We Claim:

1. A temporary bonding method comprising:

providing a stack comprising:

a first substrate having a back surface and a device surface;

a first bonding layer adjacent said device surface and having a softening temperature;

a second bonding layer adjacent said first bonding layer and having a softening temperature, wherein the softening temperature of said first bonding layer is at least about 20°C greater than the softening temperature of said second bonding layer; and

a second substrate having a carrier surface, said second bonding layer being adjacent said carrier surface; and

separating said first and second substrates.

2. The method of claim 1, wherein said first bonding layer has a thickness T_1 of at least about 24 μm.

3. The method of claim 1, wherein said second bonding layer has a thickness T_3 of less than about 35 μm.

4. The method of claim 1, wherein said first bonding layer has a softening point of at least about 100°C.

5. The method of claim 1, wherein said second bonding layer has a softening point of less than about 220°C.

6. The method of claim 1, wherein said first bonding layer is formed from a composition comprising a polymer or oligomer dissolved or dispersed in a solvent system, said polymer or oligomer being selected from the group consisting of polymers and oligomers of cyclic olefins, epoxies, acrylics, silicones, styrenics, vinyl halides, vinyl esters, polyamides, polyimides, polysulfones, polyethersulfones, cyclic olefins, polyolefin rubbers, and polyurethanes, ethylene-propylene rubbers, polyamide esters, polyimide esters, polyacetals, and polyvinyl buterol.

7. The method of claim 1, wherein said second bonding layer is formed from a composition comprising a polymer or oligomer dissolved or dispersed in a solvent system, said polymer or oligomer being selected from the group consisting of polymers and oligomers of cyclic olefins, epoxies, acrylics, silicones, styrenics, vinyl halides, vinyl esters, polyamides, polyimides, polysulfones, polyethersulfones, cyclic olefins, polyolefin rubbers, and polyurethanes, ethylene-propylene rubbers, polyamide esters, polyimide esters, polyacetals, and polyvinyl buterol.

8. The method of claim 1, wherein said device surface comprises an array of devices selected from the group consisting of integrated circuits; MEMS; microsensors; power semiconductors; light-emitting diodes; photonic circuits; interposers; embedded passive devices; and microdevices fabricated on or from silicon, silicon-germanium, gallium arsenide, and gallium nitride.

9. The method of claim 1, wherein said second substrate comprises a material selected from the group consisting of silicon, sapphire, quartz, metal, glass, and ceramics.

10. The method of claim 1, said device surface comprising at least one structure selected from the group consisting of: solder bumps; metal posts; metal pillars; and structures formed from a material selected from the group consisting of silicon, polysilicon, silicon dioxide, silicon (oxy)nitride, metal, low k dielectrics, polymer dielectrics, metal nitrides, and metal silicides.

11. The method of claim 1, further comprising subjecting said stack to processing selected from the group consisting of back-grinding, chemical-mechanical polishing, etching, metal and dielectric deposition, patterning, passivation, annealing, and combinations thereof, prior to separating said first and second substrates.

12. The method of claim 1, wherein said separating comprises heating said stack to a temperature sufficiently high so as to soften said second bonding layer sufficiently to allow said first and second substrates to be separated.

13. The method of claim 12, further comprising removing said first bonding layer from said first substrate after said separating.

14. The method of claim 12, wherein at least some of said first bonding layer remains on said first substrate after said separating and is present during subsequent processing steps.

15. An article comprising:

a first substrate having a back surface and a device surface;

a first bonding layer adjacent said device surface and having a softening temperature;

a second bonding layer adjacent said first bonding layer and having a softening temperature, wherein the softening temperature of said first bonding layer is at least about 20°C greater than the softening temperature of said second bonding layer; and

a second substrate having a carrier surface, said second bonding layer being adjacent said carrier surface.

16. The article of claim 15, wherein said first bonding layer has a thickness T_1 of at least about 24 μm.

17. The article of claim 15, wherein said second bonding layer has a thickness T_3 of less than about 35 μm.

18. The article of claim 15, wherein said first bonding layer has a softening point of at least about 100°C.

19. The article of claim 15, wherein said second bonding layer has a softening point of less than about 220°C.

20. The article of claim 15, wherein said first bonding layer is formed from a composition comprising a polymer or oligomer dissolved or dispersed in a solvent system, said polymer or oligomer being selected from the group consisting of polymers and oligomers of cyclic olefins, epoxies, acrylics, silicones, styrenics, vinyl halides, vinyl esters, polyamides, polyimides, polysulfones, polyethersulfones, cyclic olefins, polyolefin rubbers, and polyurethanes, ethylene-propylene rubbers, polyamide esters, polyimide esters, polyacetals, and polyvinyl buterol.

21. The article of claim 15, wherein said second bonding layer is formed from a composition comprising a polymer or oligomer dissolved or dispersed in a solvent system, said polymer or oligomer being selected from the group consisting of polymers and oligomers of cyclic olefins, epoxies, acrylics, silicones, styrenics, vinyl halides, vinyl esters, polyamides, polyimides, polysulfones, polyethersulfones, cyclic olefins, polyolefin rubbers, and polyurethanes, ethylene-propylene rubbers, polyamide esters, polyimide esters, polyacetals, and polyvinyl buterol.

22. The article of claim 15, wherein said device surface comprises an array of devices selected from the group consisting of integrated circuits; MEMS; microsensors; power semiconductors; light-emitting diodes; photonic circuits; interposers; embedded passive devices; and microdevices fabricated on or from silicon, silicon-germanium, gallium arsenide, and gallium nitride.

23. The article of claim 15, wherein said second substrate comprises a material selected from the group consisting of silicon, sapphire, quartz, metal, glass, and ceramics.

24. The article of claim 15, said device surface comprising at least one structure selected from the group consisting of: solder bumps; metal posts; metal pillars; and structures formed from a material selected from the group consisting of silicon, polysilicon, silicon dioxide, silicon (oxy)nitride, metal, low k dielectrics, polymer dielectrics, metal nitrides, and metal silicides.

25. A temporary bonding method comprising:

providing a stack comprising:

a first substrate having a back surface and a device surface;

a first rigid layer adjacent said device surface;

a bonding layer adjacent said first rigid layer; and

a second substrate having a carrier surface, said bonding layer being adjacent said carrier surface, wherein said stack further comprises one or both of the following:

a lift-off layer between said device surface and said first rigid layer; or

a second rigid layer between said bonding layer and said carrier surface; and

separating said first and second substrates.

26. The method of claim 25, said first rigid layer and bonding layer having respective softening temperatures, wherein the softening temperature of said first rigid layer is at least about 20°C greater than the softening temperature of said bonding layer.

27. The method of claim 25, wherein said first rigid layer has a thickness T_3 of from about 1 μm to about 35 μm.

28. The method of claim 25, wherein said bonding layer has a thickness T_3 of from about 1 μm to about 35 μm.

29. The method of claim 25, wherein said stack comprises said lift-off layer, and said lift-off layer has a thickness T_1 of less than about 3 μm.

30. The method of claim 25, wherein said stack comprises said second rigid layer, and said second rigid layer has a thickness T_3 of from about 1 μm to about 35 μm.

31. The method of claim 25, wherein said stack comprises said second rigid layer, and said second rigid layer and said bonding layer have respective softening temperatures, and the softening temperature of said second rigid layer is at least about 20°C greater than the softening temperature of said bonding layer.

32. The method of claim 25, wherein said first rigid layer has a softening point of at least about 100°C.

33. The method of claim 25, wherein said bonding layer has a softening point of less than about 220°C.

34. The method of claim 25, wherein said bonding layer is formed from a composition comprising a polymer or oligomer dissolved or dispersed in a solvent system, said polymer or oligomer being selected from the group consisting of polymers and oligomers of cyclic olefins, epoxies, acrylics, silicones, styrenics, vinyl halides, vinyl esters, polyamides, polyimides, polysulfones, polyethersulfones, cyclic olefins, polyolefin rubbers, and polyurethanes, ethylene-propylene rubbers, polyamide esters, polyimide esters, polyacetals, and polyvinyl buterol.

35. The method of claim 25, wherein said first rigid layer is formed from a composition comprising a polymer or oligomer dissolved or dispersed in a solvent system, said polymer or oligomer being selected from the group consisting of polymers and oligomers of cyclic olefins, epoxies, acrylics, silicones, styrenics, vinyl halides, vinyl esters, polyamides, polyimides, polysulfones, polyethersulfones, cyclic olefins, polyolefin rubbers, and polyurethanes, ethylene-propylene rubbers, polyamide esters, polyimide esters, polyacetals, and polyvinyl buterol.

36. The method of claim 25, wherein said stack comprises said lift-off layer, and said lift-off layer is formed from a composition comprising a polymer dissolved or dispersed in a solvent system, said polymer being selected from the group consisting of poly(vinyl pyridine) and polyamic acids.

37. The method of claim 25, wherein said stack comprises said second rigid layer, and said second rigid layer is formed from a composition comprising a polymer or oligomer dissolved or dispersed in a solvent system, said polymer or oligomer being selected from the group consisting of polymers and oligomers of cyclic olefins, epoxies, acrylics, silicones, styrenics, vinyl halides, vinyl esters, polyamides, polyimides, polysulfones, polyethersulfones, cyclic olefins, polyolefin rubbers, and polyurethanes, ethylene-propylene rubbers, polyamide esters, polyimide esters, polyacetals, and polyvinyl buterol.

38. The method of claim 25, wherein said device surface comprises an array of devices selected from the group consisting of integrated circuits; MEMS; microsensors; power semiconductors; light-emitting diodes; photonic circuits; interposers; embedded passive devices; and microdevices fabricated on or from silicon, silicon-germanium, gallium arsenide, and gallium nitride.

39. The method of claim 25, wherein said second substrate comprises a material selected from the group consisting of silicon, sapphire, quartz, metal, glass, and ceramics.

40. The method of claim 25, said device surface comprising at least one structure selected from the group consisting of: solder bumps; metal posts; metal pillars; and structures formed from a material selected from the group consisting of silicon, polysilicon, silicon dioxide, silicon (oxy)nitride, metal, low k dielectrics, polymer dielectrics, metal nitrides, and metal silicides.

41. The method of claim 25, further comprising subjecting said stack to processing selected from the group consisting of back-grinding, chemical-mechanical polishing, etching,

metal and dielectric deposition, patterning, passivation, annealing, and combinations thereof, prior to separating said first and second substrates.

42. The method of claim 25, wherein said separating comprises one or both of:

heating said stack to a temperature sufficiently high so as to soften said bonding layer sufficiently to allow said first and second substrates to be separated; or

exposing said stack to a remover solution so as to dissolve said lift-off layer, if present.

43. An article comprising:

a first substrate having a back surface and a device surface;

a first rigid layer adjacent said device surface;

a bonding layer adjacent said first rigid layer; and

a second substrate having a carrier surface, said bonding layer being adjacent said carrier surface, wherein said article further comprises one or both of the following:

a lift-off layer between said device surface and said first rigid layer; or

a second rigid layer between said bonding layer and said carrier surface.

44. The article of claim 43, said first rigid layer and bonding layer having respective softening temperatures, wherein the softening temperature of said first rigid layer is at least about 20°C greater than the softening temperature of said bonding layer.

45. The article of claim 43, wherein said first rigid layer has a thickness T_3 of from about 1 μm to about 35 μm.

46. The article of claim 43, wherein said bonding layer has a thickness T_3 of from about 1 μm to about 35 μm.

47. The article of claim 43, wherein said article comprises said lift-off layer, and said lift-off layer has a thickness T_1 of less than about 3 μm.

48. The article of claim 43, wherein said article comprises said second rigid layer, and said second rigid layer has a thickness T_3 of from about 1 μm to about 35 μm.

49. The article of claim 43, wherein said article comprises said second rigid layer, and said second rigid layer and said bonding layer have respective softening temperatures, and the softening temperature of said second rigid layer is at least about 20°C greater than the softening temperature of said bonding layer.

50. The article of claim 43, wherein said first rigid layer has a softening point of at least about 100°C.

51. The article of claim 43, wherein said bonding layer has a softening point of less than about 220°C.

52. The article of claim 43, wherein said bonding layer is formed from a composition comprising a polymer or oligomer dissolved or dispersed in a solvent system, said polymer or oligomer being selected from the group consisting of polymers and oligomers of cyclic olefins, epoxies, acrylics, silicones, styrenics, vinyl halides, vinyl esters, polyamides, polyimides, polysulfones, polyethersulfones, cyclic olefins, polyolefin rubbers, and polyurethanes, ethylene-propylene rubbers, polyamide esters, polyimide esters, polyacetals, and polyvinyl buterol.

53. The article of claim 43, wherein said first rigid layer is formed from a composition comprising a polymer or oligomer dissolved or dispersed in a solvent system, said polymer or oligomer being selected from the group consisting of polymers and oligomers of cyclic olefins, epoxies, acrylics, silicones, styrenics, vinyl halides, vinyl esters, polyamides, polyimides, polysulfones, polyethersulfones, cyclic olefins, polyolefin rubbers, and polyurethanes, ethylene-propylene rubbers, polyamide esters, polyimide esters, polyacetals, and polyvinyl buterol.

54. The article of claim 43, wherein said article comprises said lift-off layer, and said lift-off layer is formed from a composition comprising a polymer dissolved or dispersed in a solvent system, said polymer being selected from the group consisting of poly(vinyl pyridine) and polyamic acids.

55. The article of claim 43, wherein said article comprises said second rigid layer, and said second rigid layer is formed from a composition comprising a polymer or oligomer dissolved or dispersed in a solvent system, said polymer or oligomer being selected from the group consisting of polymers and oligomers of cyclic olefins, epoxies, acrylics, silicones, styrenics, vinyl halides, vinyl esters, polyamides, polyimides, polysulfones, polyethersulfones, cyclic olefins, polyolefin rubbers, and polyurethanes, ethylene-propylene rubbers, polyamide esters, polyimide esters, polyacetals, and polyvinyl buterol.

56. The article of claim 43, wherein said device surface comprises an array of devices selected from the group consisting of integrated circuits; MEMS; microsensors; power semiconductors; light-emitting diodes; photonic circuits; interposers; embedded passive devices; and microdevices fabricated on or from silicon, silicon-germanium, gallium arsenide, and gallium nitride.

57. The article of claim 43, wherein said second substrate comprises a material selected from the group consisting of silicon, sapphire, quartz, metal, glass, and ceramics.

58. The article of claim 43, said device surface comprising at least one structure selected from the group consisting of: solder bumps; metal posts; metal pillars; and structures formed from a material selected from the group consisting of silicon, polysilicon, silicon dioxide, silicon (oxy)nitride, metal, low k dielectrics, polymer dielectrics, metal nitrides, and metal silicides.

59. A temporary bonding method comprising:

providing a stack comprising:

a first substrate having a back surface and a device surface, said device surface having a peripheral region and a central region;

a second substrate having a carrier surface;

an edge bond adjacent said peripheral region and said carrier surface; and

at least one layer selected from the group consisting of:

a lift-off layer between said edge bond and said device surface;

a lift-off layer between said edge bond and said carrier surface;

an adhesion promoter layer between said edge bond and said device surface;

an adhesion promoter layer between said edge bond and said carrier surface;

a bonding layer between said edge bond and said device surface; and

a bonding layer between said edge bond and said carrier surface; and

separating said first and second substrates.

60. The method of claim 59, said edge bond being absent from at least some of said central region so as to form a fill zone.

61. The method of claim 60, said stack further comprising a fill layer in said fill zone.

62. The method of claim 61, wherein said stack comprises at least one layer selected from the group consisting of:

a bonding layer between said edge bond and said device surface; and

a bonding layer between said edge bond and said carrier surface.

63. The method of claim 59, wherein said device surface comprises an array of devices selected from the group consisting of integrated circuits; MEMS; microsensors; power semiconductors; light-emitting diodes; photonic circuits; interposers; embedded passive devices;

and microdevices fabricated on or from silicon, silicon-germanium, gallium arsenide, and gallium nitride.

64. The method of claim 59, wherein said second substrate comprises a material selected from the group consisting of silicon, sapphire, quartz, metal, glass, and ceramics.

65. The method of claim 59, said device surface comprising at least one structure selected from the group consisting of: solder bumps; metal posts; metal pillars; and structures formed from a material selected from the group consisting of silicon, polysilicon, silicon dioxide, silicon (oxy)nitride, metal, low k dielectrics, polymer dielectrics, metal nitrides, and metal silicides.

66. The method of claim 59, wherein said edge bond has a width "D" of from about 2 mm to about 15 mm.

67. The method of claim 59, wherein said edge bond is formed is formed from a composition comprising a polymer or oligomer dissolved or dispersed in a solvent system, said polymer or oligomer being selected from the group consisting of polymers and oligomers of cyclic olefins, epoxies, acrylics, silicones, styrenics, vinyl halides, vinyl esters, polyamides, polyimides, polysulfones, polyethersulfones, cyclic olefins, polyolefin rubbers, and polyurethanes, ethylene-propylene rubbers, polyamide esters, polyimide esters, polyacetals, and polyvinyl buterol.

68. The method of claim 59, further comprising subjecting said stack to processing selected from the group consisting of back-grinding, chemical-mechanical polishing, etching, metal and dielectric deposition, patterning, passivation, annealing, and combinations thereof, prior to separating said first and second substrates.

69. An article comprising:

a first substrate having a back surface and a device surface, said device surface having a peripheral region and a central region;

a second substrate having a carrier surface;

an edge bond adjacent said peripheral region and said carrier surface; and

at least one layer selected from the group consisting of:

a lift-off layer between said edge bond and said device surface;

a lift-off layer between said edge bond and said carrier surface;

an adhesion promoter layer between said edge bond and said device surface;

an adhesion promoter layer between said edge bond and said carrier surface;

a bonding layer between said edge bond and said device surface; and

a bonding layer between said edge bond and said carrier surface.

70. The article of claim 69, said edge bond being absent from at least some of said central region so as to form a fill zone.

71. The article of claim 70, said article further comprising a fill material in said fill zone.

72. The article of claim 71, wherein said stack comprises at least one layer selected from the group consisting of:

a bonding layer between said edge bond and said device surface; and

a bonding layer between said edge bond and said carrier surface.

73. The article of claim 69, wherein said first substrate comprises a device wafer having a device surface comprising an array of devices selected from the group consisting of integrated circuits; MEMS; microsensors; power semiconductors; light-emitting diodes; photonic circuits; interposers; embedded passive devices; and microdevices fabricated on or from silicon, silicon-germanium, gallium arsenide, and gallium nitride.

74. The article of claim 69, wherein said second substrate comprises a material selected from the group consisting of silicon, sapphire, quartz, metal, glass, and ceramics.

75. The article of claim 69, said device surface comprising at least one structure selected from the group consisting of: solder bumps; metal posts; metal pillars; and structures formed from a material selected from the group consisting of silicon, polysilicon, silicon dioxide, silicon (oxy)nitride, metal, low k dielectrics, polymer dielectrics, metal nitrides, and metal silicides.

76. The article of claim 69, wherein said edge bond has a width "D" of from about 2 mm to about 15 mm.

77. The article of claim 69, wherein said edge bond is formed from a composition comprising a polymer or oligomer dissolved or dispersed in a solvent system, said polymer or oligomer being selected from the group consisting of polymers and oligomers of cyclic olefins, cyclic olefins, epoxies, acrylics, silicones, styrenics, vinyl halides, vinyl esters, polyamides, polyimides, polysulfones, polyethersulfones, cyclic olefins, polyolefin rubbers, and polyurethanes, ethylene-propylene rubbers, polyamide esters, polyimide esters, polyacetals, and polyvinyl buterol.

78. A temporary bonding method comprising:

providing a stack comprising:

a first substrate having a back surface and a device surface;

a cleaning layer adjacent said device surface;

a first layer adjacent said cleaning layer, said first layer being selected from the group consisting of bonding layers and rigid layers; and

a second substrate having a carrier surface, said first layer being adjacent said carrier surface;

separating said first and second substrates; and

contacting said cleaning layer with a remover solution so as to substantially remove said cleaning layer and any first layer residue remaining after said separating.

79. The method of claim 78, further comprising a second bonding layer between said first layer and said carrier surface.

80. The method of claim 79, wherein said contacting substantially removes said second bonding layer.

81. The method of claim 78, wherein said separating comprises heating said stack to a temperature sufficiently high so as to soften said first layer sufficiently to allow said first and second substrates to be separated.

82. The method of claim 70, wherein said separating comprises heating said stack to a temperature sufficiently high so as to soften said second bonding layer sufficiently to allow said first and second substrates to be separated.

Claims

1. An article comprising:

a first substrate having a back surface and a device surface;

a first rigid layer adjacent said device surface;

a bonding layer adjacent said first rigid layer; and

a second substrate having a carrier surface, said bonding layer being adjacent said carrier surface, wherein said article further comprises one or both of the following:

a lift-off layer between said device surface and said first rigid layer; or

a second rigid layer between said bonding layer and said carrier surface;

wherein said bonding layer has a softening point of less than about 220°C.