum layer supported in adhered relationship to the polymeric material web. The procedures also may be employed with metallized (by vapor deposition or otherwise) polymeric material web bearing a metal layer of opaque thickness, except that in this case, no detackifier application step is required. In addition, the procedures may be employed with an unsupported metal layer, which is of a thickness which permits it to be processed by the

equipment, in which case the pattern of etchant-resistant material is applied, in register, to both faces of the metal layer.

The demetallizing machines 10 and 110 may be used to
5 effect selective demetallization of an etchable metal layer for a variety of purposes. For example, the demetallizing operation may be effected to produce materials useful in microwave packaging applications, such as described in the aforementioned U.S. Patent No.
10 5,117,078.

As described therein, the provision of a plurality of elongate slots formed through a flexible electroconductive metal layer normally opaque to microwave radiation enable thermal energy to be generated
15 from such microwave radiation when said metal layer is incorporated into packaging material and located adjacent a foodstuff to be cooked by microwave radiation. The demetallizing machines 10 and 110 also may be employed to form other selectively demetallized elements comprising
20 a pattern of electroconductive material adhered to a polymeric material layer, such as circuit boards and elements useful as carpet heaters or other heating applications.

The demetallizing operation carried out in the tank
25 28 or 118 employs continuous immersion of the patterned web to effect complete removal of aluminum or other etchable metal from the unprotected portions of the web surface. Any other equivalent procedure may be adopted, however, to ensure that there is repeated contact of
30 etchant with the web for at least 0.5 secs. per micron of metal layer thickness on the web. For example, there may be employed a series of longitudinally-spaced spray applicators each successively applying etchant solution to the web to effect partial etching until the web has

been completely demetallized in the desired locations of the web.

In summary of this disclosure, the present invention provides a novel selective demetallization procedure particularly suited for relatively thick films of etchable metals by employing a relatively long contact time between the etchant and metal. Modifications are possible within the scope of this invention.

1. An apparatus for effecting selective demetallization of a continuous web supporting a layer of etchable metal having a thickness of at least about 1 micron, comprising:

an elongate tank adapted to hold a bath of aqueous etchant material and having an upstream end and a downstream end,

means enclosing said elongate tank to provide an enclosure open only at said upstream end and downstream end to permit the continuous web to enter and leave said tank, and

guide means located within said tank and comprising a first lower set of guide roller elements and a second upper set of guide roller elements for receiving the continuous web, whereby the web is driven and guided in sinusoidal manner through said elongate tank from said upstream end to said downstream end below the surface level of the bath of etchant material,

said first and second sets of guide roller elements being mounted on carriage means located in said elongate tank and said carriage means is mounted to guide rails vertically extending from said elongate tank to permit said carriage to ride upon the rails for raising and lowering the carriage out of and into the tank.

2. The apparatus of claim 1, including wash tank means downstream of said elongate tank for washing the layer of etchable metal free from aqueous etchant material after the web exits said elongate tank and comprising a tank adapted to hold a bath of aqueous wash water and a first lower set of guide roller elements and a second upper set of guide roller elements for receiving the continuous web, whereby the web is guided in a sinusoidal manner through said wash tank means.

3. The apparatus of claim 1 or 2 wherein the layer of etchable metal comprises a layer of aluminium having a thickness of 1-15 microns.

4. The apparatus of claim 1, further comprising a first doctor blade proximate the downstream end of said tank for removing the etchant material from a first side of the web and a second doctor blade proximate the downstream end of said tank for removing the etchant material from a second side of the web.

5. The apparatus of claim 1, wherein at least some of said first and second sets of guide roller elements are driven by a source of power supplied thereto.

6. The apparatus of claim 1, wherein the web is driven through said elongate tank at a speed of from about 10 meters/min to about 350 meters/min.

7. The apparatus of claim 1, wherein the web is driven through said elongate tank at a speed of from about 150 meters/min to about 250 meters/min.

8. The apparatus of claim 1, wherein the continuous web includes a pattern of etchant-resistant material overlying the layer of etchable metal in areas in which it is desired to retain the metal.

9. The apparatus of claim 1, wherein said elongate tank is maintained at a subatmospheric pressure.

10. The apparatus of claim 1, wherein the bath of aqueous etchant material comprises an aqueous sodium hydroxide solution having a concentration of from about 0.1 to about 10 normal.

11. The apparatus of claim 1, wherein the bath of aqueous etchant material is maintained at a temperature of from about 50°C to about 90°C.

FIG. 1.

