

CLAIMS

1. An article comprising:
 - an electronic display having a viewable region;
 - a transparent, insulating substrate having a surface; and
 - a force-sensing element comprising at least one micropattern of metallic traces disposed upon the surface of the substrate,wherein the transparent insulating substrate is disposed upon the electronic display, and
wherein the force-sensing element overlays at least a portion of the viewable region of the electronic display without substantially obscuring the viewable region of the display.
2. An article according to claim 1, further comprising a transparent positional touch-sensing element.
3. An article according to claim 1, wherein the transparent insulating substrate comprises a polymer sheet or a glass sheet.
4. An article according to claim 3, wherein the polymer sheet comprises poly(methylmethacrylate), polycarbonate, or glass.
5. An article according to claim 1, wherein the metallic traces comprise silver, gold, palladium, platinum, copper, nickel, aluminum, molybdenum, or tungsten.

6. An article according to claim 1, wherein the force-sensing element comprises a lateral resistive strain gauge sensing element.

7. An article according to claim 1 wherein the force-sensing element has an open area fraction of at least 80 percent.

8. An article according to claim 1 wherein the metallic traces have a width between 0.5 micrometers and 20 micrometers.

9. An article comprising:

an electronic display having a viewable region;

a transparent, insulating substrate disposed upon at least a portion of the viewable region of the electronic display; and

a touch sensor disposed upon a surface of the substrate that overlays at least a portion of the viewable region of the electronic display;

wherein the touch sensor comprises a force-sensing element,

wherein the force-sensing element comprises a first set of bands of micromesh and a second set of bands of micromesh,

wherein the bands of micromesh each comprise traces of a metallic conductor,

wherein the first and second sets of bands of micromesh occupy substantially parallel planes that are spaced apart in the direction normal to the planes, and

wherein at least one band of the first set of bands of micromesh crosses over at least one band of the second set of bands of micromesh.

10. An article according to claim 9 further comprising a positional touch-sensing element that overlays at least a portion of the viewable region of the display without substantially obscuring the viewable region of the display.
11. An article according to claim 9, wherein the force-sensing element comprises a piezoresistive material, a piezoelectric material, or a capacitive force-sensing element.
12. An article according to claim 11, wherein the piezoresistive material comprises transparent conductive particles dispersed in a matrix.
13. An article according to claim 12, wherein the transparent conductive particles comprise indium tin oxide.
14. An article according to claim 11, wherein the piezoelectric material comprises a polymer.
15. An article according to claim 14, wherein the piezoelectric material comprises polyvinylidene fluoride or its derivatives.
16. An article according to claim 9, wherein the force-sensing element comprises a resistive strain gauge element.

17. An article according to claim 9, wherein the substantially parallel bands of micromesh comprise traces having a width of from about 0.5 micrometers to about 10 micrometers.

18. An article according to claim 9, wherein the micromesh of the force-sensing element has an open area fraction of at least 80 percent.

19. An article according to claim 9, wherein the first set of bands of micromesh is oriented such that the substantially parallel bands of micromesh are substantially orthogonal to the substantially parallel bands of micromesh in the second set of bands of micromesh.

20. An article according to claim 19, wherein each substantially parallel band of micromesh comprises an electrode.

21. An article according to claim 20, wherein the force-sensing element comprises one electrode from each set of parallel bands of micromesh, and wherein the force-sensing element is located where the bands cross.

CLAIMS

1. An article comprising:
an electronic display having a viewable region;
a transparent, insulating substrate having a surface; and
a force-sensing element comprising at least one micropattern of metallic traces disposed upon the surface of the substrate,
wherein the transparent insulating substrate is disposed upon the electronic display, and
wherein the force-sensing element overlays at least a portion of the viewable region of the electronic display without substantially obscuring the viewable region of the display.
2. An article according to claim 1, further comprising a transparent positional touch-sensing element.
3. An article according to claim 1, wherein the transparent insulating substrate comprises a polymer sheet or a glass sheet.
4. An article according to claim 3, wherein the polymer sheet comprises poly(methylmethacrylate), polycarbonate, or glass.
5. An article according to claim 1, wherein the metallic traces comprise silver, gold, palladium, platinum, copper, nickel, aluminum, molybdenum, or tungsten.
6. An article according to claim 1, wherein the force-sensing element comprises a lateral resistive strain gauge sensing element.
7. An article according to claim 1 wherein the force-sensing element has an open area fraction of at least 80 percent.
8. An article according to claim 1 wherein the metallic traces have a width between 0.5 micrometers and 20 micrometers.

9. An article comprising:
 - an electronic display having a viewable region;
 - a transparent, insulating substrate disposed upon at least a portion of the viewable region of the electronic display; and
 - a touch sensor disposed upon a surface of the substrate that overlays at least a portion of the viewable region of the electronic display;wherein the touch sensor comprises a force-sensing element, wherein the force-sensing element comprises a first set of bands of micromesh and a second set of bands of micromesh, wherein the bands of micromesh each comprise traces of a metallic conductor, wherein the first and second sets of bands of micromesh occupy substantially parallel planes that are spaced apart in the direction normal to the planes, and wherein at least one band of the first set of bands of micromesh crosses over at least one band of the second set of bands of micromesh.
10. An article according to claim 9 further comprising a positional touch-sensing element that overlays at least a portion of the viewable region of the display without substantially obscuring the viewable region of the display.
11. An article according to claim 9, wherein the force-sensing element comprises a piezoresistive material, a piezoelectric material, or a capacitive force-sensing element.
12. An article according to claim 11, wherein the piezoresistive material comprises transparent conductive particles dispersed in a matrix.
13. An article according to claim 12, wherein the transparent conductive particles comprise indium tin oxide.
14. An article according to claim 11, wherein the piezoelectric material comprises a polymer.
15. An article according to claim 14, wherein the piezoelectric material comprises polyvinylidene fluoride or its derivatives.

16. An article according to claim 9, wherein the force-sensing element comprises a resistive strain gauge element.

17. An article according to claim 9, wherein the substantially parallel bands of micromesh comprise traces having a width of from about 0.5 micrometers to about 10 micrometers.

18. An article according to claim 9, wherein the micromesh of the force-sensing element has an open area fraction of at least 80 percent.

19. An article according to claim 9, wherein the first set of bands of micromesh is oriented such that the substantially parallel bands of micromesh are substantially orthogonal to the substantially parallel bands of micromesh in the second set of bands of micromesh.

20. An article according to claim 19, wherein each substantially parallel band of micromesh comprises an electrode.

21. An article according to claim 20, wherein the force-sensing element comprises one electrode from each set of parallel bands of micromesh, and wherein the force-sensing element is located where the bands cross.

22. The article of claim 1, wherein the micropattern has an open area fraction of between 80 and 99.75 percent, wherein the metallic traces have a width of between 0.5 and 20 micrometers,

23. The article of claim 22, wherein the force-sensing element comprises a lateral resistive strain gauge sensing element.

24. The article of claim 22, further comprising a second force-sensing element, wherein the second force-sensing element overlays at least a portion of the viewable region of the electronic display without substantially obscuring the viewable region of the display.

25. The article of claim 22, wherein the width is about $[X + 0.5]$ in units of micrometers, and the open area fraction is between about $[95 - X]$ % and 99.5%, where $0 \leq X \leq 4.5$.

26. The article of claim 22, wherein the width is about $[X + 0.5]$ in units of micrometers, and the open area fraction is between about $[98.5 - (2.5X \div 3.5)]$ % and $[99.5 - (X \div 3.5)]$ %, where $0 \leq X \leq 3.5$.

27. The article of claim 9, wherein each of the first and second sets of bands of micromesh has an open area fraction of between 80 and 99.75 percent, and wherein the traces have a width of between 0.5 and 20 micrometers.

28. The article of claim 27, wherein the force-sensing element comprises a resistive strain gauge.

29. The article of claim 27, wherein the width is about $[X + 0.5]$ in units of micrometers, and the open area fraction is between about $[95 - X]$ % and 99.5%, where $0 \leq X \leq 4.5$.

30. The article of claim 27, wherein the width is about $[X + 0.5]$ in units of micrometers, and the open area fraction is between about $[98.5 - (2.5X \div 3.5)]$ % and $[99.5 - (X \div 3.5)]$ %, where $0 \leq X \leq 3.5$.