industries to protect the device or substrate from a variety of environments. Non-limiting examples of potential uses include coatings and methods that allow for protection of electronic devices from harsh environments and contaminates, such as particulates including dust and dirt, as well as liquids, including water and bodily fluids. Furthermore, there is a need for a coating that can be applied without the need to mask components, such as on a printed circuit board, prior to coating. There is also a need for a durable, deformable, and flowable coating that can cover an entire printed circuit board, without inhibiting the functionality of the device.

Summary

[008] In view of the foregoing, there is disclosed a composition that is used to form a durable gel-state coating to protect a device or substrate, methods of making such a coating and methods of using such a coating, as well as devices and substrates protected with such a coating.

[008a] In an aspect, there is provided a composition for forming a conformal gel coating to protect a substrate, the composition comprising:

at least one film former comprising at least one of polyolefins, polyacrylates, epoxies, polysiloxanes, or combinations thereof; and

at least one additive comprising at least one of antioxidants, passivators, UV absorbers or stabilizers, rheology modifiers, adhesion promoters, wetting agents, tackifiers, plasticizers, dispersing agents, leveling agents, defoamers, processing additives, and combinations thereof;

wherein, when the composition comprises an antioxidant, the composition also comprises a passivator; and

wherein said composition is configured to form a conformal gel coating that is deformable, flowable, and electrically insulating.

[008b] In another aspect, there is provided a conformal gel coating to protect an electronic element, the conformal gel coating comprising:

at least one film former comprising at least one of polyolefins, polyacrylates, epoxies, polysiloxanes or combinations thereof; and

at least one additive comprising at least one of antioxidants, passivators, UV absorbers or stabilizers, rheology modifiers, adhesion promoters, wetting agents, tackifiers, plasticizers, dispersing agents, leveling agents, defoamers, processing additives, and combinations thereof,

wherein, when the conformal gel coating comprises an antioxidant, the conformal gel coating also comprises a passivator; and

wherein said conformal gel coating is deformable, flowable, and electrically insulating.

[008c] In another aspect, there is provided a method of treating an electronic device with a conformal gel coating, the method comprising:

applying the conformal gel coating to the electronic device, wherein the conformal gel coating comprises:

at least one film former comprising at least one of polyolefins, polyacrylates, epoxies, polysiloxanes or combinations thereof; and

at least one additive comprising at least one of antioxidants, passivators, UV absorbers or stabilizers, rheology modifiers, adhesion promoters, wetting agents, tackifiers, plasticizers, dispersing agents, leveling agents, defoamers, processing additives, and combinations thereof,

wherein, when the conformal gel coating comprises an antioxidant, the conformal gel coating also comprises a passivator; and

wherein said conformal gel coating is deformable, flowable and electrically insulating.

[008d] In another aspect, there is provided a substrate having a conformal gel coating thereon, the conformal gel coating comprising: at least one film former comprising at least one of polyolefins, polyacrylates, epoxies, polysiloxanes or combinations thereof; and

at least one additive comprising at least one of antioxidants, passivators, UV absorbers or stabilizers, rheology modifiers, adhesion promoters, wetting agents, tackifiers, plasticizers, dispersing agents, leveling agents, defoamers, processing additives, and combinations thereof,

wherein, when the conformal gel coating comprises an antioxidant, the conformal gel coating also comprises a passivator; and

wherein the conformal gel coating is deformable, flowable, and electrically insulating.

[009] In one example, there is disclosed a composition for forming a conformal gel coating to protect a substrate from various environments, the composition comprising: at least one film former; and at least one additive and optionally at least one solvent, wherein the composition is deformable, flowable, electrically insulating, and does not contain fluorine when applied as a coating.

[010] There is also disclosed a conformal gel coating to protect an electronic element from various environments, the coating comprising: at least film former; and at least one additive and optionally at least one solvent, wherein the gel coating is deformable, flowable, electrically insulating, and does not contain fluorine.

[011] In another example, there is disclosed a method of treating an electronic device with a gel conformal coating, the method comprising: applying the gel conformal coating to the electronic device, the gel conformal coating comprising

WHAT IS CLAIMED IS:

1. A composition for forming a conformal gel coating to protect a substrate, the composition comprising:

at least one film former comprising at least one of polyolefins, polyacrylates, epoxies, polysiloxanes, or combinations thereof; and

at least one additive comprising at least one of antioxidants, passivators, UV absorbers or stabilizers, rheology modifiers, adhesion promoters, wetting agents, tackifiers, plasticizers, dispersing agents, leveling agents, defoamers, processing additives, and combinations thereof;

wherein, when the composition comprises an antioxidant, the composition also comprises a passivator; and

wherein said composition is configured to form a conformal gel coating that is deformable, flowable, and electrically insulating.

2. The composition of claim 1, wherein the antioxidants comprise a phenolic antioxidant, an amine antioxidant, a thioether antioxidant, a phosphite antioxidant, or combinations thereof.

3. The composition of claim 2, wherein the phenolic antioxidants comprise one or more compounds selected from the group consisting of: benzenepropanoic acid, 3,5-bis(1,1-dimethylethyl)- 4-hydroxy-, octadecyl ester (CAS# 2082-79-3), benzenepropanoic acid, 3,5-bis(1,1-dimethylethyl)-4- hydroxy-,2,2-bis[[3-[3,5-bis(1,1-dimethylethyl)-4-hydroxyphenyl]-1-oxopropoxy]methyl]-1,3-propanediyl ester (CAS# 6683-19-8), a reaction product of: C7-9-alkyl 3-(3,5-di-tert-butyl-4-hydroxyphenyl) propionate (CAS# 125643-61-0), 1,3,5-triazine-2,4,6(1H,3H,5H)-trione, 1,3,5- tris {[3,5-bis(1,1-dimethylethyl)-4- hydroxyphenyl] methyl}- (CAS# 27676-62-6) or Benzenepropanoic acid, 3-(1,1-dimethylethyl)- 4-hydroxy-5-methyl-, 2,4,8,10-tetraoxaspiro [5.5]undecane-3,9-diylbis(2,2-dimethyl-2,1- ethanediyl) ester (CAS# 90498-90-1), and combinations thereof.

4. The composition of claim 2, wherein the amine antioxidants comprise one or more compounds selected from the group consisting of: benzenamine, N-phenyl-,

reaction products of 2,4,4-trimethylpentene (CAS# 68411-46-1), 1-naphthalenamine, N-phenyl-ar-(1,1,3,3-tetramethylbutyl)- (CAS# 68259-36-9), 4,4'-dioctyldiphenylamine (CAS# 101-67-7), other alkylated amines, and combinations thereof.

5. The composition of claim 2, wherein the thioether antioxidants comprise one or more compounds selected from the group consisting of: propanoic acid, 3-(dodecylthio)-,1,1'-[2,2-bis[[3-(dodecylthio)-1-oxopropoxy]methyl]-1,3-propanediyl] ester (CAS# 29598-76-3), propanoic acid, 3,3'-thiobis-, 1,1'-ditridecyl ester (CAS# 10595-72-9), and combinations thereof.

6. The composition of claim 2, wherein the phosphite antioxidants comprise one or more compounds selected from the group consisting of: tris(2,4-di-tert-butylphenyl) phosphite (CAS# 31570-04-4), butylidenebis[2-tert-butyl-5-methyl-p-phenylene]-P,P,P',P'-tetratridecylbis(phosphine) (CAS# 13003-12-8), 12H-dibenzo[d,g][1,3,2]dioxaphosphocin,2,4,8,10-tetrakis(1,1-dimethylethyl)-6-[(2-ethylhexyl)oxy]- (CAS# 126050-54-2), and combinations thereof.

7. The composition of claim 1, wherein the passivators comprise a hydrazide or a triazole selected from the group consisting of dodecanedioic acid, 1,12-bis[2-(2-hydroxybenzoyl)hydrazide] (CAS# 63245-38-5), benzenepropanoic acid, 3,5-bis(1,1-dimethylethyl)- 4-hydroxy-, 2-[3-[3,5-bis(1,1-dimethylethyl)-4-hydroxyphenyl]- 1-oxopropyl]hydrazide (CAS# 32687-78-8), 1,2,4-Triazole (CAS# 288-88-0), 2-Hydroxy-N-1H-1,2,4-triazol-3-ylbenzamide (CAS# 36411-52-6), 1H-benzotriazole-1-methanamine, N,N-bis(2-ethylhexyl)-ar-methyl- (CAS# 94270-86-7), 1H-1,2,4-triazole-1-methanamine, N,N-bis(2-ethylhexyl)- (CAS# 91273-04-0), and combinations thereof.

8. The composition of claim 1, wherein the UV absorbers or stabilizers comprise one or more compounds selected from the group consisting of: carbon black, rutile titanium oxide, hindered amines, benzophenones, and combinations thereof.

9. The composition of claim 1, wherein the rheology modifiers comprise one or more compounds selected from the group consisting of: sodium polyacrylates, polyamide wax, polyethylene wax, hydrogenated castor oils, attapulgite clay, fumed silica, precipitated silica, metal-oxide particles, and combinations thereof.

10. The composition of claim 1, wherein the adhesion promoters comprise one or more compounds selected from the group consisting of: chlorinated polyolefins, cyanoacrylate primers, polyester alkyl ammonium salts, aminofunctional polyethers, maleic anhydride, carboxylated polypropylene, glycidylmethacrylate-functionalized polyolefins, trimethoxyvinylsilane, silanes, and combinations thereof.

11. The composition of claim 1, wherein the wetting or dispersing agents comprise one or more compounds selected from the group consisting of: alkylammonium salts of a polycarboxylic acid, alkylammonium salt of an acidic polymer, salt of unsaturated polyamine amides and acidic polyesters, maleic anhydride functionalized ethylene butyl acrylate copolymer, other ionic or non-ionic surfactants, and combinations thereof.

12. The composition of claim 1, wherein the tackifiers comprise at least one of hydrogenated hydrocarbon resins or cycloaliphatic hydrocarbon resins.

13. The composition of claim 1, wherein the plasticizers comprise at least one compound selected from the group consisting of: hydrogenated cycloaliphatic hydrocarbon resins, trimellitates, high molecular weight orthophthalates, silicone oils, octyl epoxy esters and hydrotreated light naphthenic petroleum distillates.

14. The composition of claim 1, wherein the leveling agents comprise at least one compound selected from the group consisting of: silicones, liquid polyacrylates, ionic surfactants, non-ionic surfactants and combinations thereof.

15. The composition of claim 1, further comprising at least one pigment or UV dye selected from the group consisting of: 2,2'-(2,5-thiophenediyl)bis(5-tert-butylbenzoxazole) (CAS# 7128-64-5), 2,2'-(1,2-ethenediyl)bis(4,1-

phenylene)bisbenzoxazole (CAS# 1533-45-5), solvent yellow 43 (CAS# 19125-99-6), carbon black (CAS# 1333-86-4), pigment yellow 101 (CAS# 2387-03-3), N,N'-bis(2,6-diisopropylphenyl)-3,4,9,10-perylenetetracarboxylic Diimide (CAS# 82953-57-9), other perylene dyes and anthracene dyes.

16. The composition of claim 1, wherein the conformal gel exhibits viscoeleastic, viscoplastic, or elasto-visco-plastic flow properties.

17. The composition of claim 1, wherein the composition is silicone-free.

18. The composition of claim 1, wherein the composition is non-halogenated.

19. The composition of claim 1, comprising a volatile organic content of 650 g/L or less.

20. The composition of claim 1, wherein the conformal gel has a thickness ranging from 25 nm to 500 μm on the substrate.

21. The composition of claim 1, wherein the conformal gel coating acts as a protective interface between the surface and an environment.

22. The composition of claim 21, wherein the surface comprises a metal, and the environment is a corrosive or conductive environment selected from environments with high humidity, condensation, tap water, sweat, sebum, salt water, carbonated beverages, coffee, liquid coolant or antifreeze.

23. The composition of claim 22, wherein the surface comprises a metal that exhibits galvanic corrosion and the environment causes galvanic corrosion, or wherein the environment is an oxidizing environment containing at least one gas selected from air, oxygen and water vapor.

24. The composition of claim 22, wherein the surface comprises electronics in a printed circuit board and the environment comprises at least one

corrosive gas selected from the group consisting of: chlorine, water vapor, hydrogen sulfide, hydrogen chloride or oxides of nitrogen and sulfur, or at least one conductive liquid selected the group consisting of: from water, sweat, and other corrosive fluids.

25. The composition of claim 1, wherein the composition exhibits electrical insulation properties that mitigate at least one of: current leakage or arcing between two metal contacts when said composition is placed between said metal contacts;

current flowing from active electronics on a printed circuit board to conductive media or environments; and electrostatic discharge from a charge carrier to active electronics on a printed circuit board.

26. The composition of claim 1, wherein said additives provides the composition with at least one property selected from: enhanced durability to oxidative degradation compared to a composition without said additives; and

enhanced mechanical stability compared to a composition without said additives, wherein the composition does not undergo liquefaction, hardening or other phase changes.

27. The composition of claim 1, wherein one or more of the additives is found at an interface between the coating and the substrate or is found at an area of the substrate that is free from the coating after application to a substrate.

28. The composition of claim 1, wherein the additive is a passivator that is found at and adsorbs onto an interface between the coating and the substrate to inhibit catalytic activity from the substrate.

29. The composition of claim 1, further comprising at least one solvent.

30. A conformal gel coating to protect an electronic element, the conformal gel coating comprising:

at least one film former comprising at least one of polyolefins, polyacrylates, epoxies, polysiloxanes or combinations thereof; and

at least one additive comprising at least one of antioxidants, passivators, UV absorbers or stabilizers, rheology modifiers, adhesion promoters, wetting agents, tackifiers, plasticizers, dispersing agents, leveling agents, defoamers, processing additives, and combinations thereof,

wherein, when the conformal gel coating comprises an antioxidant, the conformal gel coating also comprises a passivator; and

wherein said conformal gel coating is deformable, flowable, and electrically insulating.

31. The conformal gel coating of claim 30, further comprising at least one solvent.

32. A method of treating an electronic device with a conformal gel coating, the method comprising:

applying the conformal gel coating to the electronic device, wherein the conformal gel coating comprises:

at least one film former comprising at least one of polyolefins, polyacrylates, epoxies, polysiloxanes or combinations thereof; and

at least one additive comprising at least one of antioxidants, passivators, UV absorbers or stabilizers, rheology modifiers, adhesion promoters, wetting agents, tackifiers, plasticizers, dispersing agents, leveling agents, defoamers, processing additives, and combinations thereof,

wherein, when the conformal gel coating comprises an antioxidant, the conformal gel coating also comprises a passivator; and

wherein said conformal gel coating is deformable, flowable and electrically insulating.

33. The method of claim 32, wherein the conformal gel coating further comprises at least one solvent.

34. A substrate having a conformal gel coating thereon, the conformal gel coating comprising: at least one film former comprising at least one of polyolefins, polyacrylates, epoxies, polysiloxanes or combinations thereof; and

at least one additive comprising at least one of antioxidants, passivators, UV absorbers or stabilizers, rheology modifiers, adhesion promoters, wetting agents, tackifiers, plasticizers, dispersing agents, leveling agents, defoamers, processing additives, and combinations thereof,

wherein, when the conformal gel coating comprises an antioxidant, the conformal gel coating also comprises a passivator; and

wherein the conformal gel coating is deformable, flowable, and electrically insulating.