CLAIMS

1. A method of forming self-aligned vias at line ends, the method comprising the steps of:

patterning metal lines comprising alternating even and odd metal lines using a hardmask comprising a first hardmask for patterning the even metal lines and a second hardmask for patterning the odd metal lines;

cutting the hardmask and a select metal line, even or odd, using a cut mask having a window that exposes the hardmask over a cut region of the select metal line;

enlarging the window in the cut mask to expose the hardmask on either side of the cut region of the select metal line;

selectively etching the hardmask using the enlarged window in the cut mask to form a T-shaped cavity within the cut region of the select metal line;

filling the T-shaped cavity with a gap fill dielectric;

removing the hardmask; and

recessing the metal lines selective to the gap fill dielectric, wherein the gap fill dielectric overhangs portions of the select metal line that, by the recessing, form the self-aligned vias at ends of the metal lines.

2. The method of claim 1, wherein the first hardmask and the second hardmask comprise different materials.

3. The method of claim 2, wherein the first hardmask comprises a material selected from the group consisting of: titanium (Ti), tantalum (Ta), titanium oxide (TiOx), titanium nitride (TiN), tantalum nitride (TaN), and combinations thereof.

4. The method of claim 2, wherein the second hardmask comprises a material selected from the group consisting of: silicon nitride (SiN), silicon carbon nitride (SiCN), hydrogen containing silicon carbon nitride (SiCNH), silicon carbide (SiC), and combinations thereof.

5. The method of claim 1, wherein the even and odd metal lines comprise a metal selected from the group consisting of: tungsten (W), cobalt (Co), ruthenium (Ru), and combinations thereof.

6. The method of claim 1, further comprising the step of:

depositing a dielectric over the even metal lines, the odd metal lines, and the hardmask.

7. The method of claim 1, further comprising the steps of:

patterning the hardmask over the select metal line using the cut mask; and

transferring a pattern from the hardmask to the select metal line to cut the select metal line.

8. The method of claim 1, wherein a lateral etch is used to enlarge the window in the cut mask.

9. The method of claim 1, further comprising the step of:

polishing the gap fill dielectric after the recessing.

10. The method of claim 1, further comprising the steps of:

cutting the hardmask using a mask having a window that exposes the hardmask over a non-line-end of one of the metal lines to form a gap in the hardmask; and

filling the gap in the hardmask with the gap fill dielectric, whereby the recessing of the metal lines selective to the gap fill dielectric in the gap forms a non-line-end via.

11. The method of claim 1, further comprising the step of:

removing an overhang of the gap fill dielectric such that, by the recessing, a self-aligned via is formed at only one end of the select metal line.

12. ~~The~~ A method of ~~claim 1,~~ forming self-aligned vias at line ends, the method comprising~~:~~ the steps of:

patterning metal lines comprising alternating even and odd metal lines using a hardmask comprising a first hardmask for patterning the even metal lines and a second hardmask for patterning the odd metal lines;

cutting the first hardmask and a select one of the even metal lines using a first cut mask having a window that exposes the first hardmask over a cut region of the select even metal line;

enlarging the window in the first cut mask to expose the first hardmask on either side of the cut region of the select even metal line;

selectively etching the first hardmask using the enlarged window in the first cut mask to form a first T-shaped cavity within the cut region of the select even metal line;

cutting the second hardmask and a select one of the odd metal lines using a second cut mask having a window that exposes the second hardmask over a cut region of the select odd metal line;

enlarging the window in the second cut mask to expose the second hardmask on either side of the cut region of the select odd metal line;

selectively etching the second hardmask using the enlarged window in the second cut mask to form a second T-shaped cavity within the cut region of the select odd metal line;

filling the first T-shaped cavity and the second T-shaped cavity with a gap fill dielectric;

removing the first hardmask and the second hardmask; and

recessing the metal lines selective to the gap fill dielectric, wherein the gap fill dielectric overhangs portions of the select even metal line and the select odd metal line that, by the recessing, form the self-aligned vias at ends of the metal lines.

13. The method of claim 12, wherein the first hardmask and the second hardmask comprise different materials.

14. The method of claim 13, wherein the first hardmask comprises a material selected from the group consisting of: Ti, Ta, TiOx, TiN, TaN, and combinations thereof.

15. The method of claim 13, wherein the second hardmask comprises a material selected from the group consisting of: SiN, SiCN, SiCNH, SiC, and combinations thereof.

16. The method of claim 12, further comprising the step of:

polishing the gap fill dielectric after the recessing.

~~15.~~

17. The method of claim 12, further comprising the steps of:

cutting the first hardmask using a mask having a window that exposes the first hardmask over a non-line-end of one of the even metal lines to form a gap in the first hardmask; and

filling the gap in the first hardmask with the gap fill dielectric, whereby the recessing of the metal lines selective to the gap fill dielectric in the gap in the first hardmask forms a non-line-end via.

~~16.~~ 18. The method of claim 17, further comprising the steps of:

~~———~~cutting the second hardmask using another mask having a window that exposes the second hardmask over a non-line-end of one of the odd metal lines to form a gap in the second hardmask; and

~~———~~filling the gap in the second hardmask with the gap fill dielectric, whereby the recessing of the metal lines selective to the gap fill dielectric in the gap in the second hardmask forms another non-line-end via.

~~17. The~~19. A method of ~~claim 12,~~forming self-aligned vias at line ends, the method comprising~~: cutting~~ the ~~second hardmask~~steps of:

patterning metal lines comprising alternating even and ~~a select one of the~~ odd metal lines using a ~~second~~ hardmask comprising a first hardmask for patterning the even metal lines and a second hardmask for patterning the odd metal lines;

cutting the first hardmask and a select one of the even metal lines using a first cut mask having a window that exposes the ~~second~~first hardmask over a cut region of the select ~~odd~~even metal line;

~~———~~enlarging the window in the ~~second~~first cut mask to expose the ~~second~~first hardmask on either side of the cut region of the select ~~odd~~even metal line;

~~———~~selectively etching the ~~second~~first hardmask using the enlarged window in the ~~second~~first cut mask to form a ~~second~~first T-shaped cavity within the cut region of the select even metal line;

cutting the second hardmask and a select one of the odd metal lines using a second cut mask having a window that exposes the second hardmask over a cut region of the select odd metal line;

~~———~~enlarging the window in the second cut mask to expose the second hardmask on either side of the cut region of the select odd metal line;

selectively etching the second hardmask using the enlarged window in the second cut mask to form a second T-shaped cavity within the cut region of the select odd metal line;

cutting the first hardmask using a mask having a window that exposes the first hardmask over a non-line-end of one of the even metal lines to form a gap in the first hardmask;

~~———~~cutting the second hardmask using another mask having a window that exposes the second hardmask over a non-line-end of one of the odd metal lines to form a gap in the second hardmask;

~~———~~filling the first T-shaped cavity, the second T-shaped cavity, the gap in the first hardmask, and the gap in the second hardmask with a gap fill dielectric;

~~———~~removing the first hardmask and the second hardmask; and

———recessing the metal lines selective to the gap fill dielectric, wherein the gap fill dielectric overhangs portions of the even metal lines that, by the recessing, form the self-aligned vias at ends of the even and odd metal lines, and wherein the recessing of the metal lines selective to the gap fill dielectric in the gap in the first hardmask and the gap fill dielectric in the gap in the second hardmask forms non-line-end vias.

~~18.~~ 20. The method of claim ~~13 or claim 17~~19, wherein the first hardmask comprises a material selected from the group consisting of: Ti, Ta, TiOx, TiN, TaN, and combinations thereof.

~~19.~~ 21. The method of claim ~~13 or claim 17~~19, wherein the second hardmask comprises a material selected from the group consisting of: SiN, SiCN, SiCNH, SiC, and combinations thereof.

~~20.~~ 22. A structure, comprising:

———metal lines;

———a cut in a select one of the metal lines;

———vias aligned with line ends of the select metal line on either side of the cut; and

———a gap fill dielectric in between the line ends and in direct contact with the vias.

~~21.~~ 23. The structure of claim ~~20~~22, wherein a sidewall of each of the vias is coplanar with the line ends of the select metal line.

~~22.~~ 24. The structure of claim ~~20~~22, wherein the metal lines comprise a metal selected from the group consisting of: W, Co, Ru, and combinations thereof.