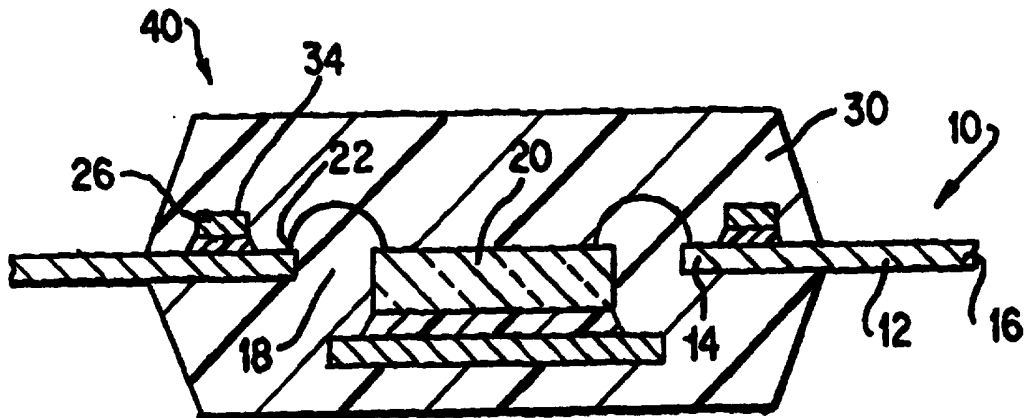




## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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<p>(21) International Application Number: PCT/US95/17057</p> <p>(22) International Filing Date: 29 December 1995 (29.12.95)</p> <p>(30) Priority Data: 373,138 13 January 1995 (13.01.95) US</p> <p>(71) Applicant: OLIN CORPORATION [US/US]; P.O. Box 586, 350 Knotter Drive, Cheshire, CT 06410-0586 (US).</p> <p>(72) Inventors: MAHULIKAR, Deepak; 20 Martleshamheath Lane, Madison, CT 06443 (US). HOFFMAN, Paul, R.; 5542 American Avenue, Modesto, CA 95356 (US).</p> <p>(74) Agents: ROSENBLATT, Gregory, S. et al.; Wiggin &amp; Dana, One Century Tower, New Haven, CT 06508-1832 (US).</p>	<p>(81) Designated States: AL, AM, AU, BB, BG, BR, BY, CA, CN, CZ, EE, FI, GE, HU, IS, JP, KE, KG, KP, KR, KZ, LK, LR, LT, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, RO, RU, SD, SG, SI, SK, TJ, TM, TT, UA, UG, UZ, VN, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</p> <p><b>Published</b> <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i></p>	

(54) Title: GUARD RING FOR INTEGRATED CIRCUIT PACKAGE



## (57) Abstract

There is provided a leadframe (10) having a plurality of coplanar electrically conductive leads (12). At least one metallic guard (26) is bonded to the leads (12) with a dielectric layer (32) disposed between the metallic guard (26) and the leads (12). The metallic guard (26) has good adhesion to a polymer molding resin (30) such that when the leadframe structure (10) is encased in a molding resin (30), delamination is minimized. By restricting delamination, the ingress of water and water soluble contaminants to an integrated circuit device (20) is inhibited.

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## GUARD RING FOR INTEGRATED CIRCUIT PACKAGE

This invention relates to a leadframe for an integrated circuit device package. More particularly, a metallic guard ring is bonded to a portion of the leads to maintain lead coplanarity.

5 Integrated circuit ("I.C.") devices such as silicon based semiconductor circuits are encased in a package for protection from mechanical shock and environmental corrosion. In one package, the I.C. device is encased in a polymer molding resin,  
10 typically an epoxy.

A leadframe, a thin, typically on the order of 0.127 mm (0.005 inch) to 0.508 mm (0.020 inch), metallic strip formed into a plurality of leads has inner lead portions approaching a central aperture.  
15 The I.C. device is positioned within this central aperture and electrically interconnected to the inner lead portions of the leadframe. The I.C. device, the electrical interconnections and the inner lead portions are then encased in the molding  
20 resin.

Outer lead portions of the leadframe extend beyond the body of the package and are electrically interconnected to external circuitry.

The inner lead portions of the leadframe  
25 typically have a width about equal to the thickness. The inner leads readily deflect and lose coplanarity

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with adjacent leads. To facilitate automated electrical interconnection of the inner lead portions to the semiconductor device such as by wire bonding or tape automated bonding, it is necessary  
5 to maintain lead coplanarity.

One way to maintain lead coplanarity is disclosed in U.S. Patent No. 4,721,994 by Mine et al. The Mine et al. patent discloses a polyimide support ring for the inner leads of a leadframe.  
10 This support ring is bonded to the leads of the leadframe by a thermally activated silicone adhesive.

Another type of support ring is disclosed in U.S. Patent No. 5,034,591 to Fang. This patent  
15 discloses a copper foil bonded to a polymer support layer. Leads are photolitho-graphically formed in the foil and, at the same time, a copper stiffening ring, joining the inner lead portions of all leads is also photolithographically formed. After the  
20 leads are bonded to a semiconductor device, that portion of the stiffening ring disposed between leads is excised by laser cutting.

A disadvantage with a polymer support ring is that adhesion between the polymer ring and the  
25 molding resin is poor. The interface is vulnerable to delamination. Delamination between the support ring and the molding resin may result in moisture accumulation at the delamination site.

I.C. devices are highly sensitive to corrosion  
30 from moisture and water soluble contaminants. Generally, any delamination between the support ring and the molding resin will cause the accumulation of

sufficient moisture to damage the semiconductor device.

Polymer support rings are usually hygroscopic. The polymer support rings absorb water leading to a potential for corrosion, electromigration of  
5 contaminants leached from the polymer and electrical leakage through the moisture laden polymer.

There remains, therefore, a need for a support ring to maintain the coplanarity of the inner leads  
10 of a leadframe that provides improved adhesion to a polymer molding resin.

Accordingly, it is an object of the invention to provide a guard ring for a leadframe having enhanced adhesion to a polymer molding resin. It is  
15 a feature of the invention that the guard ring is metallic and, preferably, coated with an adhesion enhancing layer.

Among the advantages of the metallic guard ring of the invention are improved adhesion to a molding  
20 resin reducing the risk of delamination. The metallic guard ring may function as a floating ground to reduce both lead to lead mutual inductance and self inductance as well as mutual capacitance. Alternatively, the metallic guard ring may be  
25 electrically interconnected to at least one lead and function as a ground plane or a power plane. Another advantage of the metallic guard ring is that metal is stiffer than most polymers reducing lead  
30 distortion, both lead to lead coplanarity and from one side of the leadframe to the other.

Additionally, by proper selection of the metal utilized in the metallic guard ring, an exact coefficient of thermal expansion match with the

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leadframe can be achieved. This matched coefficient of thermal expansion reduces leadframe distortion during heating. Typically, during wire bonding, the leadframe is heated to temperatures of up to 250°C.

5 In accordance with the invention, there is provided a leadframe structure. This leadframe structure contains a plurality of generally coplanar electrically conductive leads. Each lead has an inner lead end and an outer lead end with the inner  
10 lead ends approaching a central aperture. At least one metallic guard ring is bonded to the electrically conductive leads. This metallic guard ring is spaced from about 0.5 mm to about 5.0 mm from the inner lead ends. A dielectric layer is  
15 disposed between the metallic guard ring and the electrically conductive leads.

In accordance with the invention, there is also provided a package to house one or more semiconductor devices. This package contains a  
20 leadframe with a plurality of generally coplanar conductive leads. Each of the leads contains an inner lead end and an outer lead end with the inner lead ends approaching a central aperture. At least one semiconductor device is disposed within this  
25 central aperture and electrically interconnected to the inner lead ends. A metallic guard ring is bonded to the leadframe at a position separated from the central aperture by the electrical interconnection between the semiconductor device and  
30 the inner lead ends. A dielectric layer is disposed between the metallic guard and the leadframe. Finally, a polymer resin encapsulates the

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semiconductor device, the metallic guard ring and the inner lead portions.

The above stated objects, features and advantages will become more apparent from the specification and drawings that follow.

Figure 1 shows in top planar view a guard ring in accordance with the invention.

Figure 2 shows in cross-sectional representation a first embodiment of the guard ring illustrated in Figure 1.

Figure 3 shows in cross-sectional representation a second embodiment of the guard ring illustrated in Figure 1.

Figure 4 shows in cross-sectional representation a third embodiment of the guard ring illustrated in Figure 1.

Figure 5 shows in cross-sectional representation a molded plastic package in accordance with an embodiment of the invention.

Figure 6 shows in cross-sectional representation a molded plastic package in accordance with another embodiment of the invention.

Figure 1 shows in top planar view a leadframe structure 10 containing a plurality of generally coplanar electrically conductive leads 12. Each of the leads 12 has an inner lead end 14 and an outer lead end 16. The inner lead ends 14 approach a central aperture 18. Disposed within this central aperture 18 is at least one integrated circuit device 20.

The leads 12 are formed from any suitable electrically conductive material such as copper, aluminum and alloys thereof. Alloys of iron and

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nickel are also satisfactory. The leads 12 have a thickness of from about 0.127 mm (0.005 inch) to about 0.508 mm (0.02 inch) and more typically, from about 0.152 mm (0.006 inch) to about 0.254 mm (0.01  
5 inch). The width of the leads 12 is about equal to the thickness of the leads or slightly larger.

The I.C. device 20 is electrically interconnected to the inner lead ends 14 by an electrical interconnection 22 that may be thin, on  
10 the order of 0.025 mm (0.001 inch) diameter, copper, aluminum or gold wires or a thin strip, typically on the order of 0.0127-0.0508 mm (0.0005-0.002 inch), copper foil.

To facilitate assembly of the electrical  
15 interconnections 22, the I.C. device 20 is typically mounted to a die paddle 24. The die paddle 24 is generally formed from the same material as the leads 12 and is supported by tie bars (not shown) extending to the periphery of the leadframe  
20 structure 10. To maintain lead coplanarity, a metallic guard ring 26 is provided. The guard ring 26, which is generally rectangular in shape, circumscribes the central aperture 18 and supports the inner lead ends 14 and prevents shifting of the  
25 leads. The guard ring 26 may be a contiguous ring as illustrated in Figure 1 or comprise four separate strips, each forming one leg of the guard ring or various combinations of a partial ring and strips. The guard ring 26 is bonded to the inner leads 14,  
30 typically with a polymer resin such as an acrylic adhesive.

To provide for the electrical interconnections 22, an interior edge 28 of the guard ring 26 is



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spaced from the inner lead end 14 by a distance, "D", of from about 0.5 mm to about 5.0 mm. Preferably, "D" is from about 1.0 mm to about 4.0 mm.

5           The electronic package is completed by encapsulating the integrated circuit device 20, the guard ring 26 and the inner lead portions 14 in a polymer molding resin, designated by broken line 30, with the outer lead ends 16 extending beyond the  
10 molding resin 30.

          Alternatively, the electronic package is completed by encasing the integrated circuit device 20, the guard ring 26 and the inner lead portions 14 between separate base and cover components of the  
15 type disclosed in U.S. Patent No. 4,939,316 to Mahulikar et al.

          Figure 2 illustrates in cross-sectional representation that portion of the leadframe structure 10 designated by the broken arrow 2-2 in  
20 Figure 1. The guard ring 26 is bonded to the lead 12 by an adhesive 32. To prevent the leads 12 from being electrically interconnected one to another, a dielectric layer is disposed between the guard ring 26 and at least some of the electrically conductive  
25 leads 12. This dielectric layer may take the form of the adhesive 32 being a dielectric polymer 32 such as an acrylic resin.

          The guard ring 26 is formed from any suitable metal, metal alloy or metal compound. Typically,  
30 the thickness of the guard ring is from about 0.0254 mm (0.001 inch) to about 0.1016 mm (0.004 inch) with a preferred thickness of from about 0.0381 mm (0.0015 inch) to about 0.0762 mm (0.003 inch). If

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the guard ring is too thin, inadequate support of the inner lead portions is provided and lead to lead coplanarity may be lost. If the guard ring is too thick, it is difficult to handle and apply.

5 Preferred metals for the guard ring 32 are copper, aluminum and alloys thereof. A most preferred material is an aluminum alloy designated by the Aluminum Association as a 3000 Series Alloy, containing manganese as the major alloying element  
10 or an alloy designated as a 6000 Series Alloy, containing silicon and magnesium in approximate proportions to form magnesium silicide. Representative of these alloys are aluminum alloy 3003 containing 0.05-0.20% by weight copper, 1.0-  
15 1.5% manganese and the balance aluminum and aluminum alloy 6061 containing 0.40-0.8% by weight silicon, 0.15%-0.40% copper, 0.8-1.2% magnesium, 0.04-0.35% chromium and the balance aluminum.

Aluminum alloys are preferred because an anodic  
20 film is readily formed on the surface of the guard ring by electrochemical processing. This anodic film provides both electrical isolation for the guard ring, as well as enhances adhesion to a molding resin.

25 Figure 3 illustrates in cross-sectional representation a guard ring 26 coated with an exterior layer 34. This exterior layer 34 is any suitable material that enhances the adhesion of the guard ring 26 to a molding resin. Suitable coating  
30 materials include an anodic layer, such as anodized aluminum, and a mixture of chromium and zinc as generally disclosed in U.S. Patent No. 5,367,196 to Mahulikar et al.

Other suitable coatings include nickel and nickel alloys, tin and tin alloys, as well as chromium and chromium alloys as described in U.S. Patent No. 4,888,449 to Crane et al. Polymer coatings that enhance adhesion, such as an epoxy dip are also suitable. Any of the coatings may be provided with a macroscopic surface roughness, such as  $R_{\max} > 10$  microns to further enhance adhesion to the molding resin.

10 The exterior layer 34 has a thickness of from about 1 micron to about 25 microns and preferably, the thickness of this exterior layer 34 is from about 2 microns to about 15 microns.

For certain electrical applications, the guard ring 26 may constitute a portion of an electric circuit as illustrated in cross-sectional representation in Figure 4. A plurality of leads 12a, 12b and 12c are bonded to the metallic guard ring 26. Leads 12a and 12c are electrically isolated from the guard ring 26 by a dielectric adhesive 32. Lead 12b is bonded to the guard ring 26 by a conductive material 36 such as a polymer adhesive filled with an electrically conductive material such as silver, copper or graphite, or by a wire bond. Alternatively, the conductive adhesive 36 may be a low melting temperature solder such as a lead-tin alloy. In this embodiment, the guard ring 26 functions as a ground plane or a power plane to provide all electrically interconnected leads 12b at the same voltage potential.

30 Figure 5 illustrates in cross-sectional representation an electronic package 40 housing one or more I.C. devices 20 in accordance with the

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invention. A leadframe 10 contains a plurality of generally coplanar conductive leads 12 with inner lead portions 14 approaching a central aperture 18. Outer lead portion 16 of the leads 12 extend beyond the electronic package 40 perimeter as defined by a polymer molding resin 30. A metallic guard ring 26, preferably coated with an adhesion enhancing exterior layer 34, is bonded to the leads at a position separated from the central aperture 18 by the electrical interconnections 22. To provide electrical isolation between the leads 12, a dielectric layer is disposed between the metallic guard and either all, or most of the leads of the leadframe. As described above, it is within the scope of the invention for a number of the leads to be electrically interconnected to the metallic guard ring to be at the same voltage potential. The polymer molding resin 30 then encapsulates the I.C. devices 20, the metallic guard 26 and the inner lead portions 14.

In the preceding embodiments, the metallic guard 26 was identified in the Figures as on the same side of the leads as the electrical interconnections. However, the metallic guard, when in the form of a rectangular ring, may be disposed on either side of the leadframe.

Figure 6 illustrates another electronic package 50 having a metallic guard 52 disposed on the side of the leads 12 opposite the electrical interconnections 22 and extending across the central aperture 18. The metallic guard 52 is a generally rectangular plate that is separated from the electrical interconnections 22 by the leadframe.

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The semiconductor device 20 is then bonded to the metallic guard 52 which then, in addition to maintaining inner lead coplanarity, is a heat spreader to dissipate heat from the semiconductor  
5 20. This embodiment has the further advantage that it is not necessary to provide a die paddle to support the I.C. device 20. As in earlier embodiments, the metallic guard 52 is preferably coated with an adhesion enhancing exterior layer 34.

10 While the invention has been described in terms of metallic guard rings to support inner leads to maintain inner lead coplanarity, it is within the scope of the invention to provide a similar guard ring to an outer lead portion of the leads, external  
15 of the package perimeter as defined by the molding resin, to support the leads during assembly. Typically, the outer lead guard ring is severed prior to electrical interconnection of the outer leads to external circuitry.

20 It is apparent that there has been provided in accordance with this invention a metallic guard ring to support the inner leads of a leadframe that fully satisfies the objects, features and advantages set forth hereinabove. While the invention has been  
25 described in combination with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to those skilled in the art in light of the foregoing description. Accordingly, it is intended to embrace  
30 all such alternatives, modifications and variations as fall within the spirit and broad scope of the appended claims.

IN THE CLAIMS:

1. A leadframe structure (10), characterized by:
  - a plurality of generally coplanar electrically conductive leads (12) having an inner lead end (14) and an outer lead end (16), said inner lead ends (14) approaching a central aperture (18);
  - at least one metallic guard (26) bonded to said electrically conductive leads (12), said at least one metallic guard (26) having a first edge spaced from about 0.5 mm to about 5.0 mm from said inner lead end (14); and
  - a dielectric layer (32) disposed between said at least one metallic guard (26) and said electrically conductive leads (12).
2. The leadframe structure of claims 1 or 13 characterized in that said metallic guard (26) is coated with an adhesion enhancing exterior layer (34).
3. The leadframe structure of claim 2 characterized in that said adhesion enhancing exterior layer (34) has a thickness of from about 1 micron to about 25 microns.
4. The leadframe structure of claims 2 or 14 characterized in that said metallic guard (26) is formed from aluminum or an aluminum alloy.

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5. The leadframe structure of claim 4 characterized in that said adhesion enhancing exterior layer (34) is anodized aluminum.

6. The leadframe structure of claim 4 characterized in that said adhesion enhancing exterior layer (34) is a mixture of chromium and zinc.

7. The leadframe structure of claims 2 or 14 characterized in that said metallic guard (26) is formed from copper or a copper alloy.

8. The leadframe structure of claim 7 characterized in that said adhesion enhancing exterior layer (34) is a mixture of chromium and zinc.

9. The leadframe structure of claim 7 characterized in that said adhesion enhancing exterior layer (34) is nickel or a nickel alloy.

10. The leadframe structure of claim 2 characterized in that at least one of said leads (12) is electrically interconnected to said metallic guard (26).

11. The leadframe structure of claim 2 characterized in that said metallic guard (26) is a rectangular ring circumscribing said central aperture (18).

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12. The leadframe structure of claims 2 or 14 characterized in that said metallic guard (26) is a rectangular plate extending across said central aperture (18).

13. A package to house one or more integrated circuit devices (20), characterized by:

a leadframe (10) containing a plurality of generally coplanar conductive leads (12) having an inner lead end (14) and an outer lead end (16) with said inner lead ends (14) approaching a central aperture (18);

at least one integrated circuit device (20) disposed within said central aperture (18);  
an electrical interconnection (22) joining said at least one integrated circuit device (20) to said inner lead ends (14);

a metallic guard (26) bonded to said leadframe (10) and separated from said central aperture (18) by said electrical interconnection (22);

a dielectric layer (32) disposed between said metallic guard (26) and said leadframe (10);  
and

a polymer resin (30) encapsulating said at least one integrated circuit device (20), said metallic guard (26) and said inner lead portions (14).



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14. A package to house one or more integrated circuit devices (20), characterized by:

a leadframe (10) containing a plurality of generally coplanar conductive leads (12) having an inner lead end (14) and an outer lead end (16) with said inner lead ends approaching a central aperture (18);

at least one integrated circuit device (20) disposed within said central aperture (18);

an electrical interconnection (22) joining said at least one integrated circuit device (20) to said inner lead ends (14);

a metallic guard (26) coated with an adhesion enhancing exterior layer (34) bonded to said leadframe (10) and separated from said electrical interconnection (22) by said leadframe (10);

a dielectric layer (32) disposed between said metallic guard (26) and said leadframe (10);  
and

a polymer resin (30) encapsulating said at least one integrated circuit device (20), said metallic guard (26) and said inner lead portions (14).

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15. A package to house one or more integrated circuit devices (20), characterized by:

a leadframe (10) containing a plurality of generally coplanar conductive leads (12) having an inner lead end (14) and an outer lead end (16) with said inner lead ends (14) approaching a central aperture (18);

at least one integrated circuit device (20) disposed within said central aperture (18);

an electrical interconnection (22) joining said at least one integrated circuit device (20) to said inner lead ends (14);

a metallic guard (26) coated with an adhesion enhancing exterior layer (34) and bonded to said leadframe (10) external of said polymer resin (30);

a polymer resin (30) encapsulating said at least one integrated circuit device (20), said metallic guard (26) and said inner lead portions (14); and

a dielectric layer (32) disposed between said metallic guard (26) and said leadframe (10).

1/2

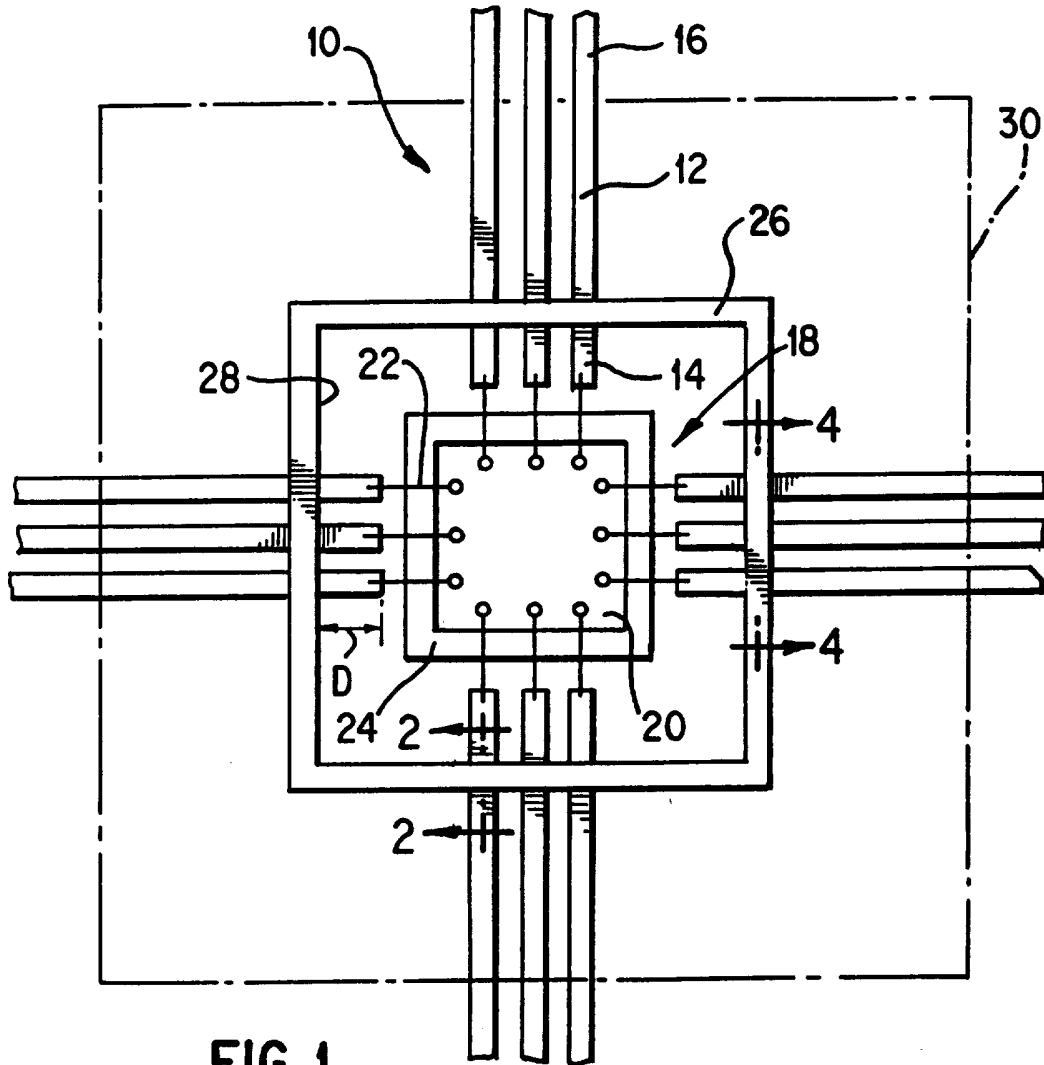


FIG. 1

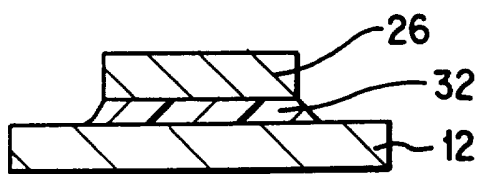


FIG. 2

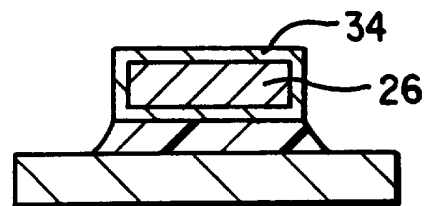


FIG. 3

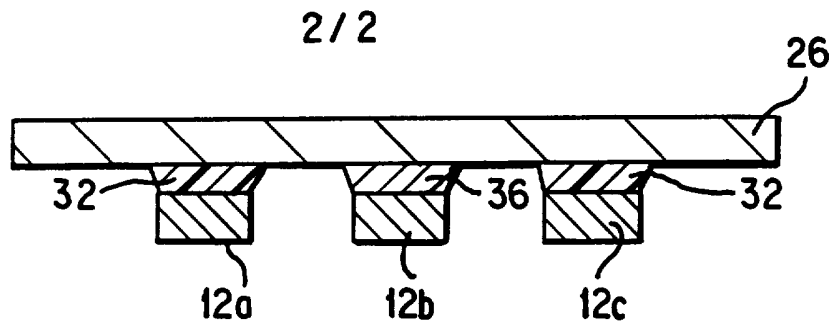


FIG. 4

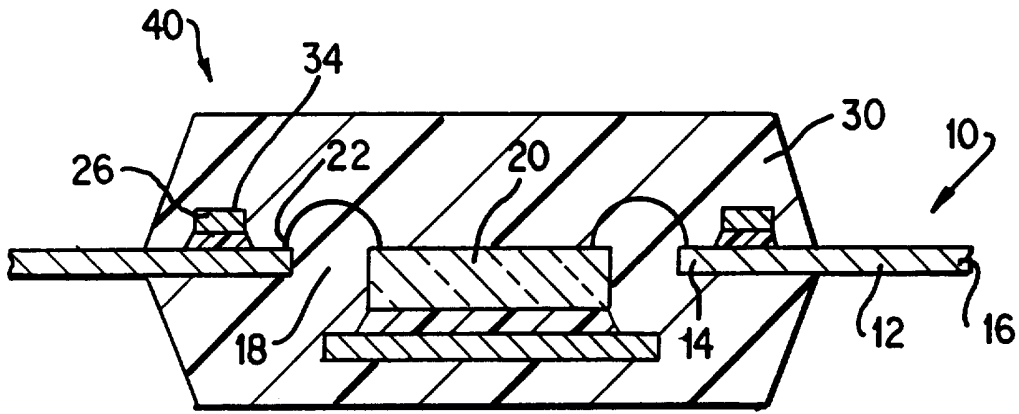


FIG. 5

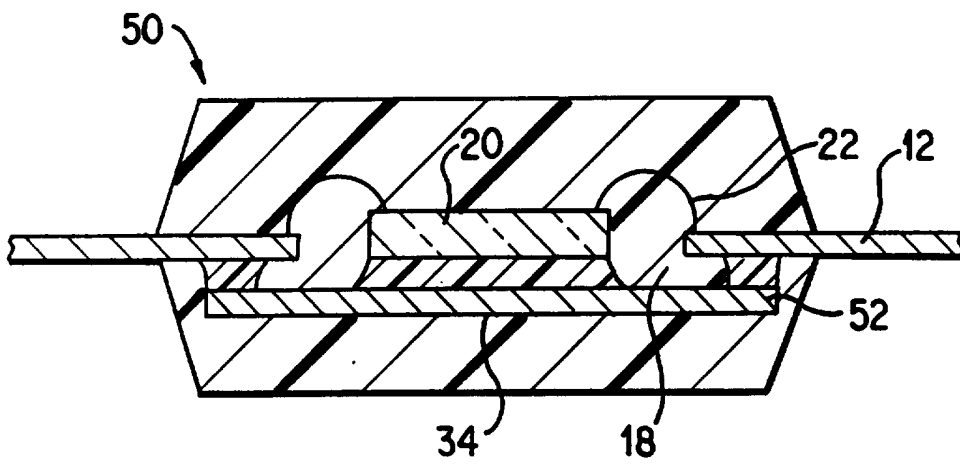


FIG. 6

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US95/17057

**A. CLASSIFICATION OF SUBJECT MATTER**

IPC(6) :HO1L 23/02,23/495.23/28

US CL :174/52.4; 257/671,787

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

U.S. : Please See Extra Sheet.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A, 5,343,074 (HIGGINS, III ET AL) 30 August 1994, see entire document.	1-15
Y	US, A, 5,065,504 (OLLA) 19 November 1991, see entire document.	1-15
Y	US,A, 4,939,316 (MAHULIKAR ET AL) 3 July 1990, see col. 5, lines 40-45.	4-6,8
Y	US,A, 5,343,073 (PARTHASARATHI ET AL) 30 August 1994, col. 5, lines 35-52.	6,8,9
Y	US,A, 4,888,449 (CRANE ET AL) 19 Dec 1989, col. 4, lines 34-44.	9

Further documents are listed in the continuation of Box C.       See patent family annex.

<p>* Special categories of cited documents:</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p>	<p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"&amp;" document member of the same patent family</p>
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Date of the actual completion of the international search

17 MARCH 1996

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30 MAY 1996

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# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US95/17057

## B. FIELDS SEARCHED

Minimum documentation searched

Classification System: U.S.

174/52.1-52.4; 257/666,670,671,676,692-694,701,734-735,773,782,783,787,788;361/813;  
29/841,855