(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
16 October 2008 (16.10.2008)

PCT

(10) International Publication Number
WO 2008/123767 A2

(51) International Patent Classification:
C09D 125/00 (2006.01) *C23C 18/18* (2006.01)
C08L 75/08 (2006.01)

(21) International Application Number:
PCT/MY2008/000029

(22) International Filing Date: 8 April 2008 (08.04.2008)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
PI 20070548 10 April 2007 (10.04.2007) MY

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:
— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
— *of inventorship (Rule 4.17(iv))*

Published:
— *without international search report and to be republished upon receipt of that report*

WO 2008/123767 A2

(54) **Title:** AN UNDERCOATING LAYER FORMULATION FOR NON-PLATABLE GRADE SUBSTRATE FOR ELECTROLESS METAL PLATING

(57) **Abstract:** Described herein is a coating formulation for non-platable grade substrate prior to undergoing an electroless metal plating process. Said coating formulation comprises of a mixture of multifunctional based monomer and diphenylmetane- 4, 4-diisocyanate (MDI), said multifunctional based monomer has allyl group or alkyl group or vinyl group or ether group or ester group or methacrylate group or acrylate group or phthalate group or combination thereof but does not include multifunctional monomer having hydroxyl group. According to the present invention, the ratio of said multifunctional based monomer is less than or equal (<) to diphenylmetane-4, 4-diisocyanate (MDI). Said coating formulation is mixed in a vacuum chamber for about 30 minutes before being applied to the surface of a non-platable grade substrate.

AN UNDERCOATING LAYER FORMULATION FOR NON-PLATABLE GRADE SUBSTRATE FOR ELECTROLESS METAL PLATING

Field of the Invention

This invention is directed to a process for electrolessly plating a conductive metal to the surface of a nonconductive and a non-platable grade material. In particular, this invention relates to a coating formulation for said non-platable grade substrate prior to undergoing electroless plating process and a method for applying said coating formulation onto said non-platable grade substrate.

Technological Background

Electroless plating process is a well-known process whereby substrate, which is a nonconductive material, is coated with metal for various applications. It is an autocatalytic process in which ionic state metal is reduced chemically without the influence of electricity. Acrylonitrile-butadiene-styrene (ABS) plastic, for example, are coated with metal for not only decorative purposes such as motorcar accessories, furniture fittings, fashion jewelry and buttons but also for functional reasons such as housings of electrical appliances in order to achieve efficient shielding from emission or immission of electromagnetic radiation. The superior properties of coated metal on substrate materials with excelled characteristics of wear resistance, surface finishing and uniform coating thickness rendered electroless plating technique a wide application window as in aerospace, automotives, electronics, computers, machinery, oil and gas production and valve industries. However, this technique is limited by the indispensable reliance on platable grade substrates.

There have also been attempts and researches to metal coat nonconductive and non-platable grade substrates as well. The main problem encountered in metal coating of non-platable substrate by electroless plating is most of the time the metal will not plate at all on the substrate. In the case when

plating is possible, the adhesion of the metal onto the surface of said non-platable grade substrate is very weak. This problem directly affects the wear resistance, surface finishing as well as the uniform coating thickness of the plated substrate. And, these problems still persist even though there have been many attempts to improve wear resistance, surface finishing as well as the uniform coating thickness of the plated substrate by applying coating formulations onto said substrate prior to the electroless plating process.

Summary of the Invention

It is therefore an object of the invention to provide for a coating formulation for non-platable grade substrate such that said non-platable grade substrate can possibly be plated with metal. Therefore, the plated substrates have improved their wear resistance, surface finishing and uniform coating thickness after undergoing an electroless plating process.

It is also another object of the present invention to provide for a method for preparing said coating formulation.

It is yet another object of the present invention to provide for a method to coat said formulation onto a non-platable grade substrate prior to the electroless plating process.

According to the first object of the invention, there is provided a coating formulation for non-platable grade substrate prior to undergoing electroless metal process wherein said coating formulation comprises a mixture of a multifunctional based monomer having allyl group or alkyl group or vinyl group or ether group or ester group or methacrylate group or acrylate group or phthalate group or a combination thereof, and diphenylmetane-4, 4-diisocyanate (MDI), said multifunctional based monomer does not include multifunctional monomer having hydroxyl group. Preferably, in said coating formulation the ratio of said multifunctional based monomer is less than or equal to ($\leq$) said diphenylmetane-4, 4-diisocyanate (MDI).

According to the second object of the invention, said coating formulation comprises a mixture of a multifunctional based monomer having allyl group or alkyl group or vinyl group or ether group or ester group or methacrylate group or acrylate group or phthalate group or combination thereof, and diphenylmetane-4, 4-diisocyanate (MDI), said multifunctional based monomer does not include multifunctional monomer having hydroxyl group, are mixed in a vacuum chamber and left for about 30 minutes to allow the polymers to mix well and stabilize before being applied to said non-platable grade substrate.

According to the third object of the invention, there is provided a method for applying said coating formulation in accordance with the present invention onto a non-platable grade substrate prior to undergoing electroless metal plating process, said method comprises the steps of:

(a) coating said formulation onto the surface of said non-platable grade substrate, preferably by brushing or dipping;
(b) curing said non-platable grade substrate in a room temperature for at least 8 hours to allow the polymers mixture to be fully cured and solidified;
(c) drying said substrate, preferably in an oven, for 2 to 3 days.

In order that the invention may be readily understood and be put into practical effect, preferred examples will be described in the following Detailed Description.

Detailed Description of the Invention

In accordance with the present invention, a coating formulation for non-platable grade substrate prior to undergoing electroless metal process comprises a mixture of a multifunctional monomer i.e. any monomer based on allyl group or alkyl group or vinyl group or ether group or ester group or methacrylate

group or acrylate group or phthalate group and inclusive any possible combination of the said groups and, diphenylmetane-4, 4-diisocyanate (MDI). Said multifunctional monomer however does not include multifunctional monomer having hydroxyl group. Further, according to the present invention, in said coating formulation the ratio of said multifunctional monomer is less than or equal to (≤) MDI.

The above mentioned coating formulation for non-platable grade is an innovative solution that compatibilizes adhesiveness between metal and non-platable grade substrate surfaces. This coating formulation offers versatility and is applicable on virtually all types of materials regardless of it nature or origin such as semi-metals like silicon, silicates, glasses, ceramics as well as non-metals like plastics, woods and shells.

According to the present invention, said multifunctional monomer comprises of any monomer based on allyl group or alkyl group or vinyl group or ether group or ester group or methacrylate group or acrylate group or phthalate group and inclusive any possible combination of the said groups except for multifunctional monomer having hydroxyl group. Some specific examples of said multifunctional monomer includes triallylcyanurate (multifunctional monomer based allyl group), trimethylolpropane trimethacrylate (multifunctional monomer based alkyl group), poly(ethylene)glycol divinyl ether or ester (multifunctional monomer based vinyl group or ether group or ester group), triethylene glycol dimethacrylate or ethyleneglycol dimethacrylate (multifunctional monomer based methacrylate group), polypropylene glycol (6) acrylate multifunctional monomer based acrylate group) and diallyl phthalate (DALP) (multifunctional monomer based phthalate group).

The monomer of diallyl phthalate (DALP) and diphenylmetane-4, 4-diisocyanate (MDI) from analytical grade are used for the preparation of said polymer solution. Mixture of monomers preferably in the ratio of 1:2 for

DALP: MDI is used. The mixing process between these two liquids must be done inside a vacuum chamber and left for 30 minutes to allow the mixture to mix well and stabilize before it can readily be used. The polymer solution must be kept inside vacuum bottle to avoid oxidation.

Although in the present invention the ratio of said multifunctional monomer is less than or equal (≤) to diphenylmetane-4, 4-diisocyanate (MDI), a more preferred ratio of 1:1 is favorable for multifunctional monomer based vinyl group or ether group or ester group such as poly(ethylene) glycol divinyl ether.

To plate non-platable grade substrate such as wood, we have to apply thin layer of this polymer solution onto the said substrate. Either dipping the substrate into the polymer or apply the polymer solution onto the substrate using brush should be fine. Then, the substrate will undergo a curing process at room temperature for at least 8 hours before further dried inside an oven for several days (2 or 3 days) After that, the substrate is ready for the next process which is conventional electroless plating process.

Conventional electroless metal plating involves five main processes. They are etching, neutralization, activation, acceleration and plating. For nickel plating process, the substrate which has been coated with the polymer formulation of the present invention is soaked into etching solution (potassium permanganate) for 5 minutes. Then, the substrate is soaked into neutralizing solution (mixture of hydrazine hydrate, sodium hydroxide and sodium tartrate, where hydrazine hydrate can be replaced with hydrogen peroxide or formaldehyde) for about 45 seconds. After the neutralization process, the substrate is then dipped into activation solution (mixture of stannous chloride, palladium chloride) for 5 minutes, followed by the acceleration solution (hydrochloric acid) for 2 minutes. Finally, the substrate is dipped into nickel plating bath.

For electroless copper plating process, the plating steps are the same as described above. However, the etching solution used is chromic acid and the plating bath is copper plating bath.

The conventional plating process i.e. etching, neutralization, activation, acceleration and plating is the same for any other metal plating.

Example 1 : Metal Plating onto Plaster of Paris

Firstly, plaster of Paris is coated with polymer formulation according to the present invention comprising a ratio of 1: 2 of diallyl phthalate (DALP) and diphenylmetane-4, 4-diisocyanate (MDI) from analytical grade.

The plaster of Paris is then cured at room temperature for 8 hours and further dried in an oven for two days. After that, said plaster of Paris undergoing a conventional electroless plating process i.e. etching, neutralization, activation, acceleration and plating.

As mentioned above, different multifunctional monomer (any monomer based on allyl group or alkyl group or vinyl group or ether group or ester group or methacrylate group or acrylate group or phthalate group and inclusive any possible combination of the said groups, except for multifunctional monomer having hydroxyl group) may be used in place of diallyl phthalate (DALP) in Example 1 given that in general the ratio of said multifunctional monomer is $\leq$ diphenylmetane-4, 4-diisocyanate (MDI) .

While the preferred embodiments of the present invention and its advantages have been disclosed in the above detailed description, the invention is not limited thereto but only by the features and scopes of the appended claims.

Claims:

1. A coating formulation for non-platable grade substrate prior to undergoing electroless metal process wherein said coating formulation comprises a mixture of a multifunctional based monomer having allyl group or alkyl group or vinyl group or ether group or ester group or methacrylate group or acrylate group or phthalate group or combination thereof, and diphenylmetane-4, 4-diisocyanate (MDI), said multifunctional based monomer does not include multifunctional monomer having hydroxyl group.

2. A coating formulation for non-platable grade substrate according to Claim 1 wherein the ratio of said multifunctional based monomer is less than or equal to said diphenylmetane-4, 4-diisocyanate (MDI).

3. A coating formulation for non-platable grade substrate according to Claim 1 or 2 wherein said multifunctional based monomer is diallyl phthalate (DALP).

4. A coating formulation for non-platable grade substrate according to Claim 3 wherein said coating formulation comprises a mixture of diallyl phthalate (DALP) and diphenylmetane-4, 4-diisocyanate (MDI) in ratio of 1: 2.

5. A coating formulation for non-platable grade substrate according to Claim 1 or 2 wherein said multifunctional monomer is poly(ethylene) glycol divinyl ether .

6. A coating formulation for non-platable grade substrate according to Claim 5 wherein said coating formulation comprises a mixture of poly(ethylene) glycol divinyl ether and diphenylmetane-4, 4-diisocyanate (MDI) in the ratio of 1:1.

7. A coating formulation for non-platable grade substrate according to Claim 1 or 2 wherein said multifunctional based monomer having allyl group or alkyl group or vinyl group or ether group or ester group or methacrylate group or acrylate group or phthalate group or combination thereof, and diphenylmetane-4, 4-diisocyanate (MDI), said multifunctional based monomer does not include multifunctional monomer having hydroxyl group, are mixed in a vacuum chamber and left for about 30 minutes to allow the polymers to mix well and stabilize before being applied to said non-platable grade substrate.

8. A coating formulation for non-platable grade substrate according to Claim 7 wherein said multifunctional based monomer is diallyl phthalate (DALP) .

9. A coating formulation for non-platable grade substrate according to Claim 7 wherein said multifunctional based monomer is poly(ethylene) glycol divinyl ether.

10. A method for applying coating formulation according to Claim 1or 2 or 7 or 8 or 9 onto a non-platable grade substrate prior to undergoing electroless metal process, said method comprises the steps of:

(a) coating said formulation onto the surface of said non-platable grade substrate, preferably by brushing or dipping;
(b) curing said non-platable grade substrate at room temperature for at least 8 hours to allow the polymers mixture to be fully cured and solidified;
(c) drying said substrate, preferably in an oven, for 2 to 3 days.