CLAIMS

~~What is claimed is:~~

1. A solution comprising:

a cobalt salt;

a complexing agent configured to deposit a cobalt layer on copper using the cobalt salt; and

a pH adjuster configured to adjust a pH of the solution to below 6.0 ~~7.0~~.

2. The solution of claim 1, further comprising a grain boundary stuffer.

3. The solution of claim 1, further comprising an additive configured to enhance small grain growth, a nodule growth suppressor, or a surfactant.

4. A solution comprising:~~The solution of claim 1,~~

a cobalt salt;

a complexing agent configured to deposit a cobalt layer on copper using the cobalt salt, the complexing agent comprising an amine compound; and

a pH adjuster configured to adjust a pH of the solution less than or equal to ~~wherein the solution has a pH below~~ 6.0.

5. The solution of claim 1, wherein the cobalt salt comprises a cobalt(II) salt.

6. The solution of claim 1, wherein the cobalt salt comprises an amine group.

7. The solution of claim 1, wherein the cobalt salt comprises an amine group in the form $[Co(II)[amine]_{1\ to\ 3}]^{2+}[anion(s)]^{2-}$.

8. The solution of claim 1, wherein the cobalt salt comprises [Co(~~En~~ethyenediamine)]SO_4, [Co(~~En~~ethyenediamine)$_2$]SO_4, [Co(~~En~~ethyenediamine)$_3$]SO_4, [Co(~~Dien~~diethylenetriamine)]$(NO_3)_2$, or [Co(~~Dien~~diethylenetriamine)$_2$]$(NO_3)_2$.

9. The solution of claim 1, wherein the complexing agent comprises an amine compound.

10. The solution of claim 9, wherein the amine compound comprises a diamine.

11. The solution of claim 4~~ claim 9~~, wherein the amine compound comprises a triamine.

12. The solution of claim 4~~ claim 9~~, wherein the amine compound comprises a polyamine of the form R"-NH-R'-R-NH-R"', wherein R, R', and R" are selected from the group consisting of an aliphatic group, an aromatic group, and a heterocyclic group.

13. The solution of claim 4~~ claim 9~~, wherein the amine compound comprises a polyamine of the form R"-NH-R'-NH-R-NH-R"', wherein R, R', R", and R"' are selected from the group consisting of an aliphatic group, an aromatic group, and a heterocyclic group.

14. The solution of claim 4~~ claim 9~~, wherein the amine compound comprises a polyamine of the form R"'-NH-[R'-NH]$_n$-[R'-NH]$_m$-R-NH-R"", wherein R, R', R", R"' and R"" are selected from the group consisting of an aliphatic group, an aromatic group, and a heterocyclic group.

15. The solution of claim 4~~ claim 9~~, wherein the amine compound is aromatic.

~~16. The solution of claim 1, wherein the reducing agent comprises DMAB.~~

16~~7~~. The solution of claim 1, wherein the solution is prepared using de-oxygenated liquids.

17~~8~~. The solution of claim 1, further including a reducing agent.

18. The solution of claim 17, wherein the reducing agent comprises DMAB.

19. A method comprising:

preparing a solution configured to deposit a cobalt layer on copper, the solution having a pH below 7.0 and comprising:

a cobalt(II) salt;

a complexing agent including at least two amine groups; and

a pH adjuster configured to adjust the pH to less than or equal to 6.0 ~~below 7.0~~;

immersing a copper surface into the solution; and

depositing a cobalt-alloy layer on the copper surface using the solution.

20. The method of claim 19, further comprising depositing a dielectric layer on the cobalt-alloy layer.

21. The method of claim 19, wherein the solution has a pH below 6.0.

22. The method of claim 19, wherein the cobalt salt comprises a cobalt(II) salt.

23. The method of claim 19, wherein the cobalt salt comprises an amine group.

24. The method of claim 19, wherein the complexing agent comprises an amine compound.

25. The method of claim 19, wherein solution further includes a reducing agent.

26. A semiconductor device manufactured using the method of Claim 19.

27. The solution of claim 1, wherein the cobalt salt has a concentration of 1×10^{-4} M or less.

28. The solution of claim 4, further including a reducing agent.

29. The solution of claim 28, wherein the reducing agent comprises DMAB.

30. The solution of claim 4, wherein the solution is prepared using de-oxygenated liquids.

31. The solution of claim 4, wherein the cobalt salt has a concentration of 1×10^{-4} M or less.