

PRINTING SCREENS, METHODS OF FABRICATING THE SAME AND METHODS OF SCREEN PRINTING

The present invention relates to printing screens, often alternatively referred to as stencils, in particular for printing narrow, elongate structures on substrates, such as the frontside conductors on silicon solar cells, methods of fabricating such printing screens and methods of screen printing.

In silicon photovoltaics, a significant barrier to continued development is the printing of the frontside metallisation, in particular at the junctions of the frontside conductors and busbars, and especially in a single printing operation.

In one aspect the present invention provides a stencil comprising a plurality of first printing apertures and a plurality of second printing apertures which intersect the first printing apertures, wherein the second printing apertures include a web which defines a plurality of sub-apertures.

In another aspect the present invention provides a screen printing method using the above-described stencil, wherein first and second print deposits in intersecting relation are printed in a single printing operation.

In one embodiment a first tension is applied along a length of the first printing apertures and a second tension lower than the first tension is applied across a width of the first printing apertures, optionally the first tension is at least 1.5 times greater than the second tension.

In a further aspect the present invention provides a stencil comprising a plurality of printing apertures, wherein the printing apertures include a web which defines a plurality of sub-apertures.

In a still further aspect the present invention provides a screen printing method for printing first and second print deposits in intersecting relation,

comprising the steps of: printing first print deposits on the workpiece in a first printing operation using the above-described stencil; and printing second print deposits on the workpiece in a second printing operation using a second stencil comprising a plurality of printing apertures.

In one embodiment at least in the second printing operation a first tension is applied along a length of the printing apertures in the second stencil and a second tension lower than the first tension is applied across a width of the printing apertures in the second stencil, optionally the first tension is at least 1.5 times greater than the second tension.

In a yet further aspect the present invention provides a method of fabricating a stencil, comprising the steps of: providing a first patterning layer, optionally a dry film resist, to a mandrel of an electro-forming apparatus; defining apertures in the first patterning layer, leaving an open image in the first patterning layer in which material can be electroformed on the mandrel; building up a first stencil layer of material in the open image in the first patterning layer; providing a second patterning layer, optionally a dry film resist, to the first patterning layer, being of corresponding size and shape to the apertures in the first patterning layer, and being in registration with the apertures in the first patterning layer; and building up a second stencil layer of material in the remaining open image in the first patterning layer.

Preferred embodiments of the present invention will now be described hereinbelow by way of example only with reference to the accompanying drawings, in which:

Figure 1 illustrates a printing screen unit in accordance with a first embodiment of the present invention;

Figure 2 illustrates a fragmentary underside view of a junction of first and second printing apertures in the stencil of the printing screen unit of Figure 1;

Figure 3 illustrates a first vertical sectional view (along section I-I in Figure 2) of the stencil of Figure 2;

Figure 4 illustrates a second vertical sectional view (along section II-II in Figure 2) of the stencil of Figure 2;

Figures 5(a) to (g) illustrate the processing steps (along section I-I in Figure 2) in the fabrication of the stencil of Figure 2;

Figures 6(a) to (g) illustrate the processing steps (along section II-II in Figure 2), counterpart to Figures 5(a) to (g), in the fabrication of the stencil of Figure 2;

Figure 7 illustrates junctions at a frontside metallization line and a frontside busbar printed using the stencil of Figure 2;

Figure 8 illustrates a fragmentary underside view of a junction of first and second printing apertures in one modified stencil of the printing screen unit of Figure 1;

Figure 9 illustrates a fragmentary underside view of a junction of first and second printing apertures in another modified stencil of the printing screen unit of Figure 1;

Figure 10 illustrates a fragmentary underside view of a junction of first and second printing apertures in a further modified stencil of the printing screen unit of Figure 1;

Figure 11 illustrates a first vertical sectional view (along section III-III in Figure 10) of the stencil of Figure 10;

Figure 12 illustrates a second vertical sectional view (along section IV-IV in Figure 10) of the stencil of Figure 10; and

Figure 13 illustrates junctions at a frontside metallization line and a frontside busbar printed using the stencil of Figure 10.

Figures 1 to 6 illustrate a printing screen unit in accordance with a first embodiment of the present invention.

The printing screen unit comprises a stencil 3, in this embodiment a metal foil, which includes a pattern of printing apertures 4 which define an image to be printed, and a frame 5 which supports the stencil 3 and allows for tensioning of the same by tensioning mechanisms separate to the frame 5.

The stencil 3 is formed from first and second layers 7, 9, the first, upper layer 7 providing a surface over which a printing element (not illustrated), such as a squeegee, is traversed and the second, lower layer 9 being in contact with an underlying workpiece, in this embodiment a wafer for a fuel or solar cell.

In this embodiment the first layer 7 is a metal layer which is fabricated prior to the second layer 9.

In this embodiment the first layer 7 is an electroformed layer, here an electroformed nickel layer.

In an alternative embodiment the first layer 7 could be formed from a sheet material by chemical etching or any other suitable cutting technology.

In this embodiment the first layer 7 has a thickness of 50 μm .

In preferred embodiments the first layer 7 has a thickness of from about 20 μm to about 100 μm , optionally from about 30 μm to about 80 μm , optionally from about 40 μm to about 60 μm .

In this embodiment the second layer 9 is a metal layer which is fabricated subsequent to the first layer 7.

In this embodiment the second layer 9 is an electroformed layer, here an electroformed nickel layer.

In an alternative embodiment the second layer 9 could be formed from a sheet material by chemical etching or any other suitable cutting technology.

In this embodiment the second layer 9 has a thickness of 50 μm .

In preferred embodiments the second layer 9 has a thickness of from about 20 μm to about 100 μm , optionally from about 30 μm to about 80 μm , optionally from about 40 μm to about 60 μm .

The first layer 7 includes a plurality of first printing apertures 15, in this embodiment parallel, narrow, elongate linear apertures, here defining the frontside metallization lines of solar cells. For ease of illustration, only one printing aperture 15 is illustrated in Figure 2.

In this embodiment the first printing apertures 15 have an average width W_1 of about 40 μm .

In preferred embodiments the first printing apertures 15 have an average width W_1 of from about 20 μm to about 100 μm , optionally from about 20 μm to about 80 μm , optionally from about 20 μm to about 60 μm , optionally from about 25 μm to about 50 μm .

In this embodiment the first printing apertures 15 have a pitch of about 1.25 mm.

In preferred embodiments the first printing apertures 15 have a pitch of from about 0.5 mm to about 2.5 mm, optionally from about 0.5 mm to about 2.0 mm, optionally from about 1 mm to about 1.5 mm.

The first layer 7 further includes a plurality of second printing apertures 17, here defining the frontside busbars of solar cells, in this embodiment elongate apertures which extend in substantially orthogonal relation to the first printing apertures 15. For ease of illustration, only one second printing aperture 17 is illustrated in Figure 2.

In this embodiment the second printing apertures 17 have an average width W_2 of about 1.25 mm.

In preferred embodiments the second printing apertures 17 have an average width W_2 of from about 0.5 mm to about 2.5 mm, optionally from about 0.5 mm to about 2.0 mm, optionally from about 1 mm to about 1.5 mm.

In this embodiment the second printing apertures 17 are tapered over the length thereof.

In an alternative embodiment the second printing apertures 17 are rectilinear over the length thereof.

The second printing apertures 17 comprise a web 21 which includes a plurality of sub-apertures 23.

In this embodiment the sub-apertures 23 have an open area which reduces in lateral size over at least a section thereof, here at a downstream end thereof, in the printing direction D, such as to present inwardly-tapering surfaces 25.

In this embodiment the inwardly-tapering surfaces 25 are substantially linear.

In this embodiment the inwardly-tapering surfaces 25 enclose an angle β_1 of substantially 90 degrees.

In preferred embodiments the enclosed angle β_1 of the inwardly-tapering surfaces 25 is less than about 120 degrees, optionally less than about 100 degrees.

In preferred embodiments the enclosed angle β_1 of the inwardly-tapering surfaces 25 is greater than about 40 degrees, optionally greater than about 60 degrees.

In an alternative embodiment the inwardly-tapering surfaces 25 are arcuate, such as defined by a smooth curve or a plurality of linear or arcuate segments.

In this embodiment the sub-apertures 23 have an open area which increases in lateral size over at least a section thereof, here at an upstream end thereof, in the printing direction D, such as to present outwardly-tapering surfaces 27.

In this embodiment the outwardly-tapering surfaces 27 are substantially linear.

In this embodiment the outwardly-tapering surfaces 27 enclose an angle β_2 of substantially 90 degrees.

In preferred embodiments the enclosed angle β_2 of the outwardly-tapering surfaces 27 is less than about 120 degrees, optionally less than about 100 degrees.

In preferred embodiments the enclosed angle β_2 of the outwardly-tapering surfaces 27 is greater than about 40 degrees, optionally greater than about 60 degrees.

In an alternative embodiment the outwardly-tapering surfaces 27 are arcuate, such as defined by a smooth curve or a plurality of linear or arcuate segments.

In this embodiment the sub-apertures 23 have an open area which is substantially square shaped, here with opposite corners thereof being aligned in the printing direction D.

In an alternative embodiment the sub-apertures 23 have an open area which is substantially rhombus or diamond shaped, here with opposite corners thereof being aligned in the printing direction D.

In another alternative embodiment the sub-apertures 23 have an open area which is substantially circular shaped.

In still another alternative embodiment the sub-apertures 23 have an open area which is substantially elliptical shaped, with the major axis of the ellipse being aligned in the printing direction D.

In this embodiment the web 21 is formed by a plurality of first elongate web elements 31 which are arranged in parallel relation and a plurality of second elongate web elements 33 which are arranged in parallel relation and in intersecting relation to the first web elements 31.

In this embodiment the first and second web elements 31, 33 are arranged in orthogonal relation.

In this embodiment the first and second web elements 31, 33 each extend in opposite directions at an inclined angle θ_1 , θ_2 to the longitudinal axis of the second printing apertures 17. In this embodiment the inclined angles θ_1 , θ_2 of the first and second web elements 31, 33 are the same.

In this embodiment the web elements 31, 33 have a width d of about 30 μm .

In preferred embodiments the web elements 31, 33 have a width d of from about 15 μm to about 100 μm , optionally from about 15 μm to about 80 μm , optionally from about 15 μm to about 60 μm , optionally from about 15 μm to about 45 μm .

In this embodiment the web elements 31, 33 each have a pitch of about 200 μm .

In preferred embodiments the web elements 31, 33 each have a pitch of from about 100 μm to about 1000 μm , optionally from about 100 μm to about 800 μm , optionally from about 100 μm to about 600 μm , optionally from about 100 μm to about 400 μm , optionally from about 150 μm to about 300 μm .

In this embodiment the inclined angles θ_1 , θ_2 of the first and second web elements 31, 33 are each 45 degrees.

In preferred embodiments the inclined angles θ_1 , θ_2 of the first and second web elements 31, 33 are from about 30 degrees to about 70 degrees, optionally from about 35 degrees to about 65 degrees.

In this embodiment the first printing apertures 15 each have an open junction with respective ones of the sub-apertures 23 of the second printing apertures 17. This arrangement has been found by the inventors to provide

significantly-improved connectivity between the first and second printing apertures 15, 17.

The second layer 9 includes a plurality of first printing apertures 41, in this embodiment parallel, narrow, elongate linear apertures, which are counterpart to the first printing apertures 15 of the first layer 7, here together therewith defining the frontside metallization lines of solar cells. For ease of illustration, only one first printing aperture 41 is illustrated in Figure 2.

The second layer 9 further includes a plurality of second printing apertures 43, in this embodiment elongate apertures which extend in substantially orthogonal relation to the first printing apertures 41, which are counterpart to the second printing apertures 17 of the first layer 7, here together therewith defining the frontside busbars of solar cells,. For ease of illustration, only one second printing aperture 43 is illustrated in Figure 2.

Figures 5(a) to (g) and 6(a) to (g) illustrate a fabrication process for the above-described stencil 3 in accordance with one embodiment of the present invention.

In a first step, as illustrated in Figures 5(a) and (b), a first photo-imageable layer 101 is applied to a mandrel 103 of an electro-forming apparatus. In this embodiment the thickness of the photo-imageable layer 101 corresponds to the combined thickness of the first and second layers 7, 9 of the required stencil 3, here 100 μm in thickness.

In this embodiment the photo-imageable layer 101 is formed from a dry film, such as a dry film resist, which is laminated to the mandrel 103.

In a second step, as illustrated in Figures 5(b) and 6(b), the first and second printing apertures 15, 17 of the first layer 7 and the first printing apertures 41 of the second layer 9 are defined in the photo-imageable layer 101 by

exposure of the photo-imageable layer 101 through a patterned mask, and the unexposed material is then subsequently removed, leaving an open image 105 in the exposed layer 101' in which material can be electroformed on the mandrel 103.

In this embodiment a negative resist is being used, but in other embodiments a positive resist could be used.

In an alternative embodiment the photo-imageable layer 101 could be exposed by direct writing thereof, such as with a laser tool, and the unexposed material is then subsequently removed. Again, in other embodiments, instead of employing a negative resist, a positive resist could be used.

In a third step, as illustrated in Figures 5(c) and 6(c), material 107, in this embodiment nickel, is built up in the open image 105 in the exposed layer 101'. This electroforming process is continued until the deposited material 107 has the thickness required of the first layer 7, in this embodiment 50 μm .

In a fourth step, as illustrated in Figures 5(d) and 6(d), a second photo-imageable layer 111 is applied to the exposed layer 101'. In this embodiment the second photo-imageable layer 111 has a thickness of 50 μm .

In this embodiment the second photo-imageable layer 111 is formed from a dry film, such as a dry film resist, which is applied to exposed layer 101'.

In this embodiment the second photo-imageable layer 111 comprises pre-patterned elements 115 which correspond in size and shape to the second printing apertures 43 of the second layer 9, being in registration with the second printing apertures 17 of the first layer 7, which is already defined by the deposited material 107.

In a fifth step, as illustrated in Figures 5(e) and 6(e), the second photo-imageable layer 111 is hot-roll laminated to the exposed layer 101', causing the second photo-imageable layer 111 to conform to the underlying structure of the exposed layer 101' and enclosing the open image 105 therebelow, and subsequently exposed to provide a second exposed layer 111'.

In a sixth step, as illustrated in Figures 5(f) and 6(f), material 115, in this embodiment nickel, is built up in the remaining open image 105 in the exposed layer 101'. This electroforming process is continued until the deposited material 115 has the thickness required of the second layer 9, in this embodiment 50 μm .

In a seventh and final step, as illustrated in Figures 5(g) and 6(g), the material of the first and second exposed layers 101', 111' is removed, leaving the electroformed stencil 3.

In this embodiment, in use of the stencil 3, a first tension F_1 can be employed along the length of the first printing apertures 15, 41 and a second tension F_2 can be employed across the width of the first printing apertures 15, 41, and along the length of the second printing apertures 17, 43.

In this embodiment the first tension F_1 is at least 1.5 times that of the second tension F_2 , optionally at least 1.75 times, optionally at least 2 times.

In this embodiment the second tension F_2 is less than 25 N, optionally less than 20 N, optionally less than 15 N, optionally less than 10 N.

In this embodiment the second tension F_2 is greater than 2 N, optionally greater than 5 N.

Figure 7 illustrates junctions at a frontside metallization line 201 and a frontside busbar 203 printed using the stencil 3 of the above-described embodiment.

As will be seen, the junctions at the frontside metallization line 201 and the frontside busbar 203 are excellent and the frontside busbar 203 is continuous, having no defect. It is postulated that this improved print is achieved by the operation of the inwardly-tapering faces 25, 27 of the sub-apertures 23 in the second printing apertures 17 of the first layer 7, which are believed to provide pressure concentrations which act to drive print medium into the volume of the second printing apertures 43 of the second layer 9 which are located below the second printing apertures 17 of the first layer 7, and act especially at the junctions of the first printing apertures 15 and the sub-apertures 23 in the second printing apertures 17 of the first layer 7.

Figure 8 illustrates a stencil 3 having a modified junction between the first printing apertures 15 and the respective sub-apertures 23 of the second printing apertures 17. As can be seen, the junctions between the first printing apertures 15 and the respective sub-apertures 23 are open, but the sub-apertures 23 are of different size.

Figure 9 illustrates a stencil 3 having another first modified junction between the first printing apertures 15 and the respective sub-apertures 23 of the second printing apertures 17. As can be seen, the junctions between the first printing apertures 15 and the respective sub-apertures 23 are open, but the sub-apertures 23 are of different size, and the first printing apertures 15 have offset or asymmetric relation to the sub-apertures 23.

Figures 10 to 12 illustrate a printing screen 3 as a modification of the printing screen 3 of the above-described first embodiment.

The printing screen 3 of this embodiment is similar to the printing screen 3 of the above-described embodiment, and thus, in order to avoid unnecessary duplication of description, only the differences will be described in detail, with like parts being designated by like reference signs.

In this embodiment the printing screen 3 differs in the arrangement of the web 21, where the sub-apertures 23 comprise elongate apertures which extend in the printing direction D.

In this embodiment the first web elements 31 have the same pitch as the first-described embodiment, and the second web elements 33 have a greater pitch, here greater than five times the pitch in the first-described embodiment.

Figure 13 illustrates junctions at a frontside metallization line 301 and a frontside busbar 303 printed using the stencil 3 of the above-described embodiment.

As will be seen, the junctions at the frontside metallization line 201 and the frontside busbar 203 have continuity, but this continuity is defect free, as in the prints achieved by the stencil 3 of the first-described embodiment. It had been expected that the stencil 3 of this embodiment would yield better prints than the stencil 3 of the first-described embodiment by virtue of the much reduced area of the web elements 31, 33 in relation to the total area of the second printing apertures 17; it being the understanding in the art that the area occupied by web elements hinders printing performance and the approach in the art being to develop printing apertures having a great an open area as possible. The results achieved by the stencil 3 of the first-described embodiment run counter to the understanding in the art, and thus are very surprising.

Finally, it will be understood that the present invention has been described in its preferred embodiments and can be modified in many different ways

without departing from the scope of the invention as defined by the appended claims.

For example, the stencils 3 of the above-described embodiments have been developed to allow a single printing operation for the printing of frontside metallization lines and busbars, but in an alternative embodiment a dual print process could be employed, with one stencil 3a, to be used in one printing operation, including the first printing apertures 15, 41 and another stencil 3b, to be used in another printing operation, including the second printing apertures 17, 43. Thus, use of these two stencils 3a, 3b in separate printing operations, allows for printing of both frontside metallization lines and busbars. As noted above, in use of the stencil 3a with the first printing apertures 15, 41, a tension can be employed which is substantially greater along the length of the first printing apertures 15, 41.

CLAIMS

1. A stencil comprising a plurality of first printing apertures and a plurality of second printing apertures which intersect the first printing apertures, wherein the second printing apertures include a web which defines a plurality of sub-apertures.
2. The stencil of claim 1, wherein the first printing apertures comprise narrow, elongate apertures, optionally extending in substantially parallel relation, and optionally for printing metallization lines on wafers.
3. The stencil of claim 2, wherein the first printing apertures have an average width of from about 20 μm to about 100 μm , optionally from about 20 μm to about 80 μm , optionally from about 20 μm to about 60 μm , optionally from about 25 μm to about 50 μm .
4. The stencil of claim 2 or 3, wherein the first printing apertures have a pitch of from about 0.5 mm to about 2.5 mm, optionally from about 0.5 mm to about 2.0 mm, optionally from about 1 mm to about 1.5 mm.
5. The stencil of any of claims 1 to 4, wherein the second printing apertures comprise elongate apertures, optionally extending in substantially orthogonal relation to the first printing apertures, and optionally for printing busbars on wafers.
6. The stencil of claim 5, wherein the second printing apertures have an average width of from about 0.5 mm to about 2.5 mm, optionally from about 0.5 mm to about 2.0 mm, optionally from about 1 mm to about 1.5 mm.
7. The stencil of claim 5 or 6, wherein the second printing apertures are tapered over a longitudinal extent thereof.

8. The stencil of claim 5 or 6, wherein the second printing apertures are rectilinear over a longitudinal extent thereof.
9. The stencil of any of claims 1 to 8, wherein the sub-apertures have an open area which reduces in lateral size over at least a section thereof, optionally at a downstream end thereof, in a direction of printing so as to present inwardly-tapering surfaces.
10. The stencil of claim 9, wherein the inwardly-tapering surfaces enclose an angle of less than about 120 degrees, optionally less than about 100 degrees.
11. The stencil of claim 9 or 10, wherein the inwardly-tapering surfaces enclose an angle of greater than about 40 degrees, optionally greater than about 60 degrees.
12. The stencil of any of claims 9 to 11, wherein the inwardly-tapering surfaces are substantially linear.
13. The stencil of any of claims 9 to 11, wherein the inwardly-tapering surfaces are arcuate, optionally as defined by a smooth curve or a plurality of linear or arcuate segments.
14. The stencil of any of claims 1 to 13, wherein the sub-apertures have an open area which increases in lateral size over at least a section thereof, optionally at an upstream end thereof, in a direction of printing so as to present outwardly-tapering surfaces.
15. The stencil of claim 14, wherein the outwardly-tapering surfaces enclose an angle of less than about 120 degrees, optionally less than about 100 degrees.
16. The stencil of claim 14 or 15, wherein the outwardly-tapering surfaces enclose an angle of greater than about 40 degrees, optionally greater than about 60 degrees.

17. The stencil of any of claims 14 to 16 the outwardly-tapering surfaces are substantially linear.
18. The stencil of any of claims 14 to 16, wherein the outwardly-tapering surfaces are arcuate, optionally as defined by a smooth curve or a plurality of linear or arcuate segments.
19. The stencil of any of claims 1 to 18, wherein the sub-apertures have an open area which is substantially square shaped, optionally with opposite corners thereof being aligned in a direction of printing.
20. The stencil of any of claims 1 to 18, wherein the sub-apertures have an open area which is substantially rhombus or diamond shaped, optionally with opposite corners thereof being aligned in a direction of printing.
21. The stencil of any of claims 1 to 18, wherein the sub-apertures have an open area which is substantially circular shaped.
22. The stencil of any of claims 1 to 18, wherein the sub-apertures have an open area which is substantially elliptical shaped, optionally with a major axis of the ellipse being aligned in a direction of printing.
23. The stencil of any of claims 1 to 22, wherein the web is formed by a plurality of first elongate web elements which are arranged in spaced, optionally substantially parallel, relation and a plurality of second elongate web elements which are arranged in spaced, optionally substantially parallel, relation and in intersecting relation to the first web elements.
24. The stencil of claim 23, wherein the first and second web elements are arranged in substantially orthogonal relation.
25. The stencil of claim 23 or 24, wherein the first and second web elements each extend in opposite directions at an inclined angle to a

longitudinal axis of the second printing apertures, and optionally the inclined angles of the first and second web elements are the same.

26. The stencil of claim 25, wherein the inclined angles of the first and second web elements are each from about 30 degrees to about 70 degrees, optionally from about 35 degrees to about 65 degrees, and optionally about 45 degrees.
27. The stencil of any of claims 23 to 26, wherein the web elements have a width of from about 15 μm to about 100 μm , optionally from about 15 μm to about 80 μm , optionally from about 15 μm to about 60 μm , optionally from about 15 μm to about 45 μm .
28. The stencil of any of claims 23 to 27, wherein the web elements each have a pitch of from about 100 μm to about 1000 μm , optionally from about 100 μm to about 800 μm , optionally from about 100 μm to about 600 μm , optionally from about 100 μm to about 400 μm , optionally from about 150 μm to about 300 μm .
29. The stencil of any of claims 1 to 28, wherein the first printing apertures each have an open junction with respective ones of the sub-apertures of the second printing apertures.
30. The stencil of any of claims 1 to 29, wherein the stencil is a sheet metal stencil, optionally electroformed.
31. The stencil of any of claims 1 to 30, wherein the stencil is formed by two layers.
32. The stencil of claim 31, comprising a first, upper layer providing a surface over which a printing element, optionally a squeegee, is traversed and the second, lower layer being contactable with an underlying workpiece, optionally a wafer.
33. The stencil of claim 32, wherein the first layer is fabricated prior to the second layer.

34. The stencil of claim 32 or 33, wherein the first layer is a metal layer.
35. The stencil of any of claims 32 to 34, wherein the first layer is an electroformed layer, optionally an electroformed nickel layer.
36. The stencil of any of claims 32 to 34, wherein the first layer is a cut sheet material, optionally cut by chemical etching.
37. The stencil of any of claims 32 to 36, wherein the first layer has a thickness of from about 20 μm to about 100 μm , optionally from about 30 μm to about 80 μm , optionally from about 40 μm to about 60 μm .
38. The stencil of any of claims 32 to 37, wherein the second layer is a metal layer.
39. The stencil of any of claims 32 to 38, wherein the second layer is an electroformed layer, optionally an electroformed nickel layer.
40. The stencil of any of claims 32 to 38, wherein the second layer is a cut sheet material, optionally cut by chemical etching.
41. The stencil of any of claims 32 to 40, wherein the second layer has a thickness of from about 20 μm to about 100 μm , optionally from about 30 μm to about 80 μm , optionally from about 40 μm to about 60 μm .
42. A stencil comprising a plurality of printing apertures, wherein the printing apertures include a web which defines a plurality of sub-apertures.
43. The stencil of claim 42, wherein the printing apertures comprise elongate apertures, optionally for printing busbars on wafers.
44. The stencil of claim 43, wherein the printing apertures have an average width of from about 0.5 mm to about 2.5 mm, optionally

from about 0.5 mm to about 2.0 mm, optionally from about 1 mm to about 1.5 mm.

45. The stencil of claim 43 or 44, wherein the printing apertures are tapered over a longitudinal extent thereof.
46. The stencil of claim 43 or 44, wherein the printing apertures are rectilinear over a longitudinal extent thereof.
47. The stencil of any of claims 42 to 46, wherein the sub-apertures have an open area which reduces in lateral size over at least a section thereof, optionally at a downstream end thereof, in a direction of printing so as to present inwardly-tapering surfaces.
48. The stencil of claim 47, wherein the inwardly-tapering surfaces enclose an angle of less than about 120 degrees, optionally less than about 100 degrees.
49. The stencil of claim 47 or 48, wherein the inwardly-tapering surfaces enclose an angle of greater than about 40 degrees, optionally greater than about 60 degrees.
50. The stencil of any of claims 47 to 49, wherein the inwardly-tapering surfaces are substantially linear.
51. The stencil of any of claims 47 to 49, wherein the inwardly-tapering surfaces are arcuate, optionally as defined by a smooth curve or a plurality of linear or arcuate segments.
52. The stencil of any of claims 42 to 51, wherein the sub-apertures have an open area which increases in lateral size over at least a section thereof, optionally at an upstream end thereof, in a direction of printing so as to present outwardly-tapering surfaces.

53. The stencil of claim 52, wherein the outwardly-tapering surfaces enclose an angle of less than about 120 degrees, optionally less than about 100 degrees.
54. The stencil of claim 52 or 53, wherein the outwardly-tapering surfaces enclose an angle of greater than about 40 degrees, optionally greater than about 60 degrees.
55. The stencil of any of claims 52 to 54 the outwardly-tapering surfaces are substantially linear.
56. The stencil of any of claims 52 to 54, wherein the outwardly-tapering surfaces are arcuate, optionally as defined by a smooth curve or a plurality of linear or arcuate segments.
57. The stencil of any of claims 42 to 56, wherein the sub-apertures have an open area which is substantially square shaped, optionally with opposite corners thereof being aligned in a direction of printing.
58. The stencil of any of claims 42 to 56, wherein the sub-apertures have an open area which is substantially rhombus or diamond shaped, optionally with opposite corners thereof being aligned in a direction of printing.
59. The stencil of any of claims 42 to 56, wherein the sub-apertures have an open area which is substantially circular shaped.
60. The stencil of any of claims 42 to 56, wherein the sub-apertures have an open area which is substantially elliptical shaped, optionally with a major axis of the ellipse being aligned in a direction of printing.
61. The stencil of any of claims 42 to 60, wherein the web is formed by a plurality of first elongate web elements which are arranged in spaced, optionally substantially parallel, relation and a plurality of second elongate web elements which are arranged in spaced, optionally

substantially parallel, relation and in intersecting relation to the first web elements.

62. The stencil of claim 61, wherein the first and second web elements are arranged in substantially orthogonal relation.
63. The stencil of claim 61 or 62, wherein the first and second web elements each extend in opposite directions at an inclined angle to a longitudinal axis of the printing apertures, and optionally the inclined angles of the first and second web elements are the same.
64. The stencil of claim 63, wherein the inclined angles of the first and second web elements are each from about 30 degrees to about 70 degrees, optionally from about 35 degrees to about 65 degrees, and optionally about 45 degrees.
65. The stencil of any of claims 61 to 64, wherein the web elements have a width of from about 15 μm to about 100 μm , optionally from about 15 μm to about 80 μm , optionally from about 15 μm to about 60 μm , optionally from about 15 μm to about 45 μm .
66. The stencil of any of claims 61 to 65, wherein the web elements each have a pitch of from about 100 μm to about 1000 μm , optionally from about 100 μm to about 800 μm , optionally from about 100 μm to about 600 μm , optionally from about 100 μm to about 400 μm , optionally from about 150 μm to about 300 μm .
67. A screen printing method using the stencil of any of claims 1 to 41, wherein first and second print deposits in intersecting relation are printed in a single printing operation.
68. The method of claim 67, wherein a first tension is applied along a length of the first printing apertures and a second tension lower than the first tension is applied across a width of the first printing

apertures, optionally the first tension is at least 1.5 times greater than the second tension.

69. A screen printing method for printing first and second print deposits in intersecting relation, comprising the steps of:
printing first print deposits on the workpiece in a first printing operation using the stencil of any of claims 42 to 66; and
printing second print deposits on the workpiece in a second printing operation using a second stencil comprising a plurality of printing apertures.
70. The method of claim 69, wherein at least in the second printing operation a first tension is applied along a length of the printing apertures in the second stencil and a second tension lower than the first tension is applied across a width of the printing apertures in the second stencil, optionally the first tension is at least 1.5 times greater than the second tension.
71. A method of fabricating a stencil, comprising the steps of:
providing a first patterning layer to a mandrel of an electro-forming apparatus;
defining apertures in the first patterning layer, leaving an open image in the first patterning layer in which material can be electroformed on the mandrel;
building up a first stencil layer of material in the open image in the first patterning layer;
providing a second patterning layer to the first patterning layer, being of corresponding size and shape to the apertures in the first patterning layer, and being in registration with the apertures in the first patterning layer; and
building up a second stencil layer of material in the remaining open image in the first patterning layer.

72. The method of claim 71, wherein the first patterning layer comprises a dry film which is laminated to the mandrel.
73. The method of claim 71 or 72, wherein the step of defining apertures in the first patterning layer comprises exposing the first patterning layer, optionally using a patterning mask or by direct writing.
74. The method of any of claims 71 to 73, wherein the first stencil layer is built up to have a thickness which is less than the thickness of the first patterning layer.
75. The method of any of claims 71 to 74, wherein the second patterning layer comprises a dry film.
76. The method of any of claims 71 to 75, wherein the second patterning layer comprises pre-patterned elements corresponding in size and shape to the apertures in the first patterning layer.
77. The method of any of claims 71 to 76, wherein the second patterning layer conforms to the underlying structure of the first patterning layer and encloses the open image therebelow.
78. The method of claim 77, wherein the second patterning layer is hot-roll laminated to the first patterning layer, causing the second patterning layer to conform to the underlying structure of the first patterning layer and enclosing the open image therebelow.
79. The method of any of claims 71 to 78, wherein the second stencil layer is built up to have a thickness which is the same as the thickness of the first patterning layer.
80. The method of any of claims 71 to 79, further comprising the step of: removing the first and second patterning layers subsequent to the step of building up the second stencil layer.