

INTERPOSER ASSEMBLY AND METHOD

Field of the Invention

The invention relates to interposer assemblies for forming electrical connections between pads on opposed substrates, to very small contact tips for establishing electrical connections on pads and to elongate strip contacts with single contact tips located on the longitudinal axis of the contact.

Background of the Invention

Conventional interposer assemblies are mounted on substrates by pins extending from the assemblies through holes on the substrates or by positioning the interposers in alignment collars mounted on the substrates. The connections between the interposer assemblies and the substrates have limited lateral compliance. This compliance permits use of the interposer assemblies for connecting substrates which are laterally offset a small distance only and permits limited shifting of the substrates in response to lateral forces after the interposer assembly has been mounted on the substrates.

In many applications, interposer assemblies are needed to establish and maintain continuous electrical circuit paths between contact pads on substrates with increased lateral compliance between the substrates. Increased compliance is needed because of possible large substrate offset when the interposer assemblies are installed. The substrates may be offset by an amount greater than can be accommodated by the limited lateral compliance provided by conventional interposer assemblies. Increased compliance is also needed because after an interposer assembly is mounted between two substrates, the substrates may be subject to lateral forces. Lateral forces should not stress mounted interposer assemblies or be transmitted from one substrate through a mounted interposer assembly to another substrate.

One interposer assembly according to the invention includes a top plate, which is mounted on a top substrate, a bottom plate, which is mounted on a bottom substrate, a shift interface between the plates and a plurality of electrical circuit paths extending through the plates and across the interface to contact surfaces on noses at the top of the top plate and at the bottom of the bottom plate. The circuit paths provide continuous electrical connections between pads on the substrates. The top and bottom plates shift laterally along the interface to provide greater lateral compliance than in conventional interposer assemblies.

The top and bottom plates may be secured together by pins. Vertical pins may extend through passages in the plates. The pins permit limited lateral movement of the plates so that the interposer assembly can be mounted on misaligned substrates. The pins permit the interposer assembly plates to move laterally along the interface in response to lateral forces exerted on the substrates.

Another interposer assembly according to the invention includes top and bottom plates and a central circuit board plate located between the top and bottom plates. The top and bottom plates are mounted on the substrates. Contact passages extend through each top and bottom plate with contacts fitted in the passages. Contact surfaces are provided on noses at the upper and lower sides of the top and bottom plates. Opposed pairs of pads are provided on the top and bottom surfaces of the central circuit board plate with metal conductors extending across the plate between top and bottom pads. The contacts on the top and bottom plates engage the pads on the circuit board plate at pressure connections. The three plates are held together by pins fitted in holes in the plates. The pins permit controlled lateral shifting of the plates at two shift interfaces.

In the disclosed interposer assemblies, top and bottom plates are mounted on the substrates using collars or pins with the contacts in the top plate engaging pads on the top substrate and contacts on the bottom plate engaging pads on the bottom substrate. Continuous electrical circuit paths extend through the assemblies to connect opposed pads on the substrates. In the two-plate interposer assembly, single contacts may be positioned in passages in both plates and form continuous metal circuit paths. In the three-plate interposer assembly, the circuit paths include contacts located in passages in the top and bottom plates, pads and conductors on the central circuit board plate and pressure electrical connections between the inner ends of the contacts and the pads on the circuit board plate.

Interposer assemblies having three plates and two shift interfaces have greater compliance than two-plate, one shift interface interposer assemblies to permit mounting on misaligned substrates and lateral shift of the substrates without transmitting forces between the substrates after the assemblies have been mounted between the substrates. Additionally, the height of the interposer assembly can be easily and inexpensively altered by varying the thickness of the central circuit board plate. Top and bottom plates may be identical.

The invention also relates to an elongate strip metal contact useful in interposer assemblies for forming electrical connections between spaced contact pads with a small, single contact tip on each end of the contact located on the end of a bent up tab on or very close to the longitudinal axis of the contact. Providing a single small contact tip located on a tab bent up from the contact at or adjacent to the longitudinal axis of the contact provides high-pressure contact engagement with pads. The central location of the contact tip with respect to the width of the contact assures that loading forces exerted on the contact by engagement with a pad extends essentially along the longitudinal axis of the contact to reduce off-center forces and prevent the compressed contact from binding in the contact passages in the interposer plates. The location of a tip on each bent up tab close to or on the longitudinal axis of the contact assures resiliency of the contacts and provides high-pressure connections with the overlying and underlying pads.

The tips on the tabs are at the intersection of two rounded shear corners on the tab and are exceedingly small. The reduced size of the contact tips increases contact pressure to improve electrical connections between the tips and pads.

Brief Summary of the Drawings

Figure 1-A is an exploded view of a prior art interposer assembly between two substrates;

Figure 1-B is a top view of the interposer assembly of Figure 1-A;

Figure 1-C is a sectional view taken along line 1-C--1-C of Figure 1-B;

Figures 1-D, 1-E and 1-F are views similar to Figure 1-C showing mounting of the interposer assembly on substrates;

Figures 1-G and 1-H are similar to Figure 1-C illustrating different types of prior art interposer assemblies;

Figures 2-A, 2-B, 2-C, 2-D, 2-E and 2-F illustrate other prior art interposer assemblies mounted on substrates using surrounding collars on the substrates and correspond generally to Figures 1-A, 1-B, 1-C, 1-D, 1-E and 1-F;

Figures 3-A and 3-B are vertical sectional views through a two-plate interposer assembly with a sliding shift interface between the plates and alignment pins extending through the plates and overlying and underlying substrates;

Figures 4-A and 4-B are vertical sectional views like Figures 3-A and 3-B showing a two-plate interposer assembly with a spaced apart shift interface and alignment pins;

Figures 5-A and 5-B are vertical sectional views like Figures 3-A and 3-B showing a two-plate interposer assembly with a sliding shift interface and different pins;

Figures 6-A and 6-B are vertical sectional views like Figures 3-A and 3-B illustrating a two-plate interposer assembly with a spaced apart shift interface and different pins;

Figures 7-A, 7-B and 7-C illustrate a two-plate interposer assembly with a sliding shift interface and pins mounted in collars on the substrates;

Figures 8-A, 8-B and 8-C are similar to Figures 7-A, 7-B and 7-C and illustrate a two-plate interposer assembly with a spaced apart shift interface and plates fitted in collars on the substrates;

Figures 9-A, 9-B, 9-C, 9-D, 9-E and 9-F illustrate a two-plate interposer assembly with a spaced apart shift interface and different pins fitted in inserts in the plates;

Figures 10-A, 10-B, 10-C, 10-D and 10-E illustrate a two-plate interposer assembly with a spaced apart shift interface and alignment pins extending from one plate into a resilient insert in the other plate;

Figures 11-A, 11-B and 11-C illustrate a two-plate interposer assembly with spaced apart shift interface and coiled spring wire pins extending between the plates for lateral shift;

Figure 11-D is a perspective view illustrating a two-plate interposer assembly with spaced

apart lateral shift interface and coil pins extending across the interface adapted to be mounted in retention collars on overlying and underlying substrates;

Figure 11-E is a perspective view illustrating a two-plate interposer assembly with spaced apart shift interface with wound coil pins at two diagonal corners and pins with spacer collars at the opposite diagonal corners, adapted to extend into alignment holes in overlying and underlying substrates;

Figure 12-A is an exploded view illustrating a three plate interposer assembly with two sliding lateral shift interfaces, pins and overlying and underlying substrates with rectangular alignment collars;

Figure 12-B is a top view of the interposer assembly of Figure 12-A;

Figure 12-C is vertical sectional view taken along line 12-C--12-C of Figure 12-B;

Figure 12-D is a view similar to Figure 12-C showing lateral shift of the interposer assembly and substrates;

Figures 13-A and 13-B are views of a three-plate interposer assembly with two lateral shift interfaces, similar to the interposer assembly of 12-A and 12-B, but with a thicker central plate;

Figures 14-A and 14-B illustrate the ends of alignment pins used in the interposer assemblies of Figures 12-C and 12-D;

Figure 15-A is an exploded view of a three-plate interposer assembly with two lateral shift interfaces and substrates;

Figure 15-B is a side view, partially broken away, of the interposer assembly of 15-A mounted in alignment collars on the substrates;

Figure 15-C is a view taken along 15-C--15-C of Figure 15-B;

Figure 15-D is a view similar to Figure 15-C illustrating an interposer assembly using larger plates;

Figures 15-E and 15-F are sectional views taken along line 15-E--15-E of Figure 15-C;

Figures 16-A and 16-B are views of an interposer assembly plate and spring clips inserted into the plate;

Figure 16-C is a sectional view taken along line 16-C--16-C of Figure 16-B;

Figures 16-D, 16-E and 16-F are views of the clip;

Figures 17-A, 17-B and 17-C are similar to Figure 16-A, 16-B and 16-C but illustrate a plate using a different clip;

Figure 18-A is a side view of a two-plate interposer assembly with a spaced apart lateral shift interface;

Figure 18-B is a top view of Figure 18-A;

Figure 18-C is an exploded view of Figure 18-A;

Figure 18-D is a top view of a plate in the interposer assembly of Figure 18-A;
Figures 18-E and 18-F are sectional views through the assembly of Figure 18-A;
Figure 18-G is a perspective view of a contact used in the assembly of Figure 18-A;
Figure 18-H is a view of a flat, stamped pre-form for the contact of Figure 18-G;
Figure 18-I is an enlarged view of one end of the pre-form of Figure 18-H;
Figure 19-A illustrates stamp-forming of the contact tip illustrated in Figure 18-I;
Figure 19-B illustrates shearing of strip stock to form sheared edges, rounded corners and sharp, drag corners;
Figure 19-C is an enlargement of portion 19-C of Figure 19-A.
Figure 19-D is a view of a contact tip;
Figure 19-E is a further enlarged view of the tip; and
Figure 19-F and 19-G are sectional views taken along lines A--A and B--B of Figure 19-E.

Description of the Prior Art

Interposer assemblies establish electrical connections between fields of contacts on opposed, parallel substrates. Conventional interposer assemblies include a single insulating plate with passages extending between top and bottom surfaces and contacts in the passages with contact noses at the top and bottom surfaces. The contacts are located in the same pattern as the pads on the substrates for establishing electrical connections between pairs of opposed pads. The interposer assemblies are mounted on the top and bottom substrates by pins or collars to position the contacts for engagement with the pads.

Figures 1-A to 1-H and 2-A to 2-F illustrate conventional one-plate interposer assemblies. Figures 1-A to 1-F illustrate a first prior art interposer assembly 10 for establishing electrical connections between fields of contact pads 12 on adjacent surfaces of opposed, parallel top and bottom substrates 14 and 16. The interposer assembly includes a single plate 18 having top surface 20 and bottom surface 22 and a series of contact passages 24 extending between the surfaces. Electrical contacts 26 are fitted in the passages and include contact surfaces or noses 28 normally extending above and below surfaces 20 and 22. Diagonally located alignment pins 30 are inserted into holes in the plate and extend above and below surfaces 20 and 22. The alignment pins 30 extend into alignment holes 32 in substrates 14 and 16 to orient the plate on the substrates.

Figure 1-C illustrates assembly 10 located between substrates 14 and 16 with the noses 28 of each contact 26 in alignment with an opposed pair of pads 12 on the substrates 14 and 16 and pins 30 located in alignment with holes 32.

As substrates 14 and 16 are moved together, pins 30 are piloted into holes 32, the contact noses 28 engage pads 12 and the contacts are compressed to form continuous electrical circuit paths between opposed pairs of pads 12 as illustrated in Figure 1-E.

Holes 32 are made slightly larger than pins 30 so that lateral forces 34 exerted on substrates 14 and 16 can move the substrates laterally slight distances as illustrated in Figure 1-F. Contact noses 28 maintain electrical connections with pads 12, despite limited lateral shifting of the substrates and flexing of the contacts. Typically, plate 18 is free to move laterally about 0.002" at the pins/hole connections between the plate and each of the upper and lower substrates. These connections allow a maximum lateral shift or compliance between the top and bottom substrates about 0.004" in any direction in the planes of the substrates. The size of the shift is exaggerated in the drawings. The lateral compliance permits mounting the assembly 10 between slightly misaligned top and bottom substrates and also permits slight lateral shifting of the substrates after the interposer assembly has been mounted between the substrates as in Figure 1-F in response to forces 34 exerted on the substrates.

The one-plate prior art interposer assembly 36 of Figure 1-G is like assembly 10 with the exception that alignment pins 38 are the end portions of elongate pins 40 fitted in bores 42 extending through the thickness of plate 44. Pins 38 fit into slightly enlarged holes 46 in the underlying and overlying substrates. The fit of pins 38 in holes 46 permits limited lateral offset and movement of the substrates as previously described.

The one-plate prior art interposer assembly 48 of Figure 1-H is like assembly 36 with the exception that pins 50 are integrally molded parts of plate 54. The pins are slightly smaller than holes 52 in the overlying and underlying substrates permitting limited lateral offset and movement of the substrates as previously described.

Figure 2-A illustrates prior art interposer assembly 56 including a one-plate 58, passages 60 extending through the plate and contacts 62 located in the passages. The interposer assembly is mounted on upper and lower substrates 64 and 66 by rectangular alignment collars 68 and 69 mounted on the substrates. The collars orient the plate 58 on the substrates so that contacts engage pads on the substrates as previously described. There is a small clearance between plate 58 and each collar 68 and 69 which permits mounting the assembly on slightly offset substrates and permits limited lateral shifting of the substrates after the interposer assembly 56 has been mounted on the substrates, as previously described. This lateral shift is about 0.002" at each circuit board with a total available shift of 0.004" between substrates.

In conventional interposer assemblies, the fits between the plates and pin holes or collars typically permit lateral movement of 0.002" at the top and at the bottom of each plate for a total lateral compliance of about 0.004" in directions parallel to the planes of the substrates.

Description of the Preferred Embodiments

Interposer assembly 70 shown in Figures 3-A and 3-B forms electrical connections between opposed pads on upper and lower substrates 74 and 76. Assembly 70 includes top plate 78, bottom

plate 80, and a sliding interface 82 between the plates. Contact passages 84 extend between the upper and lower sides of plates 78 and 80 and continuous metal strip contacts 86 are positioned in aligned pairs of passages 84 and extend across sliding interface 82.

The upper and lower plates 78 and 80 are rectangular with vertical pin holes 88 extending between the upper and lower sides of each plate at opposed diagonal corners. Pin retention collars 90 extend inwardly from holes 88 approximately midway between the top and bottom sides of the plates. Cylindrical alignment pins 92 extend through aligned holes 88 and collars 90. The pins have tapered upper and lower ends 94 which extend into alignment holes 96 in the upper and lower substrates 74, 76. The pins are smaller than holes 88 and 96 as previously described. Collars 90 are slightly smaller than pins 92 to permit limited rotation of the pins in holes 88 during lateral shift of the substrates and plates as shown in Figure 3-B.

Interposer assembly 70 is mounted on spaced apart substrates 74 and 76 by extending pin ends 94 into hole 96 and then applying a clamping force to the substrates to move the substrates over the pin ends as shown in Figure 3, compressed the contacts 86 so that the contact surfaces at the ends of the terminals establish pressure electrical connections with pad 72.

Pins 92 are preferably formed from metal and include formed retention projections 102 which may be like the projections formed on the pin illustrated in Figure 7-C. The projections 102 may be formed by compressing opposed sides of the pin inwardly to extrude metal on opposite sides of the pin outwardly from the pin. The projections 102 at each end of the pins have a maximum spacing greater than the interior diameter of collars 90. Pins 92 are inserted into the pin holes 88 of aligned plates 78 and 80 with the lead projections 102 snapped past retention collars 90 so that the pins hold the assembly together yet permit lateral shifting of the plates as illustrated in Figure 3-B.

Pins 92 are free to pivot in any direction in holes 88 to accommodate horizontal misalignment or lateral shift of the substrates 74 and 76. Electrical connections are maintained between the pads 72 on the substrates and the contacts in the interposer assembly by a conventional clamp mechanism, which biases the substrates toward each other to compress contacts 86.

Lateral movement of plates 74 and 76 pivots pins 92 in holes 88. Figure 3-B illustrates interposer assembly 70 with the pins engaging the upper and lower edges of holes 88 after maximum lateral shift of the plates in response to lateral forces 98. Lateral movement of plates 74 and 76 in response to forces 98 may move the contact noses 100 across passages 84 while retaining electrical connections between contact surfaces on the noses and the pads 72. The plates move laterally a distance of about 0.004" at the interface to increase the compliance of the assembly.

Figure 4-A and 4-B disclose interposer assembly 104 for forming electrical connections between opposed pairs of pads 106 on upper and lower substrates 108 and 110. The assembly includes top and bottom plates 112 and 114, like plates 78 and 80, and alignment pins 116 extending

through the holes in the plates. Pins 116 include central spacer rings 118 located between the bottom surface 120 of top plate 112 and the top surface 122 of bottom plate 114. The height of the rings 118 along pins 116 may be varied to adjust the height of the interposer assembly 104 according to the desired spacing between substrates 108 and 110. Spacers 118 separate surfaces 120 and 122 to provide an open lateral shift interface 124 between the plates.

Figure 4-B illustrates the application of lateral forces 126 on substrates 108 and 110 to shift the substrates laterally and rotates pins 116 in the pin holes in plates 112 and 114. The top and bottom surfaces of rings 118 are flat so that rotation of the rings increases the separation between the plates at a short distance at interface 124. The clamp force holding the substrates against assembly 104 is compliant and permits limited separation between the plates in response to lateral shift. If desired, the spacer rings 118 could include top and bottom spherical surfaces seated in spherical recesses in the adjacent plate surfaces to maintain spacing of the plates during lateral shift.

Figures 5-A and 5-B illustrate another interposer assembly 128 similar to assembly 70 shown in Figure 3-A for forming electrical connections between opposed pairs of pads 130 on upper and lower substrates 132 and 134. Assembly 128 includes top and bottom plates 136, 138 with pin holes 140 extending through the plates like holes 88 and pin retention collars 142 like collars 90 with the exception that the interior surfaces of the collars are tapered inwardly to a circular pin pivot line 144. Retention pins 145 are cylindrical and similar to pins 92 with the exception that the pins are not provided with projections 102 but include annular recesses 146 at each collar 142. The diameter of the pin away from recesses 146 is slightly greater than the interior diameter of lines 144. The pins are preferably formed from metal and are inserted into the pin holes 140 and ride past collars 142 until the collars are located in the recesses 146 as illustrated. The collar-recess engagement between the pins and the plates holds assembly 128 together and permits lateral shifting of the assembly as illustrated in Figure 5-B. The plates 136 and 138 include contact cavities 148 which receive strip metal contacts 150. Contacts 150 form continuous electrical circuit paths between opposed pairs of pads 130 despite lateral shifting of the plates in directions parallel to the substrates. Interposer assembly 128 has a sliding lateral shift interface 152 between the upper and lower plates. Contacts 150 extend across the interface.

Interposer assembly 154 shown in Figures 6-A and 6-B establishes electrical connections between opposed pairs of contact pads 156 on upper and lower substrates 158 and 160. The interposer assembly 154 includes top and bottom plates 162 and 164, contact passages, pin holes and pin retention collars as in plates 136 and 138 illustrated in Figure 5-A. Contacts 166 are fitted in the contact passages to maintain electrical connections between opposed pairs of pads 156. Alignment pins 168 extend through the pin holes and engage the retention collars on the plates as previously described. The pins 168 include central spacer rings 170, like rings 118, between the

plates 162 and 164. The spacer rings 170 vary the height of the interposer assembly 154 in accordance with the required spacing between the substrates. Interposer assembly 154 has an open lateral shift interface 172 between plates 162 and 164. Figure 6-B illustrates lateral shift of interposer assembly 154 in response to lateral forces 174 exerted on the substrates 158 and 160.

Figures 7-A, 7-B and 7-C illustrate interposer assembly 176 for forming electrical connections between contact pads 178 on upper and lower substrates 180 and 182. Assembly 176 is like assembly 70 shown in Figure 3-A, with the exception that with the ends of alignment pins 184 are recessed a slight distance below the top surface of top plate 186 and a slight distance below the bottom surface of the bottom plate 188. Rectangular alignment collar 190 is mounted on upper substrate 180. Rectangular alignment collar 192 is mounted on the lower substrate 182. Plates 186 and 188 have a slight loose fit within collars 192. This loose fit in the collar is not sufficient to move the noses of the contacts held in the passages in the plates from pads 178. As illustrated in Figure 7-C, the alignment pins include extruded projections 194 to either side of formed recesses 196. The projections extend beyond the pin retention collars 198 in holes 200 to retain plates 186 and 188 together in the assembly. Assembly 176 has a sliding lateral shift interface 201 between the plates.

Figures 8-A, 8-B and 8-C illustrate interposer assembly 202 for forming electrical connections between opposed pairs of pads 204 on upper and lower substrates 206 and 208. The interposer assembly 202 is similar assembly 176 illustrated in Figure 7-A with the exception that the alignment pins 210 include central spacer rings 212. The spacer rings can vary the height of assembly 202 according to the distance between substrates 206 and 208, as previously described. Interposer assembly 202 has an open lateral shift interface 214 between top plate 216 and bottom plate 218.

Figures 9-A, 9-B, 9-C, 9-D and 9-F illustrate interposer assembly 220 for forming electrical connections between opposed pads 222 on upper and lower substrates 224 and 226. The interposer assembly includes top and bottom plates 228 and 230, positioned in alignment collars 232 and 234 mounted on the upper and lower substrates. The collars are like collars 190 and 192 disclosed in Figure 7-A. Assembly 220 includes alignment pins 236 at opposite diagonal corners of the plates. Each pin 236 includes a spherical end 238 fitted a spherical recess 240 in resilient insert 242, illustrated in Figures 9-C, 9-D, 9-E and 9-F. Insert 242 may be made from a resilient plastic resin to permit snap fitment of pin ends 238 in recesses 240. Inserts 242 are fitted in passages 244 extending through plates 228, 230.

The pivot connections between the ends of the pins and the sockets permit lateral shift of the plates 228, 230 in directions parallel to the planes of the substrates, as illustrated in Figure 9-B. Interposer assembly 220 has an open lateral shift interface 246 between plate 228 and 230.

Figures 10-A, 10-B, 10-C, 10-D and 10-E illustrate interposer assembly 248 for forming electrical connections between opposed pads 250 on upper and lower substrates 252, 254. The assembly includes top and bottom plates 256 and 258 positioned in alignment collars 260 and 262 mounted on the substrates. The plates include contacts and contact passages as previously described.

The plates are joined together by two metal cylindrical alignment pins 264. The upper ends of the pins are press-fitted into pin holes 266 extending through top plate 256. The lower ends 267 of pins 264 extend into the centers of elastomeric inserts 268. Inserts 268 are press-fitted into insert holes 270 extending through bottom plate 258.

As illustrated in Figures 10-C, 10-D and 10-E, inserts 268 include a cylindrical body 272, a flange 274 extending outwardly from the top of the body and a central pin receiving recess 276 extending downward from the flange into the body. Resilient vertical ribs 278 extend into the recess. The spacing between opposed ribs is slightly less than the diameter of pin 264. Flanges 274 maintain spacing between plates 256 and 258. The height of the flanges may be increased to increase the height of interposer assembly 248 as required by the spacing between the substrates. Interposer assembly 248 has an open lateral shift interface 280 between the plates. The plates include contact passages and contacts in the passages, as previously described.

The plates 256 and 258 are secured together by extending the lower ends of pins 264 into recesses 276. The pins frictionally engage the ribs 278. Lateral forces exerted on the substrates bias the pins against and compress ribs to permit lateral shift, as illustrated in Figure 10-B. Flange 274 positions the inserted insert on bottom plate 258 and forms a spacer between the plates. As illustrated in Figure 10-B, interposer assembly 248 has an open lateral shift interface 280 between plates 256 and 258.

Figures 11-A, 11-B and 11-C illustrate interposer assembly 282 for forming electrical connections between pads 284 on upper and lower substrates 286 and 288. Interposer assembly 282 includes top and bottom plates 290 and 292 with contact passages and contacts fitted in the passages, as previously described. The plates are secured together in the assembly by wound spring wire pins 294. Each spring wire pin includes upper and lower ends 296 and increased diameter central portion 298 between ends 296. Ends 296 are fitted in pin holes 300 in the plates. Metal alignment pins 302 are fitted in the opposite ends of holes 300 for mounting the plates on the substrates, as previously described. The enlarged center pin portion 298 engages the adjacent recess 299 in plates 290, 292 to retain the plates on the pins and maintain spacing between the plates. The length of portions 298 may be varied to vary the height of the assembly according to the spacing between the substrates. Assembly 282 has an open lateral shift interface 303.

Figure 11-C illustrates lateral shifting of interposer assembly 282 by flexing of the spring

wire in the central portions 298 of wound spring wire pins 294.

Figure 11-D illustrates interposer assembly 304 like assembly 282 with the exception that pins 302 are removed. Assembly 304 is mounted on the upper and lower substrates by alignment collars, rather than by pins 302, as previously described.

Figure 11-E illustrates interposer assembly 306 which is like interposer assembly 282 with the exception that assembly 306 includes continuous metal alignment pins 308 extending through pin holes in the diagonal corners of the top and bottom plates away from the wound spring wire pins 310. Pins are not provided above and below the wound spring wire pins. Spacing collars 312 are provided on pins 308. The pins 308 extend through enlarged pin holes in the upper and lower plates and are aligned in the center of the holes by pin retaining collars, like collars 90 illustrated in Figure 4-A. The collars 312 provide spacing between the plates. The height of the collars may be adjusted to vary the height of assembly 306 as required by the spacing of the substrates.

Figures 12-A, 12-B, 12-C and 12-D illustrate interposer assembly 314 for forming electrical connections between opposed pads 316 on upper and lower substrates 318, 320. Interposer assembly 314 includes top plate 322, central circuit board plate 324 and bottom plate 326. Contact passages 328 extend across plates 322 and 326. Resilient strip contacts 330 are located in passages 328. The central circuit board plate 324 include opposed pairs of contact pads 332 on the top and bottom surfaces thereof, and metal electrical conductors 334 connecting aligned pairs of pads 332. Plate 324 may be of conventional circuit board construction with an insulating body 336 supporting the pads 332 and conductors 334.

Assembly 314 is held together by two alignment pins 338 located on opposed diagonal corners of the assembly. Pins 338 extend through pin holes 340, 342 and 344 in plates 322, 324 and 326. Pin retention collars 346 like collars 90 in Figure 3-A, extend inwardly at the centers of holes 340 and 344. The pins 338 have a close fit with collars 346. Projections 348 like projections 102 shown in Figure 3-A, are formed on the ends of the pins outside of collars 346 to retain the plates in place on the pins, as previously described.

The top and bottom plates 322, 326 are mounted in alignment collars 350 and 352 on substrates 318, 320. The alignment collars are like collars 190, 192 illustrated in Figure 7-A.

Figure 12-D illustrates lateral shift of assembly 314 in response to lateral forces 354 exerted on the substrates. Forces 354 shift upper plate 322 to the right, lower plate 326 to the left, to the extent permitted by the freedom of movement of pins 338 in the pin holes 340, 342 and 344. As illustrated in 12-D, lateral shift of assembly 314 in response to forces 354 shifts top plate 322 laterally to the right relative to center circuit board plate 324 and shifts bottom plate 326 relatively to the left, relative to the center circuit board plate. Lateral shift between plates 322 and 324 occurs at shift interface 354. The lateral shift between plates 324 and 326 occurs at lateral shift interface

356 between the plates. During lateral shift of the plates, contacts 330 maintain electrical connections with the pads 316 on the substrates and pads 332 on the central circuit board plate 324. Shifting of the plates may move the contacts 330 in passages 328. Shifting may wipe the contacts across the pads, without interrupting the electrical connections between the pads on the substrates 318, 320.

The interposer assemblies described herein establish continuous electrical circuit paths between opposed pairs of pads on upper and lower substrates. These connections are maintained despite lateral misalignment and lateral shifting of the substrates. In two-plate interposer assemblies, the continuous circuit paths are established by a one-piece flexible strip contacts extending across the shift interface. In interposer assembly 314, the electrical connections between pads 316 each include metal contacts in the top and bottom plates, pads on the top and bottom of the central circuit board plate and a metal conductor extending through the central circuit board plate between the pads, pressure connections between the contacts and the pads, and a pressure connection between the contacts and the pads.

The interposer assembly 314 includes two shift interfaces 354, 356 and, correspondingly, has twice the lateral compliance of a two-plate interposer assembly having a single lateral shift interface. Increased compliance of interposer assembly 314 permits mounting the assembly on substrates further out of alignment than substrates connected by an interposer assembly with a single lateral shift interface. The increased compliance permits an installed interposer assembly to accommodate greater lateral shift of the top and bottom substrates.

Figures 13-A and 13-B illustrate three-plate interposer assembly 358 which is identical to assembly 314 with the exception that the central circuit board plate 360 has a greater height than plate 324. An increase in the height of plate 360 increases the height of the entire assembly to facilitate mounting between top and bottom substrates 362 and 364 which are spaced apart a distance greater than the spacing between substrates 318 and 320. The height of the central circuit board plate 360 and pins may be easily and inexpensively varied to permit use on interposer assembly in different applications where the substrates have different spacing. Identical top and bottom plates may be used with different thickness center circuit board plates. Assembly 358 has two open lateral shift interfaces 370 and 372, as previously described.

Figures 14-A and 14-B illustrate the formed ends of the alignment pins 338 used in interposer assemblies 314 and 358. Similar pins may be used in other interposer assemblies. The pins 338 include projections 371 extending outwardly from the body of the pins. The opposed projections 371 are formed by forcing opposed tools against the pin ends to form opposed recesses 373 and bow the sides of the pin between the recesses outwardly to form projections 371.

Figures 15-A, 15-B, 15-C, 15-E and 15-F illustrate three-plate interposer assembly 374 for

forming electrical connections between opposed pairs of pads 375 on upper and lower substrates 376 and 378. Assembly 374 includes top plate 380, central circuit board plate 382 and bottom plate 384. Alignment pins 386 extend through pin holes 388 in opposed corners of the plates. Contact passages 390 extend through plates 380 and 384. Contacts 392 are located in passages 390. The components of interposer assembly 374 are like the components of interposer assembly 358, previously described.

Assembly 374 is mounted between top and bottom substrates 376 and 378, which, like all substrates disclosed herein, may be circuit boards. The top and bottom plates 380, 384, are fitted in alignment collars 404 and 406 mounted on adjacent surfaces of the substrates. The collars surround the fields of pads 375. The fields of pads are formed on the substrates in the pattern of the contacts 392 in plates 380 and 384 and the pads on plate 382.

Plates 380 and 384 are alike and include a dielectric body defining the contact passages 390. The spring contacts 392 are formed from strip metal and include contact noses normally extending above the top and bottom surfaces of the plates 380 and 384. The plates 380 and 384 and the other plates discussed in this application may be of the types disclosed in U.S. Patents Nos. 6,176,707, 6,217,342, 6,315,576, 6,290,507, 6,730,134 and 6,905,343, assigned to Amphenol Corporation of Wallingford, CT, USA, assignee of the present application. Other types of plates and contacts may be used, if desired.

Central circuit plate 382 is like plate 324 illustrated in Figure 12-C and includes a dielectric body with flat opposed top and bottom surfaces with fields of electrical contact pads on the surfaces (not illustrated), arranged in the pattern and spacing of substrate pads 375. Metal conductors (not illustrated), which may be plated through holes, extend between pairs of spaced pads on the top and bottom surfaces of plate 382. The plate may be a conventional circuit board. The plate may have a thickness depending upon the spacing between substrates 376 and 378.

The contacts, pads, conductors and pressure electrical connections form continuous electrical circuit paths between opposed pairs of pads 377 on substrates 376 and 378.

As illustrated in Figure 15-C, the contacts 392 are arranged in rows extending longitudinally along plate sides 394 and 396, between plate ends 398 and 400. Diagonal orienting surface 402 extends across one corner of plate 384 at the junction of side 396 and end 400. The plates 380 and 382 have sides, ends and orienting surfaces corresponding to the above-described sides, ends and surface. Alignment collars 404 and 406 have diagonal orienting walls 408 at one corner to facilitate proper orientation of the top and bottom plates in the collars as illustrated in Figure 15-C.

Alignment collars 404 and 406 each have side walls and end walls spaced apart distances slightly greater than the width and length of the top and bottom plates 380 and 384. As a result, plates 380 and 384 have loose fits in the collars.

Each plate 380 and 384 includes a single spring clip pocket 410 on the plate end adjacent to the orienting surface 402 and a single spring clip pocket 412 on the side adjacent the orienting surface 402.

Figure 16-A shows plate 380 for inverted from positions of Figures 15-A and 15-B. Each pocket 410, 412 extends from the top surface of the plate to a blind end and includes opposed interior grooves 414. A metal spring clip 416 is positioned in each pocket. Clip 416 is generally U-shaped and includes a flat base 418 and a cantilever contact arm 420 connected to the base at reverse bend 422. The base includes two spaced arms 424 with outwardly facing retention barbs 426. The spring clip is inserted into pocket 412 as illustrated in Figure 16-A. Arms 424 extend into grooves 414. Barbs 426 engage the bottoms of the grooves to retain the clips in the pockets. The cantilever arms 420 extend outwardly from the adjacent side or end of the plate.

Figures 17-A and 17-B illustrate a second embodiment metal spring clip 428. Metal spring clip 428 is fitted in pocket 430 from either side of the plate. Pocket 430 includes interior grooves 432 extending across the height of the plate. A central projection or bump 434 extends into the pocket 430. Side stops 436 are provided in grooves 432 midway between the top and bottom surfaces of the plate. The clip includes a flat base 440, cantilever contact arm 442, reverse bend 444 connecting the arm to the base and spaced arms 446. The width of the arms 446 is greater than the width of base 440. When clip 428 is inserted into pocket 430 from either side of the plate, the base 440 rides over the projection 434 and then falls back against the bottom of the pocket. At the same time, the outer diagonal sides of arms 446 engage side stops 436 to lock the clip in place in the pocket. See Figure 17-C.

During mounting of interposer assembly 374 on substrates 376 and 378, plate 380 is inserted into alignment collar 404 and plate 384 is inserted into alignment collar 406 with diagonal surfaces 402 adjacent diagonal walls 408 to assure proper orientation of the assembly. During insertion, the two spring clips in each plate 380, 384 bias the plates against the opposing sides of the collars so that the plates are held in desired orientations within the collars and the contacts in the plates are properly positioned over the contact pads 375 on the substrates.

Figure 15-D is a view similar to Figure 15-C but illustrates a larger plate 448 for use in interposer assemblies for forming a larger number of circuit paths between substrates. Four spring clips 450 are mounted in pockets spaced along one long side of plate 448 and a single spring clip is mounted at the short end of the plate. When the plate 448 is positioned in the alignment collar as illustrated, the clips bias the plate against opposing walls of the collar to locate the contacts in the plate in proper position for engaging pads on substrate 454.

Interposer assembly 374 is mounted in alignment collars 404 and 406 between substrates 376 and 378 as described in connection with prior embodiment interposer assemblies. The contacts

392 in plates 380 and 384 make pressure electrical connections with the pads 375 on the substrates. The contacts also make pressure electrical connections with pads on the top and bottom surfaces of central circuit board plate 382. The pads on plate 382 are connected by conductors extending through the height of the plate. As a result, the interposer assembly forms continuous electrical circuit paths between aligned pads on the substrates. Each path includes a contact in upper plate 380, two pads and a conductor joining the pads in the central plate 382 and pressure connections at the ends of the contacts in the upper and lower plates and adjacent pads. A conventional clamp (not illustrated) holds the substrates 376 and 378 together to elastically stress contacts 392 and form the pressure electrical connections with the adjacent pads. The substrates may contact the plates 404 and 406 or may be spaced from the plates.

Interposer assembly 374 accommodates lateral misalignment between substrates and a lateral shifting of the substrates after installation between the substrates. Pins 386 limit lateral shifting of the three plates at the two lateral shift interfaces 456 and 458, as previously described. See Figures 15-A and 15-F. During lateral shifting, top plate 380 is shifted laterally relative to center plate 382 and bottom plate 384 is shifted laterally in the opposite direction relative to center plate 382. Plate 382 does not shift. The pins 386 are retained in assembly 374 by rings and projections, as previously described.

Figure 18-A illustrates two-plate interposer assembly 700 for forming continuous electrical circuit paths between opposed pads 702 on upper substrate 704 and lower substrate 706. As illustrated in Figure 18-B, the pads are arranged in a rectangular high-density land grid array with 10 rows each having 30 pads with a total of 300 closely spaced pads in the array. The assembly may be mounted between misaligned substrates. The assembly also permits lateral shifting of the substrates after mounting without transmitting forces between the substrates.

Assembly 700 includes like top and bottom plates 708, 710 stacked on top of each other. The plates are rectangular, have insulating bodies 712, sides 714 and ends 716 and a uniform thickness between flat, parallel top and bottom surfaces. A large number of closely-spaced, like contact slots or passages 718 extend between the top and bottom surfaces of each plate.

Two slotted openings 720 extend vertically through the ends 716 of each plate. Each opening 720 includes a cylindrical passage or hole 722 with slots 724 to either side of the passage. The slots extend toward plate sides 714. Retention rings 726 extend into each passage 722.

Four alignment and spacing pins or posts 728 are fitted in the four aligned passages 722 at the ends of two plates 712. Each pin includes a central stand off or collar 730 located in space 731 between the plates and cylindrical portions 732 of the pins extending from the collar along passages 722 to ends located at the outer surfaces of the plates. Retention grooves 734 extend around the pin portions 732 and receive rings 726. During insertion of the pins into passages 722, the portions of

the plates between slots 724 and plate ends 716 flex outwardly until rings 726 fit in grooves 734. The pin portions 732 have a smaller diameter than passages 722 and are loose in the passages to permit limited lateral motion or shifting of the upper plate relative to the lower plate. Rings 726 fit in groove 734 to secure the plates together in assembly 700.

The alignment pins 728 permit relative shifting of the plates in any desired direction. This shifting facilitates mounting of each plate 708, 710 on a substrate so that the contacts in the plates extending outwardly from the plates to engage contact pads on the substrates without the necessity of assuring that the contact pads on the two substrates are in exact alignment. Pins 728 and other disclosed pins may be made from stainless steel.

A one-piece, stamp formed contact 736 is fitted in each vertically aligned pair of contact passages 718 in the assembly 700. As shown in Figure 18-G, contact 736 is elongated and extends between opposed contact noses 738. The contact is formed from a flat strip metal pre-form shown in Figure 18-H. The strip contact 736 includes like upper and lower halves 740 and 742 located to either side of the center of central vertical beam 744. Each contact half includes a vertical beam 746 above or below beam 744 on the same side of the contact as beam 744, and vertical beams 748 on the opposite side of the contact between beams 744 and 746. Beams 744 and 748 are joined by angled, full width transverse beams 750. Beams 746 and 748 are joined by angled, full passage width transverse beams 752. Noses 738 are connected to the outer ends of beams 746 by angled, half width transverse beams 754. Rounded contact ends 756 are connected to noses 738 by angled, half passage width arms 758.

Figure 18-H illustrates a flat stamp-formed strip metal pre-form 760 for contact 736. Pre-form 760 is a strip of uniform thickness metal symmetrical to either side of centerline 762. Contact 736 is formed by bending the flat pre-form strip to the shape of the contact. Compare Figures 18-G and 18-H. The pre-form 760 is symmetrical to either side of pre-form longitudinal centerline or axis 764, with the exception of end portions 766.

In the pre-form, each portion 766 includes a strip 768 having an edge on centerline 764 with a flat, 90-degree tab 770 joined to the strip edge at the centerline and extending from the centerline away from the strip to tab point 771. The tabs 770 are located at the contact noses 738 on formed contacts 736. As illustrated in Figure 18-G, the tabs are bent upwardly from the contact noses so that the tips 772 on the upper sides of the tab points 771 face upwardly to engage pads 702 on substrates 704 and 706. The tips 772 on tabs 770 are specially stamp formed and have a very small double curvature Hertzian shape for forming small, high-pressure and reliable electrical connections with pads, as disclosed below.

Interposer assembly 700 is mounted between substrates 704 and 706 by positioning plate 710 in alignment collar 774 on substrate 706 below substrate 704. The substrates are then brought

together to position top plate 708 in collar 774 on substrate 704. The two plates 708, 710 are free to shift laterally along the open lateral shift interface 775 between the substrates by limited rotation of pins 732 in pin holes 722, as previously described, to permit mounting of the interposer assembly between misaligned substrates. A conventional clamp assembly (not illustrated) clamps the substrates against each other to compress the contacts 736 and form high-pressure electrical connections between the small rounded tips 772 at each contact end and associated pads on the substrates. The substrates are moved together sufficiently to form electrical connections without moving the substrates and plates into physical contact with each other. Alternatively, the substrates may be moved into engagement with the plates. Compressing the contacts elastically bends the contact beams to provide high-contact force at the small area tips and assure very high contact pressure. Stressing of the contacts may move the tips short distances along the pads to assist in forming low resistance electrical connections. This movement is not sufficient to move the tips out of engagement from the pads, despite lateral shifting of the plates 708 and 710. Lateral shifting of the plates may move the contact tips slight distances along the pads without moving the tips off of the pads.

Single piece strip metal contacts 736 extend between the top and bottom of the assembly and across the lateral shift interface 775 to provide continuous metal electrical circuit paths between opposed pairs of pads on the substrates.

The contact tips 772 on the top of bent up tab 770 are located very close to or on the centerline 764 for contact 736. The formed contacts 736 are fitted in aligned passages 718 in the top and bottom plates 708 and 710 as shown in Figure 18-F. The contact beams are adjacent the narrow vertical passage sidewalls and the contact ends are adjacent opposite narrow vertical passage sidewalls. The wide passage sidewalls are slightly wider than the width of the contact to prevent binding. When the contact is uncompressed in the passage, beams 746 and end 756 engage the passage sidewalls and, in cooperation with angled surfaces in the passages, retain the contacts in the passages.

Bent up lateral tabs 770 are located at each contact nose 738. The tabs are bent above the noses so that the tips 772 on the upper sides of the tabs are above the noses and engage the substrate pads 702. The tips have a very small area and are Hertzian.

Rectangular alignment collars 774 are mounted on substrates 702 and 706 to align the top and bottom plates 708 and 710 on the substrates, as previously described. The collars include alignment keys 776 which extend into recesses 778 in plates 714 to ensure proper orientation of the plates in the collars.

During mounting of the interposer assembly on substrates 704 and 706, the contact tips of 772 on tabs 770 on each end of the contacts engage pads on the substrates. Collapse of the contact

736 in passages 718 elastically stresses the contact beams to provide high, compliant contact forces at the tips and to wipe the tips a short distance along the pads. The wipe, small contact area and high contact pressure assure reliable electrical connections are established between the contacts and the pads and reliable interconnections between adjacent aligned pads on the substrates.

Figure 18-I illustrates that tab 770 has straight edges 780 intersecting at an angle of 90° at tip 772 on the upper surface of the tab. The surfaces 780 intersect at 90 degrees in order to form the small, double curvature Hertzian tip 772. The shape of edges 780 of the tab may be straight, or may be curved, as illustrated in Figure 19-C. The edges preferably intersect at the tip at 90°.

The continuous electrical circuit paths used in the disclosed interposer assemblies are formed from strip metal contacts, either a single continuous strip metal contact that extends past a lateral shift interface or a number of strip metal contacts with pressure connections between adjacent contacts. Other types of conductors may be used for forming connections between the contact surfaces at the ends of the circuit paths. For instance, single or multi-strand wire conductors may be used.

The contact tip 772 and methods for forming the tip will now be described.

Contact 736 is formed by progressively stamping flat metal strip stock. Figures 19-A, 19-B and 19-C illustrate forming two small double curvature contact tips 782 on opposite sides of a stamped opening in strip metal stock. Contact tips 772 may be formed by the method of forming tips 782 shown in these Figures.

Figure 19-A illustrates progressively stamping thin sheet metal strip 784 to form two tips 782. First, an elongated opening 786 is stamped through the strip with a curved end 788 being formed.

As illustrated in Figure 19-B, during the stamping operation a strip portion 790 is supported by an anvil and a strip portion 792 is forced downwardly by tooling to shear apart the portions and form sheared edges 794 and 796 extending across the thickness of the strip. The shearing forms a rounded shear corner 798 at each edge 794, 796 and a sharp drag corner 800 at each edge 794 and 796. In Figure 19, metal is stamped from opening 786 to form a rounded shear corner 798 on the side of strip 786 facing the viewer.

Small area double curvature contact tips 772 are formed by punching a second opening 802 in strip 784 in the same direction opening 786 was punched. The rounded upper end of the punch tooling forming opening 802 intersects the curved lower portion of opening 786 at 90° at two tip locations. The rounded shear corner 804 at the edge of opening 802 is also on the side of strip 784 facing the viewer.

The two shear edges and two rounded shear corners 798 and 804 intersect at 90° at contact points 771. See Figure 19-C. The intersection of the two very small rounded and perpendicular

shear corners at 90° forms very small double curvature contact tips 806. The tip is located inwardly from the point. See Figures 19-D, 19-E 19-F and 19-G. Stamping of the two openings 786, 802 also forms two tabs 808, like tabs 770, extending from the tips to the strip. Tabs 808 may be bent up relative to strip 784 to position the contact tips 806 above the strip for contact engagement with a contact pad.

After stamp forming and bending of contacts 736 with small double curvature contact tips 772 on bent up tabs 770, the contacts are suitably plated prior to loading into plates 704 and 708.

A single contact tip 772 is provided at each end of contact 736. The tips are located on one side of nose 738. The contacts 736 are sufficiently long from nose to nose to assure that the slight off center forces applied at the tips do not bias the contact against passage sidewalls sufficiently to reduce contact pressure. Location of the tips 772 very close to axis 764 reduces skewing of the contacts when compressed and possible frictional engagement with sides of the passages in the plates.

Illustrated assembly 700 may have a length of about 27 mm and a width of about 9 mm and hold a 10 x 30 array of contacts 736 with the contact tips 772 spaced apart from each other at a 0.8 mm square pitch. The total height of assembly 10 may be 6.25 mm with each plate 12 having a thickness of 2.9 mm. Contacts 736 may be stamp-formed from the strip stock having a thickness .043 mm with passages 718 having a maximum width, between narrow sidewalls of .95 mm and a minimum width between the wide sidewalls of about .83 mm. The small, double curvature contact tips 772 are Hertzian and form small, high pressure, electrical connections with pads 702. As illustrated in Figure 18-G, this area is considerably smaller than the exposed area of nose 738 with resultant increased contact pressure at the tip/pad connection.

Strip contact 736 have very small Hertzian contact tips for engaging substrate pads. Tips of this type may be provided on the contacts used in all disclosed interposer assemblies. Preferably, the contact tips should be located adjacent or on the longitudinal axis of the contact to reduce skewing of the contact in a contact passage.

CLAIMS

1. An assembly for establishing electrical connections between pads on two opposed substrates, the assembly comprising first and second stacked plates positioned between the substrates; each plate formed from a dielectric material; a first lateral shift interface between the plates; and a plurality of circuit paths, each circuit path including a first contact surface on the first plate for engaging a pad on one substrate, a second contact surface on the second plate for engaging a pad on the other substrate, and a conductor joining the contact surfaces and extending through the plates and across the lateral shift interface, wherein when the plates are mounted on the substrates the assembly accommodates substrate misalignment and permits lateral shifting of the plates at the interface.
2. The assembly as in claim 1 including a third plate positioned between the first and second plates; said circuit paths extending through said third plate.
3. The assembly as in claim 2, including a second lateral shift interface.
4. The assembly as in claim 1 wherein each circuit path comprises a single conductive member extending between said contact surfaces.
5. The assembly as in claim 1 wherein said circuit path comprises a plurality of conductive members and a pressure connection between two adjacent members.
6. The assembly as in claim 5, wherein said pressure contact is located at said lateral shift interface.
7. The assembly as in claim 6, wherein said pad-engaging contacts comprise contact noses.
8. The assembly as in claim 1, wherein said circuit paths include metal strips.
9. The assembly as in claim 8, wherein each contact surface comprises a single bent up tab.
10. The assembly as in claim 9, wherein each tab is located on or adjacent the longitudinal axis of a strip.
11. The assembly as in claim 10, wherein each contact surface comprises a double curvature tip at the intersection of two shear-formed edge corners.
12. The assembly as in claim 1, including a first opening extending through the first plate, a second opening extending through the second plate and an alignment member in said openings, said openings larger than the member to permit lateral movement of the plates at the lateral shift interface.
13. The assembly as in claim 12, wherein said alignment member comprises a pin and said openings comprise holes.

14. The assembly as in claim 13, including a collar extending inwardly from each hole, said pin extending through the collars.
15. The assembly as in claim 14, including projections extending outwardly from said pins for retaining the pins in the holes.
16. The assembly as in claim 15, wherein said pin has ends located within said plates.
17. The assembly as in claim 16, wherein said pin has ends extending outwardly of said plates.
18. The assembly as in claim 1, wherein said lateral shift interface comprises a sliding lateral shift interface.
19. The assembly as in claim 1, wherein said lateral shift interface comprises an open lateral shift interface.
20. The assembly as in claim 19, including a pin extending through said plates and across the lateral shift interface, and a spacer on the pin separating the plates.
21. The assembly as in claim 1, including an alignment collar for each plate, said collars adapted for mounting on the substrates.
22. The assembly as in claim 1, wherein each circuit path comprises a first end portion including a first bent up tab having shear formed edges intersecting at a first double curvature tip.
23. The assembly as in claim 22, wherein the tip is located at or adjacent the longitudinal axis of the circuit path.
24. The assembly as in claim 22, wherein in each circuit path comprises a second end portion including a second bent up tab having shear formed edges intersecting at a second double curvature tip.
25. The method of forming electrical connections between pads on opposed substrates comprising the steps of:
 - a) positioning an interposer assembly between the opposed substrates to locate first contacts on one side of the interposer assembly adjacent pads on one substrate and to locate second contacts on another side of the interposer assembly adjacent pads on the other substrate;
 - b) laterally shifting the first and second sides of the interposer assembly about a lateral shift interface located between said sides to align the first contacts with the pads on said one substrate and align the second contacts with the pads on the second substrates;
 - c) forming electrical connections between the first contacts and the pads on said one substrate and forming electrical connections between the second contacts with the pads on the other substrate.
26. The method of claim 25, including the step of:
 - d) laterally shifting the first and second contacts along a second lateral shift interface.