

SUMMARY OF THE INVENTION

According to the invention there is provided a method for
5 laminating a shaped metal foil and a thin isotropic uncured
and ungelled dielectric thermosetting resin film layer and
forming an adhesively joined laminate conforming at one
surface to essentially the shape of the metal foil which
comprises superimposing a shaping tool containing a surface
10 containing the desired shape and forcing the shaped surface
and a surface of the metal foil into intimate contact to
deform the metal foil to assume essentially the shapes of the
surface, separating the metal foil from contact with the
surface and putting the shaped metal foil in contact with a
15 surface of a thin uncured and ungelled thermosetting resin
film, which resin film contains, as its major ingredients,

(i) a thermosetting resin that advances in molecular weight
without forming a significant volatile byproduct, and

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(ii) a flow control component capable of laminating a three
dimensionally shaped debossed foil, in which the resin film
has

25 a) an uniform areal thickness ranging from about 1 to about
250 mils as calculated from the weight of resin film for a
given area;

b) minimum and maximum thicknesses not exceeding the deviation factors set forth in Table A

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TABLE A

Range in Mils	Deviation Factor
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1 to 5	± 1 mil
5 to 10	± 2 mils
10 to 250	$\pm 20\%$

15 c) low flow at a broad temperature range;

d) the ability, to cure, gel, or near-gel, at temperatures from about 20.degree. C. to about 250.degree. C., in less than about 7 days and more than 1 second; and

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e) a low dielectric constant in the thermoset state; wherein the flow control agent is one or more of:

i) one or more electronic grade fillers; ii) a thermoplastic

25 resin that is soluble or partially soluble in the thermosetting resin;

iii) an elastomer-type polymer that provides discrete

elastomer phases in the thermosetting resin matrix; and

- 5 iv) a thixotrope; impressing the foil into the film surface
without significantly altering the shape of the foil and
causing the film surface to deform and assume the shape of
the foil, applying conditions to the film such that the film
assumes a set condition and the foil is adhesively bonded to
10 the film.

This invention relates to the processing of materials and their combination to produce a thin foil-laminated adhesive dielectric thermosetting resin film and the conversion of it by a mechanical debossing procedure to impart a debossed and/or embossed printed circuit pattern directly thereon. This invention is used to form a thin film PB or any other fine line circuitry elements that avoid CTE mismatches. The invention also relates to the formation of a PB from these components.

More particularly, this invention relates to a process for compositing a shaped metal foil containing a debossed electrical circuitry pattern and an uncured and ungelled thermosetting resin film and forming an adhesively joined composite conforming essentially to the shape of the metal foil. The process comprises placing a shaping tool with a surface possessing an embossed electrical circuitry pattern, as described in the prior art, and forcing the shaped surface and a surface of the metal foil into intimate contact whereby to deform the metal foil to assume essentially the shape of the surface. The shaped metal foil is separated from contact with the surface. The separated metal foil is placed in contact with a thin uncured and ungelled thermosetting resin film. It is forced into the film without significantly altering its shape. This causes the film to deform and assume the shape of the foil. The ambient condition associated with the film in contact with the foil are such that the film assumes a set condition and the foil is adhesively bonded to the film.

This invention relates to the use of a thin isotropic thermosetting resin film that is amenable to

Claims

1. A method for laminating a shaped metal foil and a thin isotropic uncured and ungelled dielectric thermosetting resin film layer and forming an adhesively joined laminate conforming at one surface to essentially the shape of the metal foil which comprises superimposing a shaping tool containing a surface containing the desired shape and forcing the shaped surface and a surface of the metal foil into intimate contact to deform the metal foil to assume essentially the shapes of the surface, separating the metal foil from contact with the surface and putting the shaped metal foil in contact with a surface of a thin uncured and ungelled thermosetting resin film, which resin film contains, as its major ingredients,

(i) a thermosetting resin that advances in molecular weight without forming a significant volatile byproduct, and

(ii) a flow control component capable of laminating a three dimensionally shaped debossed foil, in which the resin film has

a) an uniform areal thickness ranging from about 1 to about 250 mils as calculated from the weight of resin film for a given area;

b) minimum and maximum thicknesses not exceeding the deviation factors set forth in Table A

5 TABLE A

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c) low flow at a broad temperature range;

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d) the ability, to cure, gel, or near-gel, at temperatures from about 20°C to about 250°C, in less than about 7 days and more than 1 second; and

20 e) a low dielectric constant in the thermoset state; wherein the flow control agent is one or more of:

i) one or more electronic grade fillers;

25 ii) a thermoplastic resin that is soluble or partially soluble in the thermosetting resin;

iii) an elastomer-type polymer that provides discrete elastomer phases in the thermosetting resin matrix; and

iv) a thixotrope; impressing the foil into the film surface without significantly altering the shape of the foil and causing the film surface to deform and assume the shape of the foil, applying conditions to the film such that the film assumes a set condition and the foil is adhesively bonded to the film.

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2. The method of claim wherein the foil is debossed with a tool containing a raised electrical circuit pattern thereon, which comprises the step of impressing the tool onto the foil layer surface thereby causing the foil layer to be debossed by the raised electrical circuit pattern on the tool.

3. The method of claim 2 wherein the debossed laminate is subjected to conditions that effect one of near-gelation, gelation and cure of the attached resin film and adheres the retained pattern of the metal foil layer in the resin layer of the laminate.

4. The method of claim 3 wherein the laminate is heated to effect one or more of cure and post cure of the attached resin film.

5. The method of claim 2 wherein the pattern on the tool comprises embossed fine lines characterizing an electrical circuit of a PB.
- 5 6. The method of claim 3 wherein the pattern on the tool comprises embossed fine lines characterizing an electrical circuit of a PB.
7. The method of claim 4 wherein the pattern on the tool
10 comprises embossed fine lines characterizing an electrical circuit of a PB.
8. The method of claim 5 wherein the electrical circuit pattern debossed in the foil comprising one or more of
15 grooves, cavities, channels, ridges, sockets and plateaus.
9. The method of claim 1 wherein the dielectric thermosetting resin film layer exhibits controlled-flow and exhibits flow under pressure at a temperature below the near-gel and gel
20 temperature of the thermosetting resin.
10. The method of claim 2 wherein the dielectric thermosetting resin film layer exhibit controlled-flow and exhibits flow under pressure at a temperature below the
25 near-gel and gel temperature of the thermosetting resin.

11. The method of claim 3 whereto the dielectric thermosetting resin film layer exhibits controlled-flow and exhibits flow under pressure at a temperature below the near-gel and gel temperature of the thermosetting resin.

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12. The method of claim 4 wherein the dielectric thermosetting resin film layer exhibits controlled-flow and exhibits flow under pressure at a temperature below the near-gel and gel temperature of the thermosetting resin.

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13. The method of claim 1 wherein the surface of the dielectric thermosetting resin film layer that is opposite to the surface that contacts the debossed metal foil is adhesively bonded to a supporting layer.

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14. The method of claim 2 wherein the surface of the dielectric thermosetting resin film layer that is opposite to the surface that contacts the debossed metal foil is adhesively bonded to a supporting layer.

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15. The method of claim 3 wherein the surface of the dielectric thermosetting resin film layer that is opposite to the surface that contacts the debossed metal foil is adhesively bonded to a supporting layer.

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16. The method of claim 4 wherein the surface of the dielectric thermosetting resin film layer that is opposite to the surface that contacts the debossed metal foil is adhesively bonded to a supporting layer.

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17. The method of claim 1 wherein the supporting layer comprises a fabric.

18. The method of claim 1 wherein the supporting layer
10 comprises a thermoplastic polymer.

19. The method of claim 1 wherein the supporting layer comprises fibers.

15 20. The method of claim 2 wherein the supporting layer comprises a fabric.

21. The method of claim 2 wherein the supporting layer comprises a thermoplastic polymer.

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22. The method of claim 2 wherein the supporting layer comprises fibers.

23. The method of claim 3 wherein the supporting layer
25 comprises a fabric.

24. The method of claim 3 wherein the supporting layer comprises a thermoplastic polymer.

25. The method of claim 3 wherein the supporting layer
5 comprises fibers.

26. The method of claim 4 wherein the supporting layer comprises a fabric.

10 27. The method of claim 4 wherein the supporting layer comprises a thermoplastic polymer.

28. The method of claim 4 wherein the supporting layer comprises fibers.

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29. The method of claim 1, wherein the electrically conductive metal foil layer is deposited or wrought foil and has an uniform thickness between about 0.1 mil (2.54×10^{-4} cm) to about 20 mils (5.08×10^{-2} cm); varying ± 10 percent for
20 deposited foils and ± 5 percent for wrought foils.

30. The method of claim 2 wherein the electrically conductive metal foil layer is deposited or wrought foil and has an uniform thickness between about 0.1 mil (2.54×10^{-4} cm)

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to about 20 mils ($5.08 \times 10^{-2}\text{cm}$); varying ± 10 percent for deposited foils and ± 5 percent for wrought foils.

31. The method of claim 3 wherein the electrically conductive metal foil layer is deposited or wrought foil and has an uniform thickness between about 0.1 mil ($2.54 \times 10^{-4}\text{cm}$) to about 20 mils ($5.08 \times 10^{-2}\text{cm}$); varying ± 10 percent for deposited foils and ± 5 percent for wrought foils.

32. The method of claim 4 wherein the electrically conductive metal foil layer is deposited or wrought foil and has an uniform thickness between about 0.1 mil ($2.54 \times 10^{-4}\text{cm}$) to about 20 mils ($5.08 \times 10^{-2}\text{cm}$); varying ± 10 percent for deposited foils and ± 5 percent for wrought foils.

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33. The method of claim 1 wherein the dielectric resin film has an unimpeded thickness that is at least equal to that of the foil film bonded to it.

34. The method of claim 2 wherein the dielectric resin film has an unimpeded thickness that is at least equal to that of the foil film bonded to it.

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35. The method of claim 3 wherein the dielectric resin film has an unimpeded thickness that is at least equal to that of the foil film bonded to it.

5 36. The method of claim 4 wherein the dielectric resin film has an unimpeded thickness that is at least equal to that of the foil film bonded to it.

37. The method of claim 29 wherein the dielectric resin film
10 has an unimpeded thickness that is at least equal to that of the foil film bonded to it.

38. The method of claim 30 wherein the dielectric resin film has an unimpeded thickness that is at least equal to that of
15 the foil film bonded to it.

39. The method of claim 32 wherein the dielectric resin film has an unimpeded thickness that is at least equal to that of the foil film bonded to it.

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40. The method of claim 33 wherein the dielectric resin film has an unimpeded thickness that is at least about 1.2 times thicker than the thickness of the foil film.

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41. The method of claim 34 wherein the dielectric resin film has an unimpeded thickness that is at least about 1.2 times thicker than the thickness of the foil film.

5 42. The method of claim 35 wherein the dielectric resin film has an unimpeded thickness that is at least about 1.2 times thicker than the thickness of the foil film.

43. The method of claim 36 wherein the dielectric resin film
10 has an unimpeded thickness that is at least about 1.2 times thicker than the thickness of the foil film.

44. The method of claim 37 wherein the dielectric resin film has an unimpeded thickness that is at least about 1.2 times
15 thicker than the thickness of the foil film.

45. The method of claim 38 wherein the dielectric resin film has an unimpeded thickness that is at least about 1.2 times thicker than the thickness of the foil film.

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46. The method of claim 39 wherein the dielectric resin film has an unimpeded thickness that is at least about 1.2 times thicker than the thickness of the foil film.

25 47. The method of claim 1 wherein the thermosetting resin is isotropic wherein the method is carried out in batch mode.

48. The method of claim 2 wherein the thermosetting resin is isotropic wherein the method is carried out in batch mode.

49. The method of claim 3 wherein the thermosetting resin is isotropic wherein the method is carried out in batch mode.

50. The method of claim 1 carried out as a batch process wherein the method is carried out in batch mode.

51. The method of claim 2 carried out as a batch process wherein part of the method is carried out in continuous mode.

52. The method of claim 3 carried out as a batch process wherein part of the method is carried out in continuous mode.

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53. The method of claim 1 carried out as a batch process wherein part of the method is carried out in continuous mode.

54. The method of claim carried out as a semi-continuous process.

55. The method of claim 2 carried out as a semi-continuous process wherein all of the method is carried out in continuous mode.

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56. The method of claim 3 carried out as a semi-continuous process wherein all of the method is carried out in continuous mode.

5 57. The method of claim 4 carried out as a semi-continuous process wherein all of the method is carried out in continuous mode.

58. The method of claim 1 carried out as a continuous process
10 wherein all of the method is carried out in continuous mode.

59. The method of claim 2 carried out as a continuous process.

15 60. The method of claim 3 carried out as a continuous process.

61. The method of claim 4 carried out as a continuous process.

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62. The method of claim 1 wherein either the surface of the metal foil that is to contact the thermosetting resin film, or the thermosetting resin film before contacting the metal foil, has printed on it a release agent coating that
25 replicates the non-raised portion of the raised electrical circuit pattern which is to be debossed into the foil-resin composite.

63. The method of claim 62 wherein the printing may be effected by a release agent deposition step effected by transferring release agent from a) transfer sheets to the metal foil film, or b) through screens to the metal foil
5 film, or c) by application from rotogravure rolls, to the metal foil film.