

CLAIMS

1. A TSV structure planarization process, wherein the TSV structure includes a substrate, vias formed in the substrate, an oxide layer formed on the substrate, a barrier layer formed on the oxide layer, bottom and sidewall of the vias, a metal layer formed in the vias and on the barrier layer, wherein the TSV structure planarization process comprises:

removing most of the metal layer formed at a non-recessed area of the substrate by a stress-free polishing process; and

removing metal layer residual and the barrier layer formed at the non-recessed area by a chemical wet etch process,

wherein the chemical wet etch process comprises a plurality of periodical pulse mode steps, each pulse mode step including applying an etchant on the non-recessed area for a first period of time, and applying DIW on the non-recessed area for a second period of time.

2. The TSV structure planarization process as claimed in claim 1, wherein the chemical wet etch process includes a barrier layer chemical wet etch process.

3. The TSV structure planarization process as claimed in claim 2, wherein a material of the metal layer is copper and a material of the barrier layer contains titanium, and the etchant for the barrier layer chemical wet etch process contains hydrofluoric acid and an additive.

4. The TSV structure planarization process as claimed in claim 1, wherein the step of removing metal layer residual and the barrier layer formed at the non-recessed area by a chemical wet etch process further comprises:

removing metal layer residual formed at the non-recessed area of the substrate by a metal layer chemical wet etch process; and

removing the barrier layer formed at the non-recessed area by a barrier layer chemical wet etch process.

5. The TSV structure planarization process as claimed in claim 4, wherein a material of the metal layer is copper, and the etchant for the metal layer chemical wet etch process contains hydrogen peroxide, an additive and hydrofluoric acid.

6. The TSV structure planarization process as claimed in claim 4, wherein a material of the barrier layer contains titanium, and the etchant for the barrier layer chemical wet etch process contains hydrofluoric acid and an additive.

7. The TSV structure planarization process as claimed in claim 1, wherein after the metal layer residual and the barrier layer formed at the non-recessed area are removed by the chemical wet etch process, the oxide layer under the barrier layer is exposed, and a part of the oxide layer is removed by a CMP process.

8. The TSV structure planarization process as claimed in claim 1, wherein the oxide layer is SiO₂.

9. A TSV structure planarization process, wherein the TSV structure includes a substrate, vias formed in the substrate, an oxide layer formed on the substrate, a barrier layer formed on the oxide layer, bottom and sidewall of the vias, a metal layer formed in the vias and on the barrier layer, wherein the TSV structure planarization process comprises:

removing a large proportion of metal layer formed at a non-recessed area of the substrate by a stress-free polishing process and remaining a certain thickness of the metal layer on the non-recessed area;

removing most of the remaining metal layer formed at the non-recessed area by a metal layer chemical wet etch process,

wherein the metal layer chemical wet etch process comprises a plurality of periodical pulse mode steps, each pulse mode step including applying a first etchant on the non-recessed area for a first period of time, and applying DIW on the non-recessed area for a second period of time; and

removing metal layer residual and the barrier layer formed at the non-recessed area by a barrier layer chemical wet etch process,

wherein the barrier layer chemical wet etch process comprises a plurality of periodical pulse mode steps, each pulse mode step including applying a second etchant on the non-recessed area for a third period of time, and applying DIW on the non-recessed area for a fourth period of time.

10. The TSV structure planarization process as claimed in claim 9, wherein the thickness of the remaining metal layer on the non-recessed area after the stress-free polishing process is 0.2um-0.5um.

11. The TSV structure planarization process as claimed in claim 9, wherein a material of the metal layer is copper, and the first etchant for the metal layer chemical wet etch process contains hydrogen peroxide, an additive and hydrofluoric acid.

12. The TSV structure planarization process as claimed in claim 9, wherein a material of the barrier layer contains titanium, and the second etchant for the barrier layer chemical wet etch process contains hydrofluoric acid and an additive.

13. The TSV structure planarization process as claimed in claim 9, wherein after the metal layer residual and the barrier layer formed at the non-recessed area are removed, the oxide layer under the barrier layer is exposed and a part of the oxide layer is removed by a CMP process.

14. A TSV structure planarization process, wherein the TSV structure includes a substrate, vias formed in the substrate, an oxide layer formed on the substrate, a barrier layer formed on the oxide layer, bottom and sidewall of the vias, a metal layer formed in the vias and on the barrier layer, wherein the TSV structure planarization process comprises:

removing most of the metal layer formed at a non-recessed area of the substrate by a stress-free polishing process;

removing metal layer residual formed at the non-recessed area by a chemical-mechanical-planarization process; and

removing the barrier layer formed at the non-recessed area by a barrier layer chemical wet etch process,

wherein the barrier layer chemical wet etch process comprises a plurality of periodical pulse mode steps, each pulse mode step including applying an etchant on the non-recessed area for a first period of time, and applying DIW on the non-recessed area for a second period of time.

15. The TSV structure planarization process as claimed in claim 14, wherein a material of the barrier layer contains titanium, and the etchant for the barrier layer chemical wet etch process contains hydrofluoric acid and an additive.

16. The TSV structure planarization process as claimed in claim 14, wherein after the barrier layer formed at the non-recessed area is removed, the oxide layer under the barrier layer is exposed, and a part of the oxide layer is removed by a CMP process.

17. A TSV structure planarization process, wherein the TSV structure includes a substrate, vias formed in the substrate, an oxide layer formed on the substrate, a barrier layer formed on the oxide layer, bottom and sidewall of the vias, a metal layer

formed in the vias and on the barrier layer, wherein the TSV structure planarization process comprises:

removing a large proportion of the metal layer formed at a non-recessed area of the substrate by a stress-free polishing process or a metal layer chemical wet etch process and remaining a certain thickness of the metal layer on the non-recessed area;

removing most of the remaining metal layer formed at the non-recessed area by a chemical-mechanical-planarization process; and

removing metal layer residual and the barrier layer formed at the non-recessed area by a barrier layer chemical wet etch process,

wherein the barrier layer chemical wet etch process comprises a plurality of periodical pulse mode steps, each pulse mode step including applying a first etchant on the non-recessed area for a first period of time, and applying DIW on the non-recessed area for a second period of time.

18. The TSV structure planarization process as claimed in claim 17, wherein a material of the metal layer is copper, and a second etchant for the metal layer chemical wet etch process contains hydrogen peroxide, an additive and hydrofluoric acid.

19. The TSV structure planarization process as claimed in claim 17, wherein the metal layer chemical wet etch process comprises a plurality of periodical pulse mode steps, each pulse mode step including applying the second etchant on the non-recessed area for a third period of time, and applying DIW on the non-recessed area for a fourth period of time.

20. The TSV structure planarization process as claimed in claim 17, wherein a material of the barrier layer contains titanium, and the first etchant for the barrier layer chemical wet etch process contains hydrofluoric acid and an additive.

21. The TSV structure planarization process as claimed in claim 17, wherein the thickness of the remaining metal layer on the non-recessed area is 0.2um-0.5um.

22. The TSV structure planarization process as claimed in claim 17, wherein after the metal layer residual and the barrier layer formed at the non-recessed area are removed, the oxide layer under the barrier layer is exposed, and a part of the oxide layer is removed by a CMP process.

23. A TSV structure planarization apparatus, wherein the TSV structure includes a substrate, vias formed in the substrate, an oxide layer formed on the substrate, a barrier layer formed on the oxide layer, bottom and sidewall of the vias, a metal layer formed in the vias and on the barrier layer, wherein the TSV structure planarization apparatus comprises:

at least one SFP module for applying a stress-free polishing process to the substrate to remove the metal layer on a non-recessed area of the substrate;

a CMP module for applying a chemical-mechanical-planarization process to the substrate to remove the metal layer on the non-recessed area; and

a wet etch module for applying a chemical wet etch process to the substrate to remove the metal layer and/or the barrier layer formed at the non-recessed area,

wherein the chemical wet etch process comprises a plurality of periodical pulse mode steps, each pulse mode step including applying an etchant on the non-recessed area for a first period of time, and applying DIW on the non-recessed area for a second period of time.

24. The TSV structure planarization apparatus as claimed in claim 31, wherein the chemical wet etch process includes a metal layer chemical wet etch process and/or a barrier layer chemical wet etch process.

25. The TSV structure planarization apparatus as claimed in claim 31, further comprising:

a metrology module for measuring the thickness of the metal layer;

a brush clean module for cleaning the substrate after the chemical-mechanical-planarization process; and

a clean module for cleaning the substrate after the stress-free polishing process or the chemical wet etch process.