

**COMPOSITIONS FOR REMOVING PHOTORESIST AND ETCH RESIDUES,
METHODS OF USING AND USE THEREOF**

[0001] Field

[0002] The disclosed and claimed subject matter relates to compositions for removing photoresists and etch residue from substrates and to methods of manufacturing the same and/or employing the same for fabricating a semiconductor device.

[0003] Related Art

[0004] In semiconductor wafer manufacturing, wafer-level packaging (WLP) is the technology used to package an integrated circuit at the wafer-level including the addition of protective layers and electrical connections to the substrate before dicing. Usually, the interconnects are metal bumps produced from various processes including photolithography and metal deposition. The structures with deep holes are produced in photolithographic process and then the solder bump metals are filled into these holes. The bumps are then formed by removing the photoresist mask layer.

[0005] The photoresist layer is normally removed by a wet process using photoresist strippers. The requirements for effective photoresist strippers are not only the efficiency of photoresist removal, but also the good compatibility to the exposed substrates such as metal bumps and copper substrates. Photoresist stripper and etch residue removers for removal of photoresists and etch residue used in wafer level packaging are typically composed of different combinations of solvents, bases, corrosion inhibitors, optional co-solvents, and other additives. Conventional removers have DMSO or NMP as the solvent, and amines or quaternary ammonium hydroxides or inorganic bases, or combination thereof as bases. Bases are essential components for photoresist and etch residue removal. However, during the processes of removing photoresist layers, the copper substrates exposed to the photoresist strippers tend to be undesirably etched. As such, it is very critical for photoresist stripper and etch residue removers not to attack copper during cleaning process which can be achieved by introduction of effective and robust copper corrosion inhibitors.

[0006] Corrosion inhibitors are used to suppress the etch of exposed copper substrates. Many efforts have been used to find good copper inhibitors in photoresist strippers. The well-known copper corrosion inhibitors, such as benzotriazole, are effective in aqueous solutions. However, benzotriazole does not work efficiently in organic solvent-rich strippers, especially containing amines as strong bases. Metal salts such as copper salts are used as effective corrosion inhibitors however those salts have issues of solubility and stability in photoresist strippers.

Sugar alcohols are also used as copper corrosion inhibitors however their efficiency in such organic solvent rich strippers could not meet the requirements of copper protection.

[0007] Additionally, many photoresist strippers and post etch cleaning solutions contain environmentally unfriendly organic solvents, such as N-methyl-2-pyrrolidone (NMP) and dimethyl sulfoxide (DMSO), and dimethylacetamide (DMAC). Replacing those organic solvents with more environmentally friendly solvents is needed in development of new photoresist strippers and post etch cleaning solutions.

[0008] Therefore, there is need to develop photoresist strippers to have high efficiency of photoresist removal that contain copper inhibitors to effectively protect copper substrates while do not contain environmentally unfriendly organic solvents of NMP, DMAC and DMSO.

SUMMARY

[0009] This summary section does not specify every embodiment and/or incrementally novel aspect of the disclosed and claimed subject matter. Instead, this summary only provides a preliminary discussion of different embodiments and corresponding points of novelty over conventional techniques and the known art. For additional details and/or possible perspectives of the disclosed and claimed subject matter and embodiments, the reader is directed to the Detailed Description section and corresponding figures of the disclosure as further discussed below.

[0010] The disclosed and claimed subject matter is directed to photoresist stripper and etch residue remover solutions (collectively “remover solutions”) for removing or stripping (i) a positive or negative photoresist, (ii) photoresist etch residue after an etch process and/or (iii) etch residue from a substrate. The disclosed and claimed remover compositions are particularly compatible with copper even at high spin speed during application.

[0011] The disclosed subject matter relates to remover solutions that include, consist essentially of or consist of:

- (i) at least one organic solvent;
- (ii) at least one amine that is free of carboxylic acid moieties;
- (iii) water;
- (iv) a corrosion inhibitor including one or more of:
 - (a) an amino acid,
 - (b) an azole, and
 - (c) a phenolic acid,

where the remover solution is free of dimethylsulfoxide, N-methylpyrrolidone and dimethylacetamide.

In a further aspect of this embodiment, the (iv) corrosion inhibitor includes two or more of (a) an

amino acid, (b) an azole and (c) a phenolic acid. In one embodiment, the (iv) corrosion inhibitor includes (a) an amino acid and (b) an azole. In one embodiment, the (iv) corrosion inhibitor includes (a) an amino acid and (c) a phenolic acid. In one embodiment, the (iv) corrosion inhibitor includes (b) an azole and (c) a phenolic acid. In yet a further aspect of this embodiment, the (iv) corrosion inhibitor includes one or more of each of (a) an amino acid, (b) an azole and (c) a phenolic acid.

[0012] The disclosed and claimed subject matter further includes the use of the disclosed and claimed remover solutions. Among other things, the remover solutions can be used to remove polymeric resist materials present in a single layer or certain types of bilayer resists. For example, bilayer resists typically have either a first inorganic layer covered by a second polymeric layer or can have two polymeric layers.

[0013] Other features and advantages of the disclosed and claimed subject matter will be apparent from the following more detailed description, taken in conjunction with the example solutions which illustrate the principles of the disclosed and claimed subject matter.

[0014] The order of discussion of the different steps described herein has been presented for clarity's sake. In general, the steps disclosed herein can be performed in any suitable order. Additionally, although each of the different features, techniques, configurations, etc. disclosed herein may be discussed in different places of this disclosure, it is intended that each of the concepts can be executed independently of each other or in combination with each other as appropriate. Accordingly, the disclosed and claimed subject matter can be embodied and viewed in many different ways.

DETAILED DESCRIPTION

[0015] All references, including publications, patent applications, and patents, cited herein are hereby incorporated by reference to the same extent as if each reference were individually and specifically indicated to be incorporated by reference and were set forth in its entirety herein.

[0016] The use of the terms “a” and “an” and “the” and similar referents in the context of describing the disclosed and claimed subject matter (especially in the context of the following claims) are to be construed to cover both the singular and the plural, unless otherwise indicated herein or clearly contradicted by context. The terms “comprising,” “having,” “including,” and “containing” are to be construed as open-ended terms (*i.e.*, meaning “including, but not limited to,”) unless otherwise noted. Recitation of ranges of values herein are merely intended to serve as a shorthand method of referring individually to each separate value falling within the range, unless otherwise indicated herein, and each separate value is incorporated into the specification as if it were individually recited herein. All methods described herein can be performed in any suitable order unless otherwise indicated herein or otherwise clearly contradicted by context. The use of

any and all examples, or exemplary language (*e.g.*, “such as”) provided herein, is intended merely to better illuminate the disclosed and claimed subject matter and does not pose a limitation on the scope of the disclosed and claimed subject matter unless otherwise claimed. No language in the specification should be construed as indicating any non-claimed element as essential to the practice of the disclosed and claimed subject matter.

[0017] Preferred embodiments of this disclosed and claimed subject matter are described herein, including the best mode known to the inventors for carrying out the disclosed and claimed subject matter. Variations of those preferred embodiments may become apparent to those of ordinary skill in the art upon reading the foregoing description. The inventors expect skilled artisans to employ such variations as appropriate, and the inventors intend for the disclosed and claimed subject matter to be practiced otherwise than as specifically described herein. Accordingly, this disclosed and claimed subject matter includes all modifications and equivalents of the subject matter recited in the claims appended hereto as permitted by applicable law. Moreover, any combination of the above-described elements in all possible variations thereof is encompassed by the disclosed and claimed subject matter unless otherwise indicated herein or otherwise clearly contradicted by context.

[0018] For ease of reference, “microelectronic device” or “semiconductor substrates” correspond to semiconductor wafers, flat panel displays, phase change memory devices, solar panels and other products including solar substrates, photovoltaics, and microelectromechanical systems (MEMS), manufactured for use in microelectronic, integrated circuit, or computer chip applications. Solar substrates include, but are not limited to, silicon, amorphous silicon, polycrystalline silicon, monocrystalline silicon, CdTe, copper indium selenide, copper indium sulfide, and gallium arsenide on gallium. The solar substrates may be doped or undoped. It is to be understood that the term “microelectronic device” is not meant to be limiting in any way and includes any substrate that will eventually become a microelectronic device or microelectronic assembly. The microelectronic device or semiconductor substrates may include low-k dielectric material, barrier materials, and metals, such as, AlCu alloys, W, Ti, TiN, as well as other materials thereon.

[0019] As defined herein, “low-k dielectric material” corresponds to any material used as a dielectric material in a layered microelectronic device, wherein the material has a dielectric constant less than about 3.5. Preferably, the low-k dielectric materials include low-polarity materials such as silicon-containing organic polymers, silicon-containing hybrid organic/inorganic materials, organosilicate glass (OSG), TEOS, fluorinated silicate glass (FSG), silicon dioxide, and carbon-doped oxide (CDO) glass. It is to be appreciated that the low-k dielectric materials may have varying densities and varying porosities.

[0020] As defined herein, the term “barrier material” corresponds to any material used in the art to seal the metal lines, *e.g.*, copper interconnects, to minimize the diffusion of said metal, *e.g.*, copper, into the dielectric material. Preferred barrier layer materials include tantalum, titanium, ruthenium, hafnium, and other refractory metals and their nitrides and silicides.

[0021] “Substantially free” is defined herein as less than 2 wt. %, preferably less than 1 wt. %, more preferably less than 0.5 wt. %, and most preferably less than 0.1 wt. %. “Substantially free” also includes 0.0 wt. %. The term “free of” means 0.0 wt. %.

[0022] As used herein, the terms “about” and “approximately” are each intended to correspond to $\pm 5\%$ of the stated value.

[0023] As used herein, “neat” refers to the weight % amount of an undiluted acid or other material. For example, the inclusion 100 g of 85% phosphoric acid constitutes 85 g of the acid and 15 grams of diluent.

[0024] In all such compositions, wherein specific components of the composition are discussed in reference to weight percentage ranges including a zero lower limit, it will be understood that such components may be present or absent in various specific embodiments of the composition, and that in instances where such components are present, they may be present at concentrations as low as 0.001 weight percent, based on the total weight of the composition in which such components are employed. Note all defined weight percents of the components unless otherwise indicated are based on the total weight of the composition. Further, all weight percents unless otherwise indicated are “neat” meaning that they do not include the aqueous composition in which they are present when added to the composition. Any reference to “at least one” could be substituted with “one or more.” “At least one” and/or “one or more” includes “at least two” or “two or more” and “at least three” and “three or more” and so on.

[0025] In the broad practice the disclosed and claimed subject matter pertains to the above-described remover solutions which includes, or consists essentially of, or consists of components (i), (ii), (iii), and (iv). In some embodiments, the remover solutions can include other ingredients. In some embodiments, the remover solutions disclosed herein are formulated to be free or substantially free of at least one of the following chemical compounds: inorganic bases, quaternary ammonium hydroxides, ammonium hydroxide, amino acids, organic acids, azoles, halide ions (*e.g.*, fluoride ions, chloride ions), metal-containing chemicals, reducing agents, alkanolamine, hydroxylamine, hydroxylamine derivatives, amidoxime compounds, organic solvents, surfactants and abrasives.

[0026] In a further embodiment, the remover solutions consist essentially of (i), (ii), (iii), and (iv) in varying concentrations. In such an embodiment, the combined amounts of (i),

(ii), (iii), and (iv) do not equal 100% by weight and can include other ingredients that do not materially change the effectiveness of the remover solutions.

[0027] In another embodiment, the remover solutions consist of (i), (ii), (iii), and (iv) in varying concentrations. In such an embodiment, the combined amounts of (i), (ii), (iii), and (iv) equal or equal approximately 100% by weight but may include other small and/or trace amounts of impurities that are present in such small quantities that they do not materially change the effectiveness of the composition. For example, in one such embodiment, the remover solutions can contain 2% by weight or less of impurities. In another embodiment, the remover solutions can contain 1% by weight or less than of impurities. In a further embodiment, the remover solutions can contain 0.05% by weight or less than of impurities.

[0028] When referring to compositions of the inventive composition described herein in terms of weight %, it is understood that in no event shall the weight % of all components, including non-essential components, such as impurities, add to more than 100 weight %. In compositions “consisting essentially of” recited components, such components may add up to 100 weight % of the composition or may add up to less than 100 weight %. Where the components add up to less than 100 weight %, such composition may include some small amounts of a non-essential contaminants or impurities. For example, in one such embodiment, the remover solutions can contain 2% by weight or less of impurities. In another embodiment, the remover solutions can contain 1% by weight or less than of impurities. In a further embodiment, the remover solutions can contain 0.05% by weight or less than of impurities. In other such embodiments, the ingredients can form at least 90 wt%, more preferably at least 95 wt%, more preferably at least 99 wt%, more preferably at least 99.5 wt%, most preferably at least 99.9 wt%, and can include other ingredients that do not materially affect the performance of the remover solutions. Otherwise, if no significant non-essential impurity component is present, it is understood that the combination of all essential constituent components will essentially add up to 100 weight %.

[0029] The ensuing detailed description provides preferred exemplary embodiments only, and is not intended to limit the scope, applicability, or configuration of the disclosed and claimed subject matter. Rather, the ensuing detailed description of the preferred exemplary embodiments will provide those skilled in the art with an enabling description for implementing the preferred exemplary embodiments of the disclosed and claimed subject matter. Various changes may be made in the function and arrangement of elements without departing from the spirit and scope of the disclosed and claimed subject matter, as set forth in the appended claims.

[0030] Remover Solutions

[0031] It is to be understood that both the foregoing general description and the following

detailed description are illustrative and explanatory, and are not restrictive of the subject matter, as claimed. The objects, features, advantages and ideas of the disclosed subject matter will be apparent to those skilled in the art from the description provided in the specification, and the disclosed subject matter will be readily practicable by those skilled in the art on the basis of the description appearing herein. The description of any “preferred embodiments” and/or the examples which show preferred modes for practicing the disclosed subject matter are included for the purpose of explanation and are not intended to limit the scope of the claims.

[0032] It will also be apparent to those skilled in the art that various modifications may be made in how the disclosed subject matter is practiced based on described aspects in the specification without departing from the spirit and scope of the disclosed subject matter disclosed herein.

[0033] In particular, the disclosed and claimed remover solutions include, consist essentially of or consist of:

- (i) at least one organic solvent;
- (ii) at least one amine that is free of carboxylic acid moieties;
- (iii) water;
- (iv) a corrosion inhibitor including one or more of:
 - (a) an amino acid,
 - (b) an azole, and
 - (c) a phenolic acid,

where the remover solution is free of dimethylsulfoxide, N-methylpyrrolidone and dimethylacetamide.

In a further aspect of this embodiment, the (iv) corrosion inhibitor includes two or more of (a) an amino acid, (b) an azole and (c) a phenolic acid. In one embodiment, the (iv) corrosion inhibitor includes (a) an amino acid and (b) an azole. In one embodiment, the (iv) corrosion inhibitor includes (a) an amino acid and (c) a phenolic acid. In one embodiment, the (iv) corrosion inhibitor includes (b) an azole and (c) a phenolic acid. In yet a further aspect of this embodiment, the (iv) corrosion inhibitor includes one or more of each of (a) an amino acid, (b) an azole and (c) a phenolic acid.

[0034] In some aspects of this embodiment, the remover solutions can include other optional ingredients.

[0035] I. Organic Solvent

[0036] As noted above, the remover solutions include at least one organic solvent which is not dimethylsulfoxide, N-methylpyrrolidone and dimethylacetamide. One type of solvent that can be used in the compositions of the disclosed and claimed solutions is ether alcohol solvents or an amide type solvent other than DMAC, or mixtures thereof. The ether alcohol solvent may

be a glycol ether or other alcohols having an ether group. One or more ether alcohol solvents, including glycol ether solvents, may be used in the disclosed and claimed solutions. Suitable glycol ether solvents include diethylene glycol butyl ether (DB), diethylene glycol methyl ether, diethylene glycol ethyl ether, diethylene glycol propyl ether, propylene glycol methyl ether, dipropylene glycol methyl ether, propylene glycol propyl ether, dipropylene glycol propyl ether, propylene glycol phenyl ether, propylene glycol n-butyl ether, dipropylene glycol n-butyl ether, ethylene glycol propyl ether, ethylene glycol butyl ether, ethylene glycol phenyl ether, tripropylene glycol methyl ether, dipropylene glycol dimethyl ether, diethylene glycol methyl ethyl ether, diethylene glycol dimethyl ether, diethylene glycol diethyl ether, diethylene glycol (DEG), dipropylene glycol, or propylene glycol phenyl ether (glycol ether PPH). Examples of alcohol ether solvents that are not glycol ethers are 3-methoxy-3-methyl-1-butanol (MMB), furfuryl alcohol, tetrahydrofurfuryl alcohol. An example of an amide type solvent useful in the disclosed and claimed solutions includes but not limited to N,N-dimethylformamide, diethylformamide(DEF), dimethylacetamide and cyclic amide. Each solvent can be used alone, in mixtures of the same types or in combinations of any or all of the different types.

[0037] The remover solution will include about 20% to about 70%, or from about 30% to about 65% by wt. of the at least one organic solvent. Other preferred embodiments of the disclosed and claimed solutions include from about 30% to about 62%, about 40% to about 62%, about 50% to about 62%, about 30% to about 50%, or about 30% to about 40% by wt. of the glycol ether solvent. The alcohol ether solvent(s) or ether alcohol solvents may be present in an amount that falls within a range defined by the following list of weight percents: 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, and 70. In one embodiment the alcohol ether solvent can be present in the composition ranges from about 20% to about 70%, about 20% to about 60%, about 25% to about 45%, about 30% to about 62%. The amide solvent can be present in the composition in an amount that falls within a range defined by the following list of weight percents: 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, and 70. In one embodiment the amide solvent can be present in the composition ranges from about 20% to about 70%, about 20% to about 60%, about 25% to about 45%, about 30% to about 62%.

[0038] Some embodiments may contain from about 5% to about 30% of a secondary solvent such as benzyl alcohol or propylene glycol, different from the ether alcohol solvents or the amide solvents described above. Alternatively, in some embodiments, the stripper solutions may be free or substantially free of a secondary solvent.

[0039] Secondary organic solvent alcohols may be linear or branched chain aliphatic or aromatic alcohols. Examples of the secondary alcohols that the composition may comprise include benzyl alcohol, propylene glycol, ethylene glycol, methanol, ethanol, propanol,

isopropyl alcohol, butanol, tert-butyl alcohol, tert-amyl alcohol, 3-methyl-3-pentanol, 1-octanol, 1-decanol, 1-undecanol, 1-dodecanol, 1-tridecanol, 1-tetradecanol, 1-pentadecanol, 1-hexadecanol, 9-hexadecen-1-ol, 1-heptadecanol, 1-octadecanol, 1-nonadecanol, 1-eicosanol, 1-heneicosanol, 1-docosanol, 13-docosen-1-ol, 1-tetracosanol, 1-hexacosanol, 1-heptacosanol, 1-octacosanol, 1-triacontanol, 1-dotriacontanol, 1-tetratriacontanol and cetearyl alcohol.

[0040] When used, the secondary organic solvent may comprise from about 3% to about 45%, or from about 5% to about 35%, or from about 8% to about 30%, or from about 10% to about 30% of the composition. In alternative embodiments the secondary solvent may be present in any amount defined by the endpoints selected from the following weight percents: 3, 5, 8, 10, 12, 15, 17, 20, 23, 25, 38, 30, 32, 35, 37, 40, 43 and 45.

[0041] II. Amines Free of Carboxylic Acid Moieties

[0042] As noted above, the remover solutions at least one amine that is free of carboxylic acid moieties. Suitable amines include, but are not limited to, alkanolamines that include one or more of ethanolamine, N-methylethanolamine, N-ethylethanolamine, N-propylethanolamine, N-butylethanolamine, dimethylethanolamine, diethylethanolamine, diethanolamine, triethanolamine, N-methyldiethanolamine, N-ethyldiethanolamine, isopropanolamine, diisopropanolamine, triisopropanolamine, N-methylisopropanolamine, N-ethylisopropanolamine, N-propylisopropanolamine, 2-aminopropane-1-ol, N-methyl-2-aminopropane-1-ol, N-ethyl-2-aminopropane-1-ol, 1-aminopropane-3-ol, N-methyl-1-aminopropane-3-ol, N-ethyl-1-aminopropane-3-ol, 1-aminobutane-2-ol, N-methyl-1-aminobutane-2-ol, N-ethyl-1-aminobutane-2-ol, 2-aminobutane-1-ol, N-methyl-2-aminobutane-1-ol, N-ethyl-2-aminobutane-1-ol, 3-aminobutane-1-ol, N-methyl-3-aminobutane-1-ol, N-ethyl-3-aminobutane-1-ol, 1-aminobutane-4-ol, N-methyl-1-aminobutane-4-ol, N-ethyl-1-aminobutane-4-ol, 1-amino-2-methylpropane-2-ol, 2-amino-2-methylpropane-1-ol, 1-aminopentane-4-ol, 2-amino-4-methylpentane-1-ol, 2-aminohexane-1-ol, 3-aminoheptane-4-ol, 1-aminooctane-2-ol, 5-aminooctane-4-ol, 1-aminopropane-2,3-diol, 2-aminopropane-1,3-diol, tris(oxymethyl)aminomethane, 1,2-diaminopropane-3-ol, 1,3-diaminopropane-2-ol, 2-(2-aminoethoxy)ethanol, 4-(2-hydroxyethyl)morpholine, 1-(2-hydroxyethyl)piperidine, and 1-(2-hydroxyethyl)piperazine. Preferred alkanolamines include N-methylethanolamine, triethanolamine, N-ethylethanolamine, ethanolamine, N-methyldiethanolamine, monoisopropanolamine and aminoethoxyethanol.

[0043] Suitable amines also include amines that are free of hydroxyl groups which include diethylenetriamine (DETA), triethylenetetramine (TETA), tetraethylenepentamine (TEPA), aminoethylpiperazine, 3-morpholinopropylamine (APM), benzylamine (BA), 1,5-

diamino-2-methylpentane, 1,3-diaminopentane, piperazine, 1-(2-aminoethyl)piperazine, 1,2-diaminocyclohexane, 1,3-diaminopropane, 1-(2-aminoethyl)piperidine, pentamethyldiethylenetriamine, 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU) Preferred amines without hydroxyl group include diethylenetriamine, triethylenetetramine, tetraethylenepentamine, aminoethylpiperazine, 3-morpholinopropylamine, 1,8-diazabicyclo[5.4.0]undec-7-ene and benzylamine.

[0044] Suitable levels of the required for at least one amine can range from about 2 wt% to about 60 wt% of the composition. In some embodiments, the amine is from about 3 wt% to about 50 wt% of the composition. In alternative embodiments the amine may be present in any amount defined by the endpoints selected from the following weight percents: 3, 5, 20, 25, 30, 35, 40, 45, 50, 55 and 60.

[0045] In one embodiment, the solutions include about 2 wt% to about 60 wt% of one amine. In one embodiment, the solutions include about 3 wt% to about 60 wt% of one amine. In one embodiment, the solutions include about 10 wt% to about 45 wt% of one amine. In one embodiment, the solutions include about 10 wt% to about 40 wt% of amine. In one embodiment, the solutions include about 10 wt% to about 35 wt% of one amine. In one embodiment, the solutions include about 10 wt% to about 30 wt% of one amine. In one embodiment, the solutions include about 10 wt% to about 25 wt% of one amine. In one embodiment, the solutions include about 10 wt% to about 20 wt% of one amine. In one embodiment, the solutions include about 20 wt% to about 60 wt% of one amine. In one embodiment, the solutions include about 20 wt% to about 50 wt% of one amine. In one embodiment, the solutions include about 20 wt% to about 45 wt% of one amine. In one embodiment, the solutions include about 20 wt% to about 40 wt% of one amine. In one embodiment, the solutions include about 20 wt% to about 35 wt% of one amine. In one embodiment, the solutions include about 20 wt% to about 30 wt% of one amine. In one embodiment, the solutions include about 30 wt% to about 60 wt% of one amine. In one embodiment, the solutions include about 30 wt% to about 50 wt% of one amine. In one embodiment, the solutions include about 30 wt% to about 40 wt% of one amine.

[0046] III. Water

[0047] As noted above, the remover solutions include water. Suitable water levels can range from about 0.1 wt% to about 35 wt% of the composition. In some embodiments, water is from about 5 wt% to about 25 wt% of the composition. In alternative embodiments the amine may be present in any amount defined by the endpoints selected from the following weight percents: 0.1, 0.5, 1.0, 1.5, 2.0, 2.5, 5, 7.5, 10, 12.5, 15, 17.5, 20, 22.5, 25, 30, 35.

[0048] In one embodiment, the solutions include about 0.1 wt% to about 30 wt% of water. In one embodiment, the solutions include about 5 wt% to about 30 wt% of water. In one embodiment, the solutions include about 5 wt% to about 25 wt% of water. In one embodiment, the solutions include about 5 wt% to about 22 wt% of water. In one embodiment, the solutions include about 5 wt% to about 20 wt% of water. In one embodiment, the solutions include about 5 wt% to about 17.5 wt% of water. In one embodiment, the solutions include about 5 wt% to about 15 wt% of water. In one embodiment, the solutions include about 5 wt% to about 12.5 wt% of water. In one embodiment, the solutions include about 10 wt% to about 25 wt% of water. In one embodiment, the solutions include about 10 wt% to about 22.5 wt% of water. In one embodiment, the solutions include about 10 wt% to about 20 wt% of water. In one embodiment, the solutions include about 10 wt% to about 17.5 wt% of water. In one embodiment, the solutions include about 10 wt% to about 15 wt% of water. In one embodiment, the solutions include about 10 wt% to about 12.5 wt% of water.

[0049] **IV. Corrosion Inhibitor**

[0050] As noted above, the remover solutions include a corrosion inhibitor including one or more of (a) an amino acid, (b) an azole and (c) a phenolic acid. In some embodiments, the corrosion inhibitor includes two or more of (a) an amino acid, (b) an azole and (c) a phenolic acid (*i.e.*, the corrosion inhibitor can include an amino acid and an azole; an amino acid and a phenolic acid or an azole and a phenolic acid). In some embodiments, the corrosion inhibitor includes one or more of each of (a) an amino acid, (b) an azole and (c) a phenolic acid (*i.e.*, includes at least one amino acid, at least one azole and at least one phenolic acid).

[0051] **(a) Amino Acid**

[0052] Amino acids suitable for use in the disclosed and claimed remover solutions include at least one amine group and one carboxylic acid group. Suitable amino acids corrosion inhibitors include, but are not limited to, glycine, histidine, arginine, alanine, isoleucine, cysteine, asparagine, leucine, glutamine, aspartic acid, lysine, glutamic acid, methionine, proline, serine, phenylalanine, tyrosine, threonine, tryptophan, valine, n-(2-hydroxyethyl)ethylenediamine-N,N,N-triacetic acid, 2-picolinic acid, L-cystine, 3,4-diaminobenzoic acid, iminoacetic acid. A preferred amino acid for use in the disclosed and claimed remover solutions is glycine.

[0053] The amino acids may be present in any neat amounts ranging from about 0.01 wt % to about 10 wt%, from about 0.05 wt % to about 10 wt%, 0.01 wt% to about 5 wt%, or from about 0.05 wt% to about 2 wt%, or from about 0.05 wt% to about 1 wt% or from about 0.1 wt% to about 5 wt%, or from about 0.1 wt% to about 3 wt%, or from about 0.1 wt% to

about 2 wt%, or from about 0.1 wt% to about 1 wt%, or from about 0.3 wt% to about 5 wt%, or from about 0.3 wt% to about 1 wt%, based on the total weight of the composition. In certain preferred compositions, the amino acid is present at about 0.1 wt% to 1 wt%. In certain preferred compositions, the amino acid is present at about 0.3 wt% to 1 wt%. In certain preferred compositions, the amino acid is present at about 0.5 wt% to 1 wt%.

[0054] (b) Azoles

[0055] Suitable azole corrosion inhibitors include, but are not limited to, benzotriazole, benzotriazole-5-carboxylic acid, 1,2,4-triazole, 5-aminotetrazole, 5-methyl-1H-benzotriazole, 1-hydroxybenzotriazole, 5-amino-1,3,4-thiadiazol-2-thiol, 3-amino-1H-1,2,4 triazole, 3,5-diamino-1,2,4-triazole, tolyltriazole, 5-phenyl-benzotriazole, 5-nitro-benzotriazole, 3-amino-5-mercapto-1,2,4-triazole, 1-amino-1,2,4-triazole, 2-(5-amino-pentyl)-benzotriazole, 1-amino-1,2,3-triazole, 1-amino-5-methyl-1,2,3-triazole, 3-mercapto-1,2,4-triazole, 3-isopropyl-1,2,4-triazole, 5-phenylthiol-benzotriazole, naphthotriazole, 1-H-tetrazole-5-acetic acid, 2-mercaptobenzothiazole (2-MBT), 1-phenyl-2-tetrazoline-5-thione, 2-mercaptobenzimidazole (2-MBI), 4-methyl-2-phenylimidazole, 2-mercaptothiazoline, 2,4- diamino-6-methyl-1,3,5-triazine, thiazole, imidazole, benzimidazole, triazine, 5-methyl-1H-benzotriazole, 4-methylbenzotriazole, 1-methylbenzotriazole, 1-methyltetrazole and 5-methyl-1H-tetrazole. Preferred azoles for use in the disclosed and claimed remover solutions is tolyltriazole (TTL) and benzotriazole (BZT).

[0056] The azole inhibitor may be present in any neat amounts ranging from about 0.01 wt % to about 10 wt%, from about 0.05 wt % to about 10 wt%, 0.01 wt% to about 5 wt%, or from about 0.05 wt% to about 2 wt%, or from about 0.05 wt% to about 1 wt% or from about 0.1 wt% to about 5 wt%, or from about 0.1 wt% to about 3 wt%, or from about 0.1 wt% to about 2 wt%, or from about 0.1 wt% to about 1 wt%, or from about 0.3 wt% to about 5 wt%, or from about 0.3 wt% to about 1 wt%, based on the total weight of the composition. In certain preferred compositions, the azole is present at about 0.1 wt% to 1 wt%. In certain preferred compositions, the azole inhibitor is present at about 0.3 wt% to 1 wt%. In certain preferred compositions, the azole inhibitor is present at about 0.5 wt% to 1 wt%.

[0057] (c) Phenolic Acid

[0058] Suitable phenolic acid corrosion inhibitors are hydroxybenzoic acids with one or more hydroxyl groups and at least one carboxylic group attached on benzene ring. Such phenolic acids include, but are not limited to gallic acid, phloroglucinol carboxylic acid, 2,3-dihydroxybenzoic acid (hypogallic acid), 2,4-dihydroxybenzoic acid, 2,5-dihydroxybenzoic acid (gentisic acid), 2,6-dihydroxybenzoic acid, 3,4-dihydroxybenzoic acid (protocatechuic

acid), 3,5-dihydroxybenzoic acid, vanillic acid, syringic acid, veratric acid, 2-hydroxybenzoic acid (salicylic acid), 3-hydroxybenzoic acid, 4-hydroxybenzoic acid and pyrogallol. A preferred phenolic acid for use in the disclosed and claimed remover solutions is gallic acid.

[0059] The phenolic acid may be present in any neat amounts ranging from about 0.01 wt % to about 10 wt%, from about 0.05 wt % to about 10 wt%, 0.01 wt% to about 5 wt%, or from about 0.05 wt% to about 2 wt%, or from about 0.05 wt% to about 1 wt% or from about 0.1 wt% to about 5 wt%, or from about 0.1 wt% to about 3 wt%, or from about 0.1 wt% to about 2 wt%, or from about 0.1 wt% to about 1 wt%, or from about 0.3 wt% to about 5 wt%, or from about 0.3 wt% to about 1 wt%, based on the total weight of the composition. In certain preferred compositions, the phenolic acid is present at about 0.1 wt% to 1 wt%. In certain preferred compositions, the phenolic acid is present at about 0.3 wt% to 1 wt%. In certain preferred compositions, the phenolic acid inhibitor is present at about 0.5 wt% to 1 wt%.

[0060] Excluded Ingredients

[0061] In some embodiments, the remover solutions disclosed herein are formulated to be free or substantially free of at least one of the following chemical compounds: inorganic bases, inorganic acids, quaternary ammonium hydroxides, ammonium hydroxide, organic acids, sulfur-containing organic chemicals, phosphorus-containing organic chemicals, halide ions (*e.g.*, fluoride ions, chloride ions), metal-containing chemicals, reducing agents, oxidizing agents, hydrogen peroxide, hydroxylamine, hydroxylamine derivatives, amidoxime compounds, organic solvents, organic silanes, surfactants and abrasives.

[0062] In some embodiments, the solution may be substantially free of or free of a halide-containing compound, for example it may be substantially free or free of one or more of the following: fluorine, bromine-, chlorine- or iodine-containing compounds. In other embodiments, the solution may be substantially free or free of sulfates and/or nitrates and/or sulfites and/or nitrites.

[0063] In some embodiments, the disclosed and claimed remover solutions are substantially free of or free of ammonium hydroxide and/or ethyl diamine. In other embodiments, the solution may be substantially free of or free of sodium-containing compounds and/or calcium-containing compounds and/or manganese-containing compounds or magnesium-containing compounds and/or chromium-containing compounds and/or sulfur-containing compounds. In other embodiments, the solution may be substantially free or free of amidoxime compounds and/or abrasives.

[0064] In some embodiments, the disclosed and claimed remover solutions are substantially free of or free of other ammonium salts and/or quaternary ammonium hydroxide, quaternary ammonium salts and metal ions.

[0065] In some embodiments, the disclosed and claimed solutions are substantially free

or free of sulfonic acid and/or phosphoric acid and/or sulfuric acid and/or nitric acid and/or hydrochloric acid.

[0066] In some embodiments, the disclosed and claimed solutions are substantially free or free of amphoteric salts, and/or cationic surfactants, and/or anionic surfactants, and/or zwitterionic surfactants, and/or non-ionic surfactants.

[0067] In some embodiments, the disclosed and claimed solutions are substantially free of or free of pyrrolidones and/or acetamides.

[0068] In some embodiments, the disclosed and claimed solutions are substantially free of or free of peroxy-compounds, and/or peroxides, and/or persulfates, and/or percarbonates, and acids thereof, and salts thereof.

[0069] In some embodiments, the disclosed and claimed solutions are substantially free of or free of iodates, and/or perboric acid, and/or percarbonates, and/or peroxyacids, and/or cerium compounds, and/or cyanides, and/or periodic acid and/or ammonium molybdate, and/or ammonia and/or abrasives.

[0070] In some embodiments, the disclosed and claimed solutions are substantially free of or free of oxidation products of one or more antioxidants, reducing agents and phenolic acids.

[0071] In some embodiments, the disclosed and claimed solutions are substantially free of or free of sugar alcohol(s).

[0072] **pH**

[0073] The disclosed and claimed solutions have a pH of about 9 or greater, such as, about 9 to about 14 or about 10 to about 12 or any pH in a range having the beginning and endpoints of 9, 9.5, 10, 10.5, 11, 11.5, 12, 12.5, 13, 13.5 or 14. In one embodiment, the disclosed and claimed remover solutions have a pH of above about 9. In one embodiment, the disclosed and claimed remover solutions have a pH of above about 9.5. In one embodiment, the disclosed and claimed remover solutions have a pH of above about 10. In one embodiment, the disclosed and claimed remover solutions have a pH of above about 10.5. In one embodiment, the disclosed and claimed remover solutions have a pH of above about 11. In one embodiment, the disclosed and claimed remover solutions have a pH of above about 11.5. In one embodiment, the disclosed and claimed remover solutions have a pH of above about 12. In one embodiment, the disclosed and claimed remover solutions have a pH of above about 12.5. In one embodiment, the disclosed and claimed remover solutions have a pH of above about 13.

[0074] **Exemplary Embodiments**

[0075] All values in the following exemplary embodiments are neat values unless otherwise indicated.

[0076] In one exemplary embodiment, the disclosed and claimed remover solutions include, consist essentially of or consist of:

- (i) about 30% to about 62% of organic solvent;
- (ii) about 10% to about 40% of at least one amine that is free of carboxylic acid moieties;
- (iii) about 5% to about 30% of water; and
- (iv) a corrosion inhibitor including, consisting essentially of or consisting of (a) about 0.1% to about 1.5% of an amino acid; (b) about 0.1% to about 1.5% of an azole; and (c) about 0.1% to about 1.5% of a phenolic acid,

where the remover solution is free of dimethylsulfoxide, N-methylpyrrolidone and dimethylacetamide.

In one aspect of this embodiment, the remover solutions include, consist essentially of or consist of (i) about 40% to about 45% of diethylene glycol monoethyl ether; (ii) about 30% to about 35% of n-methylethanolamine; (iii) about 22.5% to about 25% of water; and (iv) (a) about 0.1% to about 0.5% of glycine, (b) about 0.75% to about 1.25% of benzotriazole and (c) about 0.25% to about 0.75% of gallic acid.

[0077] In one exemplary embodiment, the disclosed and claimed remover solutions include, consist essentially of or consist of:

- (i) about 30% to about 62% of organic solvent;
- (ii) about 10% to about 40% of at least one amine that is free of carboxylic acid moieties;
- (iii) about 5% to about 30% of water; and
- (iv) a corrosion inhibitor including, consisting essentially of or consisting of (a) about 0.1% to about 1.5% of an amino acid; (b) about 0.1% to about 1.5% of an azole,

where the remover solution is free of dimethylsulfoxide, N-methylpyrrolidone and dimethylacetamide.

In one aspect of this embodiment, the remover solutions include, consist essentially of or consist of (i) about 40% to about 45% of diethylene glycol monoethyl ether; (ii) about 30% to about 35% of n-methylethanolamine; (iii) about 22.5% to about 25% of water; and (iv) (a) about 0.1% to about 0.5% of glycine, (b) about 0.75% to about 1.25% of benzotriazole.

[0078] In one exemplary embodiment, the disclosed and claimed remover solutions include, consist essentially of or consist of:

- (i) about 30% to about 62% of organic solvent.
- (ii) about 10% to about 40% of at least one amine that is free of carboxylic acid moieties;
- (iii) about 5% to about 20% of water; and

- (iv) about 0.1% to about 1.5% of a corrosion inhibitor including, consisting essentially of or consisting of an azole corrosion inhibitor,
- where the remover solution is free of dimethylsulfoxide, N-methylpyrrolidone and dimethylacetamide.

In one aspect of this embodiment, the remover solutions include, consist essentially of or consist of (i) about 50% to about 60% of diethylene glycol monoethyl ether; (ii) about 7.5% to about 12.5% of triethanolamine and about 15% to about 25% of n-methylethanolamine; (iii) about 10% to about 15% of water; and (iv) about 1% to about 1.5% of tolytriazole.

[0079] In one exemplary embodiment, the disclosed and claimed remover solutions include, consist essentially of or consist of:

- (i) about 40% to about 80% of organic solvent.
 - (ii) about 5 % to about 40% of at least one amine that is free of carboxylic acid moieties;
 - (iii) about 2% to about 40% of a second amine that is free of carboxylic acid moieties;
 - (iv) about 5% to about 20% of water; and
 - (v) about 0.3% to about 1.8% of a corrosion inhibitor including, consisting essentially of or consisting of an azole corrosion inhibitor,
- where the remover solution is free of dimethylsulfoxide, N-methylpyrrolidone and dimethylacetamide.

In one aspect of this embodiment, the remover solutions include, consist essentially of or consist of (i) about 70.0% to about 75.0% of diethylformamide; (ii) about 7.5% to about 12.5% of 3-morpholinopropylamine and about 2.5% to about 5% of 1,8-diazabicyclo[5.4.0]undec-7-ene; (iii) about 10% to about 15% of water; and (iv) about 1% to about 1.5% of tolytriazole.

[0080] Methods of Use

[0081] The disclosed and claimed subject matter further includes a method of removing, in whole or on part, one or more photoresists or etch residue or similar materials from a substrate using one or of the disclosed and claims photoresist stripper and etch residue remover solutions. As noted above, the disclosed and claimed photoresist stripper and etch residue remover solutions can be used to remove polymeric resist materials present in a single layer or certain types of bilayer resists. Utilizing the methods taught below, a single layer of polymeric resist can be effectively removed from a standard wafer having a single polymer layer. The same methods can also be used to remove a single polymer layer from a wafer having a bilayer composed of a first inorganic layer and a second or outer polymer layer. Finally, two polymer layers can be

effectively removed from a wafer having a bilayer composed of two polymeric layers.

[0082] In one aspect of this embodiment, the process or method for removing a photoresist or etch residue from a substrate includes the steps of:

- (i) contacting the substrate with one or more of the photoresist stripper and etch residue remover solutions for a time sufficient to remove a desired amount of the photoresist or similar material;
- (ii) removing the substrate from the solution;
- (iii) rinsing the solution from the substrate with DI water or a solvent; and
- (iv) optionally drying the substrate.

[0083] In one embodiment, step (i) includes immersing the substrate one or more of the photoresist stripper and etch residue remover solutions and optionally agitating the substrate to facilitate photoresist removal. Such agitation can be affected by mechanical stirring, circulating or by bubbling an inert gas through the composition.

[0084] In one embodiment, step (ii) includes rinsing the substrate rinsed with water or an alcohol. In one aspect of this embodiment, DI water is a preferred form of water. In another aspect of this embodiment, isopropanol (IPA) is a preferred solvent. In another aspect of this embodiment, components subject to oxidation are or can be rinsed under an inert atmosphere.

[0085] Utilizing the above methods (as well as variants thereof), the disclosed and claimed photoresist stripper and etch residue remover solutions can be used for removal of thick and thin positive or negative tone photoresists. Thick photoresists may be a resist of from about 5 μm to about 100 μm or more, or about 15 μm to 100 μm , or from about 20 μm to about 100 μm in advanced packaging applications for semiconductor devices. In other cases, the chemical solutions may be used to remove photoresist from about 0.1 μm to about 100 μm or more, or about 0.2 μm to 100 μm , or from about 0.3 μm to about 100 μm .

[0086] EXAMPLES

[0087] Reference will now be made to more specific embodiments of the present disclosure and experimental results that provide support for such embodiments. The examples are given below to more fully illustrate the disclosed subject matter and should not be construed as limiting the disclosed subject matter in any way.

[0088] It will be apparent to those skilled in the art that various modifications and variations can be made in the disclosed subject matter and specific examples provided herein without departing from the spirit or scope of the disclosed subject matter. Thus, it is intended that the disclosed subject matter, including the descriptions provided by the following examples, covers the modifications and variations of the disclosed subject matter that come

within the scope of any claims and their equivalents.

[0089] Materials and Methods:

[0090] All materials used in this patent were purchased from and/or are available from Sigma Aldrich and were used in the formulations as received. Amounts of materials in all of the tables are reported as weight % values and reflect “neat” values where appropriate unless indicated otherwise. The balance of the formulation weights is from water present in the raw materials.

[0091] Testing was performed using blanket Cu wafer. For the immersion process, 2 coupon-sized samples of semiconductor wafers were processed in beakers. Beakers were filled with 100 grams of a stripping composition and heated to the target temperature. When the stripping composition was at the target temperature of 50 °C, 2 coupons were placed in a holder in the beaker. Temperature was maintained at the process temperature throughout the process. After a total processing time, for example 1 minute, 5 minutes or 30 minutes under agitation of 1200 rpm the copper substrates were rinsed with water and dried by blowing nitrogen gas.

[0092] Cu etch rates are determined by measuring film thickness using CDE four-point probe RESMAP before and after processing in the formulations. Typical starting layer thickness was 1000 Å for copper substrates.

[0093] The follow abbreviations are used in the various compositions in the tables below:

Abbreviation	Full Name	CAS Number
BZT	Benzotriazole	95-14-7
NMEA	N-methylethanolamine	109-83-1
N-MDEA	N-methyl diethanolamine	105-59-9
DETA	Diethylenetriamine	111-40-0
DE	Diethylene glycol monoethyl ether	111-90-0
DEF	Diethylformamide	617-84-5
BDG	Diethylene glycol monobutyl ether	112-34-5
MMB	3-methoxy-3-methyl-1-butanol	56539-66-3
TTL	Tolytriazole	29385-43-1
ABT	1-Aminobenzotriazole	1614-12-6
TEA	Triethanolamine	102-71-6
DPGME	Di(propylene glycol) methyl ether	34590-94-8
PPH	Propylene glycol phenyl ether	770-35-4
DIW	Deionized Water	7732-18-5
APM	3-Morpholinopropylamine	123-00-2
DBU	1,8-Diazabicyclo[5.4.0]undec-7-ene	6674-22-2

[0094] Amounts of materials in all of the tables are reported as wt% values and reflect “neat” values where appropriate unless indicated otherwise. All listed ingredients for the exemplary and comparative formulations total 100 wt%.

[0095] Table 1 shows the effect of single, individual corrosion inhibitor on Cu etch rates. Both BZT and glycine had significantly reduced Cu etch rates compared to control

without any corrosion inhibitors. Gallic acid instead increased Cu etch rates.

Ex.	BZT	Gallic Acid	Glycine	DIW	NMEA	DE	Cu E/R (Å/min)
1-1 (Comp.)	--	--	--	22	44.5	33.5	15.80
1-2	0.5	--	--	22	44.5	33	3.30
1-3	1	--	--	22	44.5	32.5	3.55
1-4	--	0.5	--	22	44.5	33	55.0
1-5	--	1	--	22	44.5	32.5	18.22
1-6	--	--	0.60	22	44.5	32.9	3.5
1-7	--	--	1.2	22	44.5	32.3	3.78

Table 1. Effect of Single Corrosion Inhibitor on Cu Etch Rate

[0096] Tables 2-4 show the effect of two corrosion inhibitors combination on Cu etch rates. Table 2 shows the combination of BZT and glycine obviously decreased Cu etch rates compared with BZT or glycine alone in example 2 and 6. Table 3 shows the addition of gallic acid in BZT containing formulations also further decreased Cu etch rates. Table 3 shows the addition of gallic acid in glycine containing formulations increased Cu etch rates. However, the addition of BZT significantly decreased Cu etch rates, even lower than the combination of BZT and glycine in formulations.

Ex.	BZT	Glycine	DIW	NMEA	DE	Cu E/R (Å/min)
2-1 (Comp.)	--	--	22	44.5	33.5	15.80
2-1	0.5	0.6	22	44.5	32.4	1.19
2-2	0.5	1.2	22	44.5	31.8	1.24
2-3	1	0.6	22	44.5	31.9	1.45
2-4	1	1.2	22	44.5	31.3	1.24

Table 2. Effect of Combined BZT and Glycine on Cu Etch Rate

Ex.	BZT	Gallic Acid	DIW	NMEA	DE	Cu E/R (Å/min)
3-1	0.5	0.3	22	44.5	32.7	3.13
3-2	0.5	0.6	22	44.5	32.4	3.2
3-3	1	0.3	22	44.5	32.2	2.62
3-4	1	0.6	22	44.5	31.9	2.32

Table 3. Effect of Combined Gallic Acid and BZT on Cu Etch Rate

Ex.	Gallic Acid	Glycine	BZT	DIW	NMEA	DE	Cu E/R (Å/min)
4-1	0.3	0.4	--	22	44.5	32.8	5.36
4-2	0.3	0.4	0.5	22	44.5	32.3	0.6
4-3	0.3	0.8	--	22	44.5	32.4	5.14
4-4	0.3	0.8	0.5	22	44.5	31.9	0.71
4-5	0.6	0.4	--	22	44.5	32.5	6.48
4-6	0.6	0.8	--	22	44.5	32.1	5.66

Table 4. Effect of Combined Gallic Acid and Glycine on Cu Etch Rate

Chemical	5-1	5-2	5-3	5-4	5-5	5-6
TEA	5	5	5	10	10	--
NMEA	5	5	5	10	10	--
APM	--	--	--	--	--	10
DBU	--	--	--	--	--	3
Water	20	20	20	20	20	13.1
DE solvent	69.4	69.4	69.4	59.4	59.4	--
DEF solvent	--	--	--	--	--	72.7
BZT	0.6	--	--	--	--	--
TTL	--	0.6	--	0.6	--	1.2
ABT	--	--	0.6	--	0.6	--
Cu E/R (Å/min)	1.5	0.74	17.5	1.37	13.7	1.07

Table 5. Effect of Azole Inhibitors on Cu Etch Rates

Chemical	6-1	6-2	6-3	6-4	6-5	6-6	6-7
TTL	1.2	1.2	1.2	0.9	1.2	0.9	0.9
Water	12.5	12.5	12.5	12.5	12.5	12.5	0
NMEA	20	15	20	15	17.5	17.5	20
TEA	10	10	15	10	10	10	10
DE	56.3	61.3	51.3	61.6	58.8	59.1	69.1
Cu E/R (Å/min)	0.7	0.4	2.2	1.7	1.6	2.1	0.7

Table 6. Effect of Alkanolamine and TTL Concentration on Cu Etch Rates

[0097] Tables 5 shows the effect of different azole inhibitors on Cu etch rates. TTL shows the lowest Cu etch rates compared to BZT and ABT in formulations with different alkanolamine concentrations while ABT shows the highest Cu etch rates. Higher alkanolamine concentration of NMEA and TEA resulted in higher Cu etch rates. In Example 5-6, the Cu etch rate (Cu -1000A E/R (Å/min) @5 min/800 rpm/40 °C) was 1.07, the Al etch rate was 9.93 (Al -800A E/R (Å/min) @1 min/800 rpm/40 °C).

[0098] Tables 6 shows the effect of the concentration of alkanolamine and TTL on Cu etch rates in formulations with lower water concentration of 12.5%. Higher alkanolamine concentration of NMEA and TEA resulted in higher Cu etch rates at same TTL concentration while higher TTL concentration resulted in lower Cu etch rates at the same alkanolamine concentration.

[0099] Table 7 shows the Cu etch rates using various amino acids to replace glycine. Glycine is best to suppress Cu etch among all the amino acids at 0.5% loading using DE as solvent.

Ex.	Amino Acid (0.5%)	BZT	Gallic Acid	DIW	NMEA	DE	Cu E/R (Å/min)
7-1	Glycine	0.7	0.3	22	35	41.5	1.13
7-2	Phenylalanine-A3	0.7	0.3	22	35	41.5	2.57
7-3	Iminodiacetic acid	0.7	0.3	22	35	41.5	2.37
7-4	L-glutamic acid	0.7	0.3	22	35	41.5	2.85
7-5	Histidine	0.7	0.3	22	35	41.5	2.8
7-6	Valine	0.7	0.3	22	35	41.5	2.73

Table 7. Effect of Various Amino Acids on Cu Etch Rate

[0100] Table 8 shows the Cu etch rates using various amino acids to replace glycine by using MMB solvent. Glycine is best to suppress Cu etch among all the amino acids at 0.1% loading using MMB as solvent.

Ex.	Amino Acid (0.1%)	BZT	Gallic Acid	DIW	NMEA	MMB	Cu E/R (Å/min)
8-1	--	1	1	17.5	49	31.5	2.02
8-2	Glycine	1	1	17.5	49	31.4	0.98
8-3	3,4-Diaminobenzoic acid	1	1	17.5	49	31.4	2.47
8-4	L-Cystine 98%	1	1	17.5	49	31.4	6.33
8-5	L-Glutamic acid ≥99%	1	1	17.5	49	31.4	1.23
8-6	2-Picolinic acid 99%	1	1	17.5	49	31.4	1.9
8-7	L-Cysteine 98%	1	1	17.5	49	31.4	10.95
8-8	n-(2-Hydroxyethyl)ethylenediamine -N,N,N-tris-acetic acid ≥98%	1	1	17.5	49	31.4	1.6

Table 8. Effect of Various Amino Acids on Cu Etch Rate

[0101] Tables 9 shows the Cu etch rates using DE and DEF solvents. DE solvent shows a lower Cu etch rate than DEF.

#	Gallic Acid	Glycine	BZT	DIW	NMEA	DE	DEF	Cu E/R (Å/min)
9-1 (Comparative)	--	--	--	22	44.5	33.5	--	15.80
9-2	0.3	0.4	0.5	22	44.5	32.3	--	0.6
9-3	--	--	--	22	44.5	--	33.5	47.65
9-4	0.3	0.4	0.5	22	44.5	--	32.3	0.91

Table 9. Effect of DEF and DE Solvents on Cu Etch Rate

[0102] Table 10 shows the Cu etch rates using various solvents. With all 3 corrosion inhibitors combined, no significant difference in Cu etch rates among ether solvents.

Chemical	10-1	10-2	10-3	10-4
H ₂ O	17.5	17.5	17.5	17.5
Gallic Acid	1	1	1	1
BZT	1	1	1	1
NMEA	49	49	49	49
Glycine	0.1	0.1	0.1	0.1
MMB	31.4	--	--	--
DE	--	31.4	--	--
BDG	--	--	31.4	--
DPGME	--	--	--	31.4
Total	100	100	100	100
Cu E/R (Å/min)	1.73	1.82	1.85	1.78

Table 10. Effect of Various Solvents on Cu Etch Rate

[0103] Table 11 shows the Cu etch rates using various amines using DEF as solvent. With only BZT as corrosion inhibitor, TEA and N-MDEA shows significantly lower Cu etch rates than the other amines tested including DETA, DGA and benzylamine.

No.	BZT	DEF	Amine (29 %)	DIW	Cu E/R (Å/min)
11-1	0.5	55.5	N-MDEA (N-methyl diethanolamine)	15	3.63
11-2	0.5	55.5	TEA(Triethanolamine)	15	0.36
11-3	0.5	55.5	DETA (Diethylenetriamine)	15	77.04
11-4	0.5	55.5	Diglycolamine(DGA)	15	>100
11-55	0.5	55.5	Benzylamine	15	17.47

Table 11. Effect of Various Amines on Cu Etch Rate Using DEF as Solvent

[0104] Table 12 shows the Cu etch rates with water level ranging from 12%-27%. 24.5% water gives lowest Cu etch rate in the range above. Further optimized inhibitor concentration obviously decreased Cu etch rate.

No.	BZT	Glycine	Gallic Acid	DIW	NMEA	DE	Cu E/R (Å/min)
12-1	1	0.8	1	12	35.2	50	1.52
12-2	1	0.8	1	17	35.2	45	1.04
12-3	1	0.8	1	19.5	35.2	42.5	1.19
12-4	1	0.8	1	22	35.2	40	1.2
12-5	1	0.8	1	24.5	35.2	37.5	0.97
12-6	0.9	0.3	0.4	24.5	32.2	41.7	0.47

Table 12. Effect of Water Level on Cu Etch Rate

[0105] Table 13 shows the Cu etch rates with various secondary solvents. PPH shows slightly lower Cu etch rate than all other secondary solvents.

Chemical	13-1 (control)	13-2	13-3	13-4	13-5
DE	44.1	44.1	44.1	44.1	44.1
DETA	35	35	35	35	35
WATER	20	20	20	20	20
BZT	0.9	0.9	0.9	0.9	0.9
PG	--	10	--	--	--
Benzylamine	--	--	10	--	--
PPH	--	--	--	10	--
Benzyl Alcohol	--	--	--	--	10
Total	--	100	100	100	100
Cu E/R (Å/min)	1.2	1.33	1.15	0.95	1.14

Table 13. Effect of Various Secondary Solvents on Cu Etch Rate

[0106] Although the invention has been described and illustrated with a certain degree of particularity, it is understood that the disclosure has been made only by way of example, and that numerous changes in the conditions and order of steps can be resorted to by those skilled in the art without departing from the spirit and scope of the invention.

CLAIMS

What is claimed is:

1. A remover solution comprising:
 - (i) at least one organic solvent;
 - (ii) at least one amine that is free of carboxylic acid moieties;
 - (iii) water; and
 - (iv) a corrosion inhibitor including one or more of:
 - (a) an amino acid;
 - (b) an azole, and
 - (c) a phenolic acid,wherein the remover solution is free of dimethylsulfoxide, N-methylpyrrolidone and dimethylacetamide.
2. The remover solution of claim 1, wherein the at least one organic solvent comprises one or more of ether alcohol solvents or an amide type solvent other than dimethylacetamide.
3. The remover solution of claim 1, wherein the at least one organic solvent comprises one or more ether alcohol solvent.
4. The remover solution of claim 1, wherein the at least one organic solvent comprises one or more of diethylene glycol butyl ether (DB), diethylene glycol methyl ether, diethylene glycol ethyl ether, diethylene glycol propyl ether, propylene glycol methyl ether, dipropylene glycol methyl ether, propylene glycol propyl ether, dipropylene glycol propyl ether, propylene glycol phenyl ether, propylene glycol n-butyl ether, dipropylene glycol n-butyl ether, ethylene glycol propyl ether, ethylene glycol butyl ether, ethylene glycol phenyl ether, tripropylene glycol methyl ether, dipropylene glycol dimethyl ether, diethylene glycol methyl ethyl ether, diethylene glycol dimethyl ether, diethylene glycol diethyl ether, diethylene glycol (DEG), dipropylene glycol and propylene glycol phenyl ether (glycol ether PPH).
5. The remover solution of claim 1, wherein the at least one organic solvent comprises one or more of 3-methoxy-3-methyl-1-butanol (MMB), furfuryl alcohol and tetrahydrofurfuryl alcohol.
6. The remover solution of claim 1, wherein the at least one organic solvent comprises one or more of N,N-dimethylformamide, diethylformamide (DEF), dimethylacetamide and cyclic amide.
7. The remover solution of claim 1, wherein the at least one organic solvent comprises from about 20% to about 70% of the remover solution.
8. The remover solution of claim 1, wherein the at least one organic solvent comprises

from about 20% to about 60% of the remover solution.

9. The remover solution of claim 1, wherein the at least one organic solvent comprises from about 30% to about 65% of the remover solution.

10. The remover solution of claim 1, wherein the at least one organic solvent comprises from about 30% to about 62% of the remover solution.

11. The remover solution of claim 1, wherein the at least one organic solvent comprises from about 40% to about 62% of the remover solution.

12. The remover solution of claim 1, wherein the at least one organic solvent comprises from about 50% to about 62% of the remover solution.

13. The remover solution of claim 1, wherein the at least one organic solvent comprises from about 30% to about 50% of the remover solution.

14. The remover solution of claim 1, wherein the at least one organic solvent comprises from about 30% to about 40% of the remover solution.

15. The remover solution of claim 1, wherein the at least one organic solvent comprises from about 25% to about 45% of the remover solution.

16. The remover solution of claim 1, wherein the at least one amine that is free of carboxylic acid moieties comprises one or more alkanolamine.

17. The remover solution of claim 1, wherein the at least one amine that is free of carboxylic acid moieties comprises one or more alkanolamine selected from the group of ethanolamine, N-methylethanolamine, N-ethylethanolamine, N-propylethanolamine, N-butylethanolamine, dimethylethanolamine, diethylethanolamine, diethanolamine, triethanolamine, N-methyldiethanolamine, N-ethyldiethanolamine, isopropanolamine, diisopropanolamine, triisopropanolamine, N-methylisopropanolamine, N-ethylisopropanolamine, N-propylisopropanolamine, 2-aminopropane-1-ol, N-methyl-2-aminopropane-1-ol, N-ethyl-2-aminopropane-1-ol, 1-aminopropane-3-ol, N-methyl-1-aminopropane-3-ol, N-ethyl-1-aminopropane-3-ol, 1-aminobutane-2-ol, N-methyl-1-aminobutane-2-ol, N-ethyl-1-aminobutane-2-ol, 2-aminobutane-1-ol, N-methyl-2-aminobutane-1-ol, N-ethyl-2-aminobutane-1-ol, 3-aminobutane-1-ol, N-methyl-3-aminobutane-1-ol, N-ethyl-3-aminobutane-1-ol, 1-aminobutane-4-ol, N-methyl-1-aminobutane-4-ol, N-ethyl-1-aminobutane-4-ol, 1-amino-2-methylpropane-2-ol, 2-amino-2-methylpropane-1-ol, 1-aminopentane-4-ol, 2-amino-4-methylpentane-1-ol, 2-aminoheptane-1-ol, 3-aminoheptane-4-ol, 1-amino-octane-2-ol, 5-amino-octane-4-ol, 1-aminopropane-2,3-diol, 2-aminopropane-1,3-diol, tris(hydroxymethyl)aminomethane, 1,2-diaminopropane-3-ol, 1,3-diaminopropane-2-ol,

2-(2-aminoethoxy)ethanol, 4-(2-hydroxyethyl)morpholine, 1-(2-hydroxyethyl)piperidine, and 1-(2-hydroxyethyl)piperazine.

18. The remover solution of claim 1, wherein the at least one amine that is free of carboxylic acid moieties comprises one or more alkanolamine selected from the group of N-methylethanolamine, triethanolamine, N-ethylethanolamine, ethanolamine, N-methyldiethanolamine, monoisopropanolamine and aminoethoxyethanol.

19. The remover solution of claim 1, wherein the at least one amine that is free of carboxylic acid moieties comprises one or more amine that is free of hydroxyl groups.

20. The remover solution of claim 1, wherein the at least one amine that is free of carboxylic acid moieties comprises one or more amine that is free of hydroxyl groups selected from the group of diethylenetriamine (DETA), triethylenetetramine (TETA), tetraethylenepentamine (TEPA), aminoethylpiperazine, 3-morpholinopropylamine, benzylamine (BA), 1,5-diamino-2-methylpentane, 1,3-diaminopentane, piperazine, 1-(2-aminoethyl)piperazine, 1,2-diaminocyclohexane, 1,3-diaminopropane, 1-(2-aminoethyl)piperidine, pentamethyldiethylenetriamine and 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU).

21. The remover solution of claim 1, wherein the at least one amine that is free of carboxylic acid moieties comprises one or more amine that is free of hydroxyl groups selected from the group of diethylenetriamine, triethylenetetramine, tetraethylenepentamine, aminoethylpiperazine, 3-morpholinopropylamine and benzylamine.

22. The remover solution of claim 1, wherein the at least one amine that is free of carboxylic acid moieties comprises from about 10 wt% to about 60 wt% of the remover solution.

23. The remover solution of claim 1, wherein the at least one amine that is free of carboxylic acid moieties comprises from about 10 wt% to about 50 wt% of the remover solution.

24. The remover solution of claim 1, wherein the at least one amine that is free of carboxylic acid moieties comprises from about 10 wt% to about 45 wt% of the remover solution.

25. The remover solution of claim 1, wherein the at least one amine that is free of carboxylic acid moieties comprises from about 10 wt% to about 40 wt% of the remover solution.

26. The remover solution of claim 1, wherein the at least one amine that is free of carboxylic acid moieties comprises from about 10 wt% to about 35 wt% of the remover solution.

27. The remover solution of claim 1, wherein the at least one amine that is free of carboxylic acid moieties comprises from about 10 wt% to about 30 wt% of the remover solution.

28. The remover solution of claim 1, wherein the at least one amine that is free of carboxylic acid moieties comprises from about 10 wt% to about 25 wt% of the remover solution.

29. The remover solution of claim 1, wherein the at least one amine that is free of carboxylic

acid moieties comprises from about 10 wt% to about 20 wt% of the remover solution.

30. The remover solution of claim 1, wherein the at least one amine that is free of carboxylic acid moieties comprises from about 20 wt% to about 60 wt% of the remover solution.

31. The remover solution of claim 1, wherein the at least one amine that is free of carboxylic acid moieties comprises from about 20 wt% to about 50 wt% of the remover solution.

32. The remover solution of claim 1, wherein the at least one amine that is free of carboxylic acid moieties comprises from about 20 wt% to about 45 wt% of the remover solution.

33. The remover solution of claim 1, wherein the at least one amine that is free of carboxylic acid moieties comprises from about 20 wt% to about 40 wt% of the remover solution.

34. The remover solution of claim 1, wherein the at least one amine that is free of carboxylic acid moieties comprises from about 20 wt% to about 35 wt% of the remover solution.

35. The remover solution of claim 1, wherein the at least one amine that is free of carboxylic acid moieties comprises from about 20 wt% to about 30 wt% of the remover solution.

36. The remover solution of claim 1, wherein the at least one amine that is free of carboxylic acid moieties comprises from about 30 wt% to about 60 wt% of the remover solution.

37. The remover solution of claim 1, wherein the at least one amine that is free of carboxylic acid moieties comprises from about 30 wt% to about 50 wt% of the remover solution.

38. The remover solution of claim 1, wherein the at least one amine that is free of carboxylic acid moieties comprises from about 30 wt% to about 40 wt% of the remover solution.

39. The remover solution of claim 1, wherein the water comprises from about 0.1 wt% to about 30 wt% of the remover solution.

40. The remover solution of claim 1, wherein the water comprises from about 5 wt% to about 30 wt% of the remover solution.

41. The remover solution of claim 1, wherein the water comprises from about 5 wt% to about 25 wt% of the remover solution.

42. The remover solution of claim 1, wherein the water comprises from about 5 wt% to about 22 wt% of the remover solution.

43. The remover solution of claim 1, wherein the water comprises from about 5 wt% to about 20 wt% of the remover solution.

44. The remover solution of claim 1, wherein the water comprises from about 5 wt% to about 17.5 wt% of the remover solution.

45. The remover solution of claim 1, wherein the water comprises from about 5 wt% to about 15 wt% of the remover solution.

46. The remover solution of claim 1, wherein the water comprises from about 5 wt% to

about 12.5 wt% of the remover solution.

47. The remover solution of claim 1, wherein the water comprises from about 10 wt% to about 25 wt% of the remover solution.

48. The remover solution of claim 1, wherein the water comprises from about 10 wt% to about 22.5 wt% of the remover solution.

49. The remover solution of claim 1, wherein the water comprises from about 10 wt% to about 20 wt% of the remover solution.

50. The remover solution of claim 1, wherein the water comprises from about 10 wt% to about 17.5 wt% of the remover solution.

51. The remover solution of claim 1, wherein the water comprises from about 10 wt% to about 15 wt% of the remover solution.

52. The remover solution of claim 1, wherein the water comprises from about 10 wt% to about 12.5 wt% of the remover solution.

53. The remover solution of claim 1, wherein the corrosion inhibitor comprises one or more amino acid.

54. The remover solution of claim 1, wherein the corrosion inhibitor comprises one or more azole.

55. The remover solution of claim 1, wherein the corrosion inhibitor comprises one or more phenolic acid.

56. The remover solution of claim 1, wherein the corrosion inhibitor comprises two or more of (a) an amino acid, (b) an azole and (c) a phenolic acid.

57. The remover solution of claim 1, wherein the corrosion inhibitor comprises (a) an amino acid and (b) an azole.

58. The remover solution of claim 1, wherein the corrosion inhibitor comprises (a) an amino acid and (c) a phenolic acid.

59. The remover solution of claim 1, wherein the corrosion inhibitor comprises (b) an azole and (c) a phenolic acid.

60. The remover solution of claim 1, wherein the corrosion inhibitor comprises one or more of each of (a) an amino acid, (b) an azole and (c) a phenolic acid.

61. The remover solution of claim 1, wherein the corrosion inhibitor comprises one or more amino acid comprising at least one amine group and one carboxylic acid group.

62. The remover solution of claim 1, wherein the corrosion inhibitor comprises one or more amino acid selected from the group of glycine, histidine, arginine, alanine, isoleucine, cysteine, asparagine, leucine, glutamine, aspartic acid, lysine, glutamic acid, methionine, proline, serine,

phenylalanine, tyrosine, threonine, tryptophan, valine, n-(2-hydroxyethyl)ethylenediamine-N,N,N-triacetic acid, 2-picolinic acid, L-cystine, 3,4-diaminobenzoic acid, iminodiacetic acid.

63. The remover solution of claim 1, wherein the corrosion inhibitor comprises glycine.

64. The remover solution of claim 1, wherein the amino acid comprises from about 0.01 wt % to about 10 wt% of the remover solution.

65. The remover solution of claim 1, wherein the amino acid comprises from about 0.05 wt % to about 10 wt% of the remover solution.

66. The remover solution of claim 1, wherein the amino acid comprises from about 0.01 wt % to about 5 wt% of the remover solution.

67. The remover solution of claim 1, wherein the amino acid comprises from about 0.05 wt % to about 2 wt% of the remover solution.

68. The remover solution of claim 1, wherein the azole comprises from about 0.05 wt % to about 1 wt% of the remover solution.

69. The remover solution of claim 1, wherein the amino acid comprises from about 0.1 wt % to about 5 wt% of the remover solution.

70. The remover solution of claim 1, wherein the amino acid comprises from about 0.1 wt % to about 3 wt% of the remover solution.

71. The remover solution of claim 1, wherein the amino acid comprises from about 0.1 wt % to about 2 wt% of the remover solution.

72. The remover solution of claim 1, wherein the amino acid comprises from about 0.1 wt % to about 1 wt% of the remover solution.

73. The remover solution of claim 1, wherein the amino acid comprises from about 0.3 wt % to about 5 wt% of the remover solution.

74. The remover solution of claim 1, wherein the amino acid comprises from about 0.3 wt % to about 1 wt% of the remover solution.

75. The remover solution of claim 1, wherein the amino acid comprises from about 0.5 wt % to about 1 wt% of the remover solution.

76. The remover solution of claim 1, wherein the corrosion inhibitor comprises one or more azole selected from the group of benzotriazole, benzotriazole-5-carboxylic acid, 1,2,4-triazole, 5-aminotetrazole, 5-methyl-1H-benzotriazole, 1-hydroxybenzotriazole, 5-amino-1,3,4-thiadiazol-2-thiol, 3-amino-1H-1,2,4 triazole, 3,5-diamino-1,2,4-triazole, tolyltriazole, 5-phenyl-benzotriazole, 5-nitro-benzotriazole, 3-amino-5-mercapto-1,2,4-triazole, 1-amino-1,2,4-triazole, 2-(5-amino-pentyl)-benzotriazole, 1-amino-1,2,3-triazole, 1-amino-5-methyl-1,2,3-triazole, 3-mercapto-1,2,4-triazole, 3-isopropyl-1,2,4-triazole, 5-phenylthiol-

benzotriazole, naphthotriazole, 1-H-tetrazole-5-acetic acid, 2-mercaptobenzothiazole (2-MBT), 1-phenyl-2-tetrazoline-5-thione, 2-mercaptobenzimidazole (2-MBI), 4-methyl-2-phenylimidazole, 2-mercaptothiazoline, 2,4- diamino-6-methyl-1,3,5-triazine, thiazole, imidazole, benzimidazole, triazine, 5-methyl-1H-benzotriazole, 4-methylbenzotriazole, 1-methylbenzotriazole, 1-methyltetrazole and 5-methyl-1H-tetrazole.

77. The remover solution of claim 1, wherein the corrosion inhibitor comprises tolytriazole (TTL).

78. The remover solution of claim 1, wherein the corrosion inhibitor comprises benzotriazole (BZT).

79. The remover solution of claim 1, wherein the azole comprises from about 0.01 wt % to about 10 wt% of the remover solution.

80. The remover solution of claim 1, wherein the azole comprises from about 0.05 wt % to about 10 wt% of the remover solution.

81. The remover solution of claim 1, wherein the azole comprises from about 0.01 wt % to about 5 wt% of the remover solution.

82. The remover solution of claim 1, wherein the azole comprises from about 0.05 wt % to about 2 wt% of the remover solution.

83. The remover solution of claim 1, wherein the azole comprises from about 0.05 wt % to about 1 wt% of the remover solution.

84. The remover solution of claim 1, wherein the azole comprises from about 0.1 wt % to about 5 wt% of the remover solution.

85. The remover solution of claim 1, wherein the azole comprises from about 0.1 wt % to about 3 wt% of the remover solution.

86. The remover solution of claim 1, wherein the azole comprises from about 0.1 wt % to about 2 wt% of the remover solution.

87. The remover solution of claim 1, wherein the azole comprises from about 0.1 wt % to about 1 wt% of the remover solution.

88. The remover solution of claim 1, wherein the azole comprises from about 0.3 wt % to about 5 wt% of the remover solution.

89. The remover solution of claim 1, wherein the azole comprises from about 0.3 wt % to about 1 wt% of the remover solution.

90. The remover solution of claim 1, wherein the azole comprises from about 0.5 wt % to about 1 wt% of the remover solution.

91. The remover solution of claim 1, wherein the corrosion inhibitor comprises one or more

phenolic acid comprising hydroxybenzoic acids with one or more hydroxyl groups and at least one carboxylic group attached on benzene ring.

92. The remover solution of claim 1, wherein the corrosion inhibitor comprises one or more phenolic acid selected from the group of gallic acid, phloroglucinol carboxylic acid, 2,3-dihydroxybenzoic acid (hypogallic acid), 2,4-dihydroxybenzoic acid, 2,5-dihydroxybenzoic acid (gentisic acid), 2,6-dihydroxybenzoic acid, 3,4-dihydroxybenzoic acid (protocatechuic acid), 3,5-dihydroxybenzoic acid, vanillic acid, syringic acid, veratric acid, 2-hydroxybenzoic acid (salicylic acid), 3-hydroxybenzoic acid, 4-hydroxybenzoic acid and pyrogallol.

93. The remover solution of claim 1, wherein the corrosion inhibitor comprises gallic acid.

94. The remover solution of claim 1, wherein the phenolic acid comprises from about 0.01 wt % to about 10 wt% of the remover solution.

95. The remover solution of claim 1, wherein the phenolic acid comprises from about 0.05 wt % to about 10 wt% of the remover solution.

96. The remover solution of claim 1, wherein the phenolic acid comprises from about 0.01 wt % to about 5 wt% of the remover solution.

97. The remover solution of claim 1, wherein the phenolic acid comprises from about 0.05 wt % to about 2 wt% of the remover solution.

98. The remover solution of claim 1, wherein the phenolic acid comprises from about 0.05 wt % to about 1 wt% of the remover solution.

99. The remover solution of claim 1, wherein the phenolic acid comprises from about 0.1 wt % to about 5 wt% of the remover solution.

100. The remover solution of claim 1, wherein the phenolic acid comprises from about 0.1 wt % to about 3 wt% of the remover solution.

101. The remover solution of claim 1, wherein the phenolic acid comprises from about 0.1 wt % to about 2 wt% of the remover solution.

102. The remover solution of claim 1, wherein the phenolic acid comprises from about 0.1 wt % to about 1 wt% of the remover solution.

103. The remover solution of claim 1, wherein the phenolic acid comprises from about 0.3 wt % to about 5 wt% of the remover solution.

104. The remover solution of claim 1, wherein the phenolic acid comprises from about 0.3 wt % to about 1 wt% of the remover solution.

105. The remover solution of claim 1, wherein the phenolic acid comprises from about 0.5 wt % to about 1 wt% of the remover solution.

106. The remover solution of claim 1, wherein the remover comprises

- (i) about 30% to about 62% of organic solvent
- (ii) about 10% to about 40% of at least one amine that is free of carboxylic acid moieties;
- (iii) about 5% to about 30% of water; and
- (iv) a corrosion inhibitor including, consisting essentially of or consisting of (a) about 0.1% to about 1.5% of an amino acid; (b) about 0.1% to about 1.5% of an azole; and (c) about 0.1% to about 1.5% of a phenolic acid,

wherein the remover solution is free of dimethylsulfoxide, N-methylpyrrolidone and dimethylacetamide.

107. The remover solution of claim 1, wherein the remover comprises (i) about 40% to about 45% of diethylene glycol monoethyl ether; (ii) about 30% to about 35% of n-methylethanolamine; (iii) about 22.5% to about 25% of water; and (iv) (a) about 0.1% to about 0.5% of glycine, (b) about 0.75% to about 1.25% of benzotriazole and (c) about 0.25% to about 0.75% of gallic acid.

108. The remover solution of claim 1, wherein the remover comprises

- (i) about 30% to about 62% of organic solvent;
- (ii) about 10% to about 40% of at least one amine that is free of carboxylic acid moieties;
- (iii) about 5% to about 30% of water; and
- (iv) a corrosion inhibitor including, consisting essentially of or consisting of (a) about 0.1% to about 1.5% of an amino acid; (b) about 0.1% to about 1.5% of an azole,

wherein the remover solution is free of dimethylsulfoxide, N-methylpyrrolidone and dimethylacetamide.

109. The remover solution of claim 1, wherein the remover comprises (i) about 40% to about 45% of diethylene glycol monoethyl ether; (ii) about 30% to about 35% of n-methylethanolamine; (iii) about 22.5% to about 25% of water; and (iv) (a) about 0.1% to about 0.5% of glycine, (b) about 0.75% to about 1.25% of benzotriazole.

110. The remover solution of claim 1, wherein the remover comprises

- (i) about 30% to about 62% of organic solvent;
- (ii) about 10% to about 40% of at least one amine that is free of carboxylic acid moieties;
- (iii) about 5% to about 20% of water; and
- (iv) about 0.1% to about 1.5% of a corrosion inhibitor including, consisting

essentially of or consisting of an azole corrosion inhibitor,

wherein the remover solution is free of dimethylsulfoxide, N-methylpyrrolidone and dimethylacetamide.

111. The remover solution of claim 1, wherein the remover comprises (i) about 50% to about 60% of diethylene glycol monoethyl ether; (ii) about 7.5% to about 12.5% of triethanolamine and about 15% to about 25% of n-methylethanolamine; (iii) about 10% to about 15% of water; and (iv) about 1% to about 1.5% of tolytriazole.

112. The remover solution of claim 1, wherein the remover comprises

- (i) about 40% to about 80% of organic solvent.
- (ii) about 5 % to about 40% of at least one amine that is free of carboxylic acid moieties;
- (iii) about 2% to about 40% of a second amine that is free of carboxylic acid moieties;
- (iv) about 5% to about 20% of water; and
- (v) about 0.3% to about 1.8% of a corrosion inhibitor including, consisting essentially of or consisting of an azole corrosion inhibitor,

wherein the remover solution is free of dimethylsulfoxide, N-methylpyrrolidone and dimethylacetamide.

113. The remover solution of claim 1, wherein the remover comprises (i) about 70.0% to about 75.0% of diethylformamide; (ii) about 7.5% to about 12.5% of 3-morpholinopropylamine and about 2.5% to about 5% of 1,8-diazabicyclo[5.4.0]undec-7-ene; (iii) about 10% to about 15% of water; and (iv) about 1% to about 1.5% of tolytriazole.

114. The remover solution of any of claims 1-113, wherein the remover solution has a pH of about 9 to about 14.

115. The remover solution of any of claims 1-113, wherein the remover solution has a pH of about 10 to about 12.

116. The remover solution of any of claims 1-113, wherein the remover solution has a pH of above about 9.

117. The remover solution of any of claims 1-113, wherein the remover solution has a pH of above about 9.5.

118. The remover solution of any of claims 1-113, wherein the remover solution has a pH of above about 10.

119. The remover solution of any of claims 1-113, wherein the remover solution has a pH of above about 10.5.

- 120.** The remover solution of any of claims 1-113, wherein the remover solution has a pH of above about 11.
- 121.** The remover solution of any of claims 1-113, wherein the remover solution has a pH of above about 11.5.
- 122.** The remover solution of any of claims 1-113, wherein the remover solution has a pH of above about 12.
- 123.** The remover solution of any of claims 1-113, wherein the remover solution has a pH of above about 12.5.
- 124.** The remover solution of any of claims 1-113, wherein the remover solution has a pH of above about 13.
- 125.** A method for removing a photoresist or etch residue from a substrate comprising the steps of:
- (i)** contacting the substrate with a remover solution of any of claims 1-124 for a time sufficient to remove a desired amount of the photoresist or similar material;
 - (ii)** removing the substrate from the remover solution;
 - (iii)** rinsing the remover solution from the substrate with DI water or a solvent; and
 - (iv)** optionally drying the substrate.
- 126.** The method of claim 125, wherein step (i) comprises immersing the substrate in the remover solution and optionally agitating the substrate to facilitate photoresist removal.