compound. Additional details of an exemplary ALD process are found in International Application WO 2004/007796, which is incorporated in its entirety by reference.

[0040] Optionally, directional ion etching may be used to remove some or all of the barrier material that overlies conductive material **20**, such as copper, at the bottom of via holes. This step allows connections with lower resistance between the via and the underlying copper layers **20**. Fig. 1 illustrates the device in which the diffusion barrier layer is removed above copper layer **20**.

[0041] Next, a layer of cobalt nitride (Co_xN) **80** is deposited onto the barrier layer. The cobalt nitride layer **80** may be applied using any convenient method. The Co_xN layers generally have values of x between about 1 and 10, for example, between about 2 and 6, or between about 3 and 5. In one or more embodiments, a compound in the cobalt nitride layer is Co_4N. x need not be an integer.

[0042] In some embodiments, the ~~Cu~~Co_4N layer is polycrystalline. This structure promotes epitaxial growth of copper grains with the same orientation. The strong adhesion between these epitaxially oriented copper grains and the cobalt nitride is believed to enhance the stability and lifetime of the interconnect structures.

[0043] In one or more embodiments, CVD is used for depositing the Co_xN layer, but other methods, such as sputtering are also contemplated. The layer **90** is a copper seed layer, which may be deposited by any convenient method known in the art, including a chemical method such as CVD or physical methods such as sputtering or PVD. The trenches **100** and vias **110** are then filled with copper using conventional methods, such as electroplating or electroless deposition, which are well-known in the art.

[0044] In certain embodiments, the Co_xN diffusion barrier layer is deposited by CVD. In one CVD method, a cobalt amidinate is mixed with a vaporous source of nitrogen and hydrogen and exposed to a heated substrate to deposit a conformal cobalt nitride layer. The composition x of the Co_xN layer can be adjusted by changing the composition of the CVD gas mixture. Increasing the ratio of H_2 to NH_3 in the CVD gas mixture increases the value of x. The composition can also be adjusted by annealing the layer after deposition at a temperature of 180 to 400 °C. Increasing the ratio of H_2 to NH_3 in the anneal atmosphere also increases the value of x.

[0045] In one or more embodiments, cobalt amidinates have the structure, $[M(AMD)_x]$, where M is Co, AMD is an amidinate and x = 2 or 3. Some of these compounds have a structure **3**,

CLAIMS:

1. An integrated circuit interconnect structure formed on a substrate, the interconnect structure comprising:

a conformal polycrystalline Co_4N ~~cobalt nitride~~ layer located on a substrate surface defining an interconnect structure~~, the cobalt nitride having the composition Co_xN, where x is between 3 and 5~~; and

a conductive layer comprising copper located over the polycrystalline Co_4N ~~cobalt nitride~~ layer.

~~2. The structure of claim 1, wherein the cobalt nitride has the composition Co_4N.~~

3~~2~~. The structure of claim 1 ~~or 2~~ further comprising a diffusion barrier between the polycrystalline Co_4N ~~cobalt nitride~~ layer and the substrate.

4~~3~~. The structure of claim 3~~2~~ in which the diffusion barrier is selected from the group consisting of tantalum nitride, tantalum carbide, tungsten nitride, tungsten carbide and mixtures thereof.

5~~4~~. The interconnect structure according to claim 1 ~~or 2~~ wherein the polycrystalline Co_4N ~~cobalt nitride~~ layer is a chemical vapor deposited layer.

6~~5~~. The interconnect structure according to claim 3~~2~~ wherein the diffusion barrier layer is a chemical vapor deposited layer.

7~~6~~. The interconnect structure according to claim 1 ~~or 2~~ wherein at least part of the copper-comprising conductive layer is a chemical vapor deposited layer.

8~~7~~. The interconnect structure according to claim 1 ~~or 2~~ wherein at least part of the copper-comprising conductive layer is an electrochemically deposited layer.

9~~8~~. A method of making an integrated circuit interconnect structure formed on a substrate, comprising:

depositing a conformal polycrystalline Co_4N ~~cobalt nitride~~ layer on a substrate defining an interconnect structure of an integrated circuit structure by chemical vapor

deposition from a composition of matter that comprises bis(N-tert-butyl-N'-ethyl propionamidinato) cobalt(II), ~~the cobalt nitride having the composition Co_xN, where x is between 3 and 5~~; and

depositing a conductive layer comprising copper directly over the polycrystalline Co_4N ~~cobalt nitride~~ layer.

~~10. The method of claim 9, in which the cobalt nitride has the composition Co_4N.~~

~~11~~9. The method of claim ~~9 or 10~~8, in which the gaseous mixture further comprises a reducing agent.

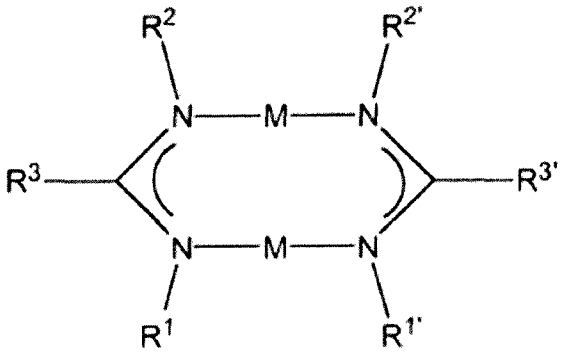
~~12~~10. The method of claim ~~11~~9, in which the reducing agent is dihydrogen.

~~13~~11. The method of claim ~~9 or 10~~8, wherein at least part of the copper-comprising conductive layer is a deposited by chemical vapor deposition.

~~14~~12. The method of claim ~~13~~11, wherein at least part of the copper-comprising conductive layer is deposited by electrochemical deposition.

~~15~~13. The method of claim ~~9 or 10~~8, wherein at least part of the copper-comprising conductive layer is deposited from a gaseous mixture comprising a vapor of a copper amidinate.

~~16~~14. The method of claim ~~15~~13, wherein the copper amidinate has the formula $[Cu(AMD)]_2$, and the structure



in which M is copper, R^1, R^2, R^3, $R^{1'}$, $R^{2'}$ and $R^{3'}$ may be chosen independently from hydrogen, alkyl, aryl, alkenyl, alkynyl, trialkylsilyl or fluoroalkyl groups or other non-metal atoms or groups.

~~17~~15. The method of claim ~~15~~13, wherein the gaseous mixture comprises an oxygen-containing compound and a copper oxide is deposited in a first deposition step.

~~18~~16. The method of claim ~~15~~13, wherein the gaseous mixture comprises an oxygen-containing compound and a nitrogen containing compound and a copper oxynitride is formed in a first deposition step.

~~19~~17. The method of claim ~~18~~16, further comprising exposing the copper oxynitride to a reducing agent.

~~20~~18. The method of claim ~~17~~15, further comprising exposing the copper oxide to a reducing agent.

~~21~~19. ~~The~~A method of forming a polycrystalline Co_4N ~~Co_xN~~ layer~~, where x is between 3 and 5,~~ by chemical vapor deposition comprising:

exposing a substrate to a gaseous mixture comprising vapors of one or more bis(N-tert-butyl-N'-ethyl propionamidinato) cobalt(II) and a nitrogen containing gas.

~~22. The method of claim 21, in which x is 4.~~

~~23~~20. The method of claim ~~21 or 22~~19, in which the nitrogen-containing gas is ammonia or hydrazine.

~~24~~21. The method of claim ~~23~~20, in which the gaseous mixture further comprises a reducing agent.

~~25~~22. The method of claim ~~24~~21, in which the reducing agent is dihydrogen gas.

~~26~~23. A composition of matter for use in a vapor deposition process of a polycrystalline Co_4N ~~cobalt nitride~~ layer~~, the cobalt nitride having the composition Co_xN, where x is between 3 and 5,~~ that comprises bis(N-tert-butyl-N'-ethyl propionamidinato) cobalt(II).