

United States Patent

[11] 3,585,455

[72]	Inventor	Ronald Naylor Cheadle, England
[21]	Appl. No.	793,444
[22]	Filed	Jan. 23, 1969
[45]	Patented	June 15, 1971
[73]	Assignee	Ferranti, Limited
[32]	Priority	Jan. 26, 1968
[33]		Great Britain
[31]		4093/68

[56]

References Cited

UNITED STATES PATENTS

3,155,881	11/1964	St. Jean	317/101 CP (UX)
3,189,847	6/1965	Rymaszewski et al.	333/84 M (UX)
3,211,922	10/1965	Gregory et al.	317/100 X
3,365,620	1/1968	Butler et al.	317/100 X
3,390,308	6/1968	Marley	317/100
3,418,533	12/1968	Perotto	317/101 CM (UX)

Primary Examiner—David Smith, Jr.

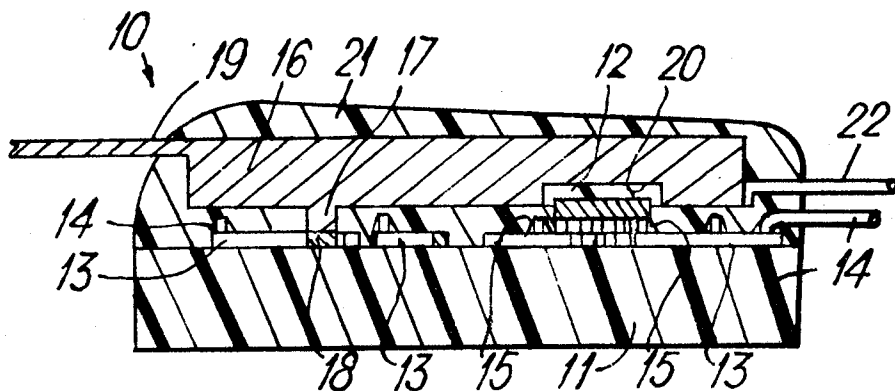
Attorney—Cameron, Kerkam and Sutton

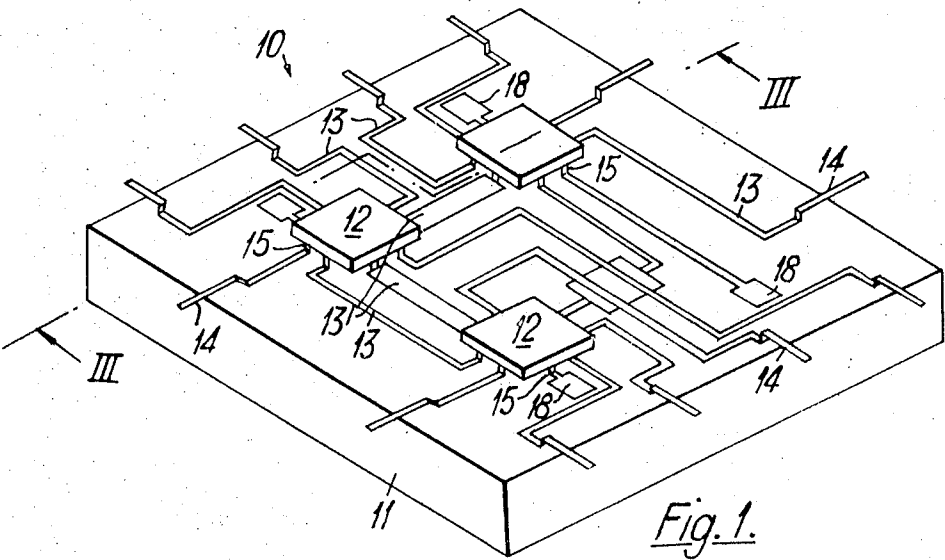
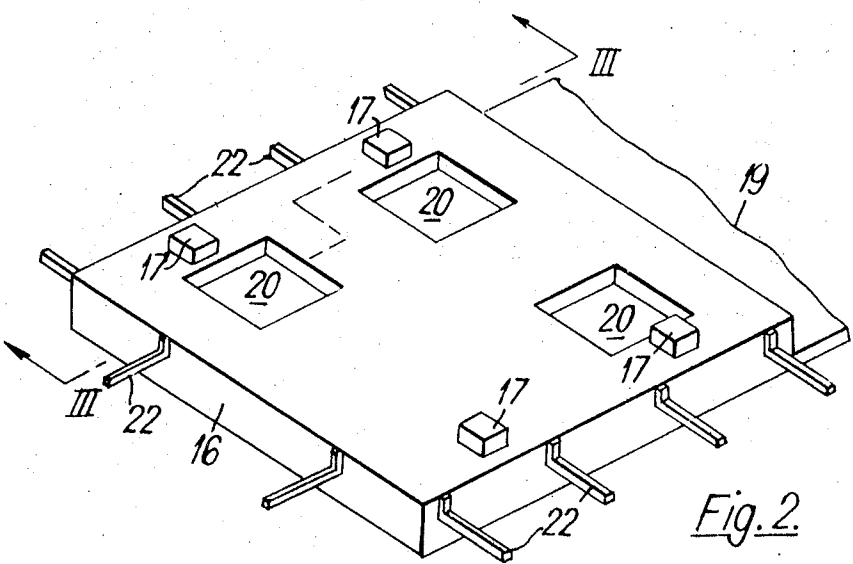
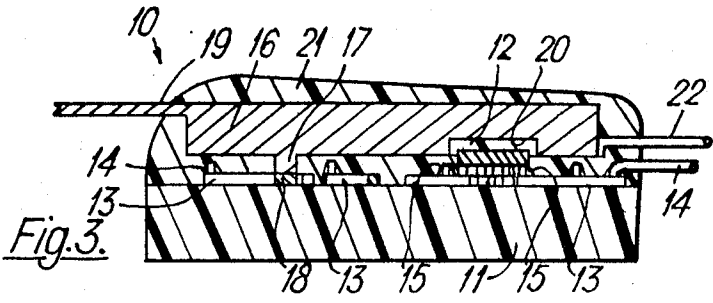
[54] CIRCUIT ASSEMBLIES

14 Claims, 4 Drawing Figs.

[52]	U.S. Cl.	317/101, 333/84
[51]	Int. Cl.	H05k 1/04
[50]	Field of Search	317/101, 101 CC, 101 CM, 100; 333/84 M

ABSTRACT: In a circuit assembly having matched signal transmission lines, and which may include semiconductor devices, one face of a substrate member has signal conductors cooperating with a common conductive plane in the form of a metal plate and the plate is mounted so as to span the conductor-bearing face of the substrate member, a dielectric medium filling the space between the plate and the conductors.





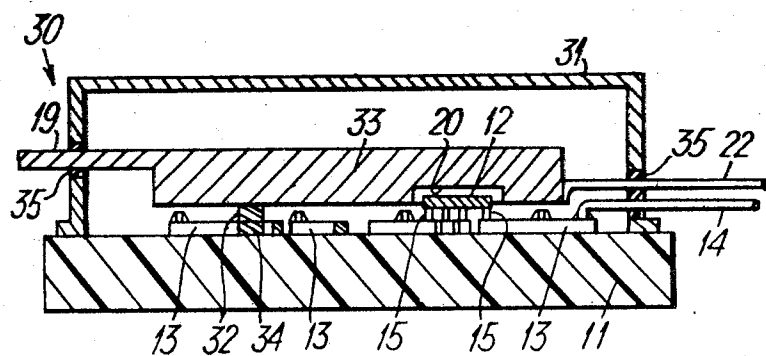


Fig.4.

CIRCUIT ASSEMBLIES

This invention relates to circuit assemblies, each assembly comprising a plurality of discrete devices with each device forming at least one circuit element, the devices being mounted on a common substrate member and being interconnected by conductors on one surface of the substrate member.

It is important in some circuit assemblies to eliminate the possibility of reflection of signal pulses transmitted by signal conductors of the circuit assemblies. It is known to provide signal conductors in the form of transmission lines, but reflections are also likely to occur in this case unless these lines are matched i.e. the characteristic impedance of each line is arranged to be equal to the impedance by which the line is terminated, the terminating impedance comprising, for example, the resistance presented by a discrete device connected to the line. With matched signal transmission lines interconnecting the discrete devices of a circuit assembly, with the resultant elimination of reflections of signal pulses, it is possible to improve the manner of operation of the circuit assembly.

Further, in microminiature circuit assemblies closely spaced signal conductors not in the form of transmission lines are cross-coupled by mutual inductance and capacitance. The magnitude of this cross-coupling is dependent both upon the closeness of the spacing between the signal conductors and upon the frequency value associated with the signal pulses. However, with signal transmission lines undesirable "cross-talk" between adjacent signal conductors is prevented because the extent of pickup of noise by a transmission line of small cross sectional area is negligible.

Matched transmission lines may have many different constructions but in one known construction used in circuit assemblies a conductive plane maintained at a reference potential is provided on one major plane surface of a laminar substrate member and the conductive plane comprises a common component of each transmission line. Each signal conductor, comprising the other component of each signal transmission line, and the H.T. conductors of power lines and the discrete devices are provided on the opposite major plane surface of the substrate member. The signal conductors are maintained exactly parallel to the common conductive plane and the magnitude of the characteristic impedance of each transmission line is determined by the spacing between the components of the transmission line, the dimensions of the conductors, and the dielectric constant of the substrate member between these components. With this construction electrical interconnections between the common conductive plane and the conductors on the opposite major substrate surface, for example, in order to complete the connections to the signal transmission lines, are made through bores in the substrate member.

It is an object of the present invention to obviate the need to provide bores through the substrate member when providing matched signal transmission lines in a circuit assembly.

According to the present invention a circuit assembly comprises a common substrate member on one plane surface of which are mounted a plurality of discrete devices, signal conductors on said plane surface of the substrate member, the conductors extending between the devices, a common conductive plane in the form of a metal member arranged to be spaced from said substrate surface and to span and to have a surface parallel to the signal conductors, and a dielectric medium between the metal member and the signal conductors, the metal member cooperating with the signal conductors to form matched signal transmission lines.

The metal member may have a substantially plane surface parallel with the plane conductor-bearing surface of the substrate member and transmission lines of different characteristic impedances may be provided by having conductors of different appropriate dimensions on the substrate member.

The metal member may be supported on the conductor-bearing surface of the substrate member by electrical interconnections between the metal member and the conductors

on the substrate member, the electrical interconnections comprising mounting pillars. The mounting pillars are bonded to or are part of either the conductors or metal pads on the conductor-bearing substrate member surface where the desired electrical interconnections with the metal member are required to be formed, the metal pads, when provided, cooperating with the conductors in an appropriate manner.

The mounting pillars either are integral with the metal member and protrude therefrom or are bonded to the metal member. In the latter case they may be formed by plating parts of the conductor-bearing surface of the substrate member, i.e. parts of the conductors, or the metal pads if provided.

The metal member may be of molybdenum.

The dielectric medium between the metal member and the signal conductors may comprise a rarefied gas such as is found in a so-called "vacuum," in this case the discrete devices and the signal transmission lines are enclosed in an hermetically sealed container, or the dielectric medium comprises a suitable potting compound which also encapsulates the circuit assembly.

The metal member may be arranged to extend to and make good electrical contact with a member external of the circuit assembly, which member in use is at a reference potential. This reference potential may be zero.

The metal member may be provided with apertures or recesses in which the discrete devices of the circuit assembly at least partially extend.

The metal member may be arranged to be used as the return lead for power lines of the circuit assembly.

At least one discrete device may comprise a semiconductor wafer, in which case the device contacts may be on one major wafer face and the device may be mounted on the substrate member with the contact-bearing wafer face supported by mounting pillars between the device contacts and the conductors on the substrate member.

The present invention will now be described by way of example with reference to the accompanying drawings, in which

FIG. 1 is a perspective view of discrete semiconductor devices and interconnecting conductors provided on a common substrate member of a circuit assembly,

FIG. 2 is a perspective view of a conductive plane in the form of a metal member for the circuit assembly, the Figure showing in detail the face of the metal member which is adjacent to the conductors in the completed circuit assembly,

FIG. 3 is a cross section of the circuit assembly after encapsulation in a potting compound and taken along the lines indicated at III-III in FIGS. 1 and 2, and

FIG. 4 is a cross section corresponding to that of FIG. 3 of a modified circuit assembly encapsulated in an hermetically sealed container.

The circuit assembly 10 shown in FIG. 1 comprises a ceramic substrate member 11 of laminar form, four silicon wafers 12 mounted on one major plane surface of the substrate member, and signal conductors and power lines 13 interconnecting the wafers 12 and connecting the wafers with leads 14 extending laterally from the circuit assembly 10. The conductors 13 are of gold underlaid with a thin nichrome layer which facilitates the adhesion of the gold conductors to the ceramic substrate member.

The silicon wafers 12 comprise discrete semiconductor devices, each device providing at least one circuit element such as a transistor or resistor of the assembly 10 and having aluminum device contacts (not shown) on one major wafer face, which face is passivated by a layer of silicon oxide. Each device 12 is mounted with the contact-bearing wafer face spaced from the substrate member 11 and is supported by at least three, and usually 16 or more, electrical interconnections 15 in the form of gold pillars of uniform height bonded to the contacts on the device and to the conductors 13 on the substrate member 11. The gold pillars 15 are formed integrally on the conductors 13 by selectively electroplating portions of these conductors through appropriately positioned apertures in a photo-resist layer, and using a solution of a gold salt as the

electrolyte. The pillars 15 are bonded to the contacts by ultrasonic or thermocompression techniques using magnifying optical apparatus and jig arrangements to position the wafer 12 accurately in its required location.

In the illustrated embodiment the signal conductors 13 comprise part of matched signal transmission lines formed by providing a common conductive plane spaced from but spanning and parallel with each signal conductor 13 on the substrate member 11.

The common conductive plane comprises a metal member or plate 16, shown in FIG. 2, the plate 16 being of molybdenum, and in use is maintained at a reference potential, possibly zero potential. The plate has a substantially plane surface parallel to the conductors 13 and is arranged to be supported on the conductor-bearing surface of the substrate member 11 by at least three uniformly high mounting pillars 17 formed integrally with the plate 16, for example, by milling a plate of appropriate thickness. The mounting pillars 17 are positioned where the electrical interconnections between the plate 16 and the signal conductors 13 are required, and also so that the plate 16 comprises the return lead of each power line of the circuit assembly. The mounting pillars 17 are bonded to the conductors 13 or, as shown in FIG. 1, to gold pads 18 which are formed on the conductor-bearing surface of substrate member 11 simultaneously with the conductors 13 and where the desired electrical interconnections between the conductors 13 and the plate 16 are required. The pads 18 are connected to the conductors in an appropriate manner and the mounting pillars 17 of the plate 16 are bonded to the pads 18 by soldering.

A relatively thin portion 19 of the plate 16 extends to and makes good electrical contact with a rail (not shown) externally of the circuit assembly 10, which rail in use is at the reference potential. In this way a low impedance earth or ground plane is provided for the circuit assembly 10 by the plate 16 in a convenient manner which facilitates the manufacture of a circuit assembly with matched signal transmission lines. The plate 16 is common to each matched signal transmission line. The provision of the matched signal transmission lines in the circuit assembly ensures that there is no reflection of signal pulses in the signal lines and no appreciable pickup of noise by these lines.

The circuit assembly 10 is completed by covering the discrete semiconductor devices 12 with a potting compound 21. The medium 21 permeates between the plate 16 and the conductors 13 and comprises the desired dielectric material between the components of the transmission lines in addition to protecting the circuit assembly from mechanical shocks.

The characteristic impedance of each matched signal transmission line of the circuit assembly is arranged to be equal to the impedance at the end of the line by designing the circuit assembly accordingly. The impedance at the end of the line comprises the resistance presented by a discrete semiconductor device 12 connected to the line, and usually this impedance associated with each signal transmission line in a circuit assembly is the same, for example, 60 ohms. Thus the height of the mounting pillars 17 between the plate 16 and the signal conductors 13 is arranged to provide a characteristic impedance of this value for each signal transmission line of the circuit assembly and by having conductors 13 on the substrate member of a convenient width. However, if signal transmission lines of different characteristic impedances are required in a circuit assembly these may be provided by having conductors of appropriately different widths as shown at 13'. The conductor widths are conveniently in the range 0.002 inch to 0.01 inch.

The height of the mounting pillars 17 may be of the order of 0.02 inch, in which case the plate 16, as is shown in FIG. 3, is arranged to span not only the conductors 13 on the substrate member 11, but also the discrete semiconductor devices 12. However the mounting pillars 17 alone are of insufficient height to permit the plate 16 to span the devices 12 and these devices are partially accommodated in appropriately posi-

tioned recesses 20 formed in the plate 16. Alternatively, apertures extending through the plate 16 may be provided where the devices 12 are to be located.

The externally extending leads 14 of the circuit assembly also are in the form of matched transmission lines since they cooperate in the required manner with the thin portion 19 of the plate 16 or with leads 22 soldered to the plate 16 and extending laterally therefrom. The characteristic impedances of such lines are determined by the dimensions of the leads 14 and 22, their spacing apart and the value of the dielectric constant of the material present between these leads.

Any suitable permeable dielectric medium may be used to fill the space between the conductors and the plate, and the circuit assembly in this form may then be encapsulated with a different material comprising a suitable potting compound, for example, the epoxy resin sold under the trademark STYCAST.

The dielectric medium may comprise the rarefied gas found in a so-called "vacuum" within an hermetically sealed container for the circuit assembly. In this case the circuit assembly may not be encapsulated in a potting compound.

The circuit assembly 30 shown in FIG. 4, and in respect of which Figure generally the same reference numerals are used to indicate identical or closely resembling parts to those shown in FIGS. 1 to 3, includes an hermetically sealed container 31 cooperating with the substrate member 11. The rarefied gas within the container comprises the dielectric medium and the circuit assembly is not encapsulated in a potting compound.

Otherwise the construction of the circuit assembly 30 is the same as that of the circuit assembly 10 of FIGS. 1 to 3, except that the mounting pillars 32 between the metal member 33 and the substrate member 11 are formed by plating-up the metal pads 34 on the substrate member through appropriately positioned apertures in a photoresist layer over the metal pads 34 and the conductors 13. The leads 14 and 22, and the thin portion 19 of the plate 33, extend externally of the circuit assembly 30 through glass seals 35 in the container 31.

The circuit assembly constructions with matched signal transmission lines as described above are particularly advantageous when the discrete semiconductor devices 12 are mounted on the substrate member 11 with the contact-bearing faces of the devices spaced from the substrate members, because the plates 16 may be mounted in like manner on the substrate members 11 as the devices 12 and possibly also simultaneously therewith.

The presence of the metal plate 16 within the circuit assembly 10 facilitates the dissipation of heat from the discrete semiconductor devices 12 by providing a heat sink and heat conduction paths to spread the heat within the assembly. If the plate 16 extends externally from the assembly, and especially if it is secured to a substantial metal earthing member, then heat generated by the discrete semiconductor devices during normal operation is removed rapidly from the circuit assembly. It will be appreciated that the metal member providing the common conductive plane need not be in the form of a plate.

The mounting pillars between the metal member and the substrate member may be formed on or be bonded to the conductors on the substrate member, and the metal pads connected to the conductors may not be provided.

The metal member may not be supported on the substrate member, in which case the electrical interconnections between the metal member and the conductors do not comprise mounting pillars. In such a construction the conductors and the discrete devices may be covered with a partially cured dielectric medium and the metal member placed on the medium before the circuit assembly is encapsulated.

The semiconductor wafers 12 may be mounted on the substrate member 11 in any convenient manner and not necessarily as described above by being supported by mounting pillars 15 bonded to the conductors 13 and the contact pads on the wafers 12.

It may be that in certain circuit assemblies not all the device wafers have circuit elements formed therein, such wafers comprising interconnection members of the circuit assembly. Further it is possible that thin film circuit elements are formed on the device wafers.

Although the circuit assembly described above has all the constituent discrete devices in the form of semiconductor wafers at least some of these devices may comprise thin or thick film circuit elements.

I claim:

1. A circuit assembly comprising a common substrate member on one plane surface of which are mounted a plurality of discrete devices, matched signal transmission lines interconnecting the discrete devices, signal conductors on said plane surface of the substrate surface member, the conductors extending between the devices, a common conductive plane in the form of a metal member arranged to be spaced from said substrate surface and to span said devices and said conductors and to have a surface parallel to the signal conductors, the metal member cooperating with the signal conductors to form said matched signal transmission lines.

2. A circuit assembly as claimed in claim 1 in which the metal member has a substantially plane surface parallel with the plane conductor-bearing surface of the substrate member.

3. A circuit assembly as claimed in claim 2 in which transmission lines of different characteristic impedances are provided by having conductors of different appropriate dimensions on the substrate member.

4. A circuit assembly as claimed in claim 1 in which the metal member is supported on the conductor-bearing surface of the substrate member by electrical interconnections between the metal member and the conductors on the substrate member, the electrical interconnections comprising mounting pillars.

5. A circuit assembly as claimed in claim 4 in which the mounting pillars are integral with the metal member and

protrude therefrom.

6. A circuit assembly as claimed in claim 4 in which the mounting pillars are formed by plating parts of the conductor-bearing surface of the substrate member and these mounting pillars are bonded to the metal member.

7. A circuit assembly as claimed in claim 1 in which the metal member is of molybdenum.

8. A circuit assembly as claimed in claim 1 having a dielectric medium between the metal member and the signal conductors comprising a potting compound, which potting compound also encapsulates the circuit assembly.

9. A circuit assembly as claimed in claim 1 in which the dielectric medium between the metal member and the signal conductors comprises a rarefied gas and the discrete devices and the signal transmission lines are enclosed in an hermetically sealed container.

10. A circuit assembly as claimed in claim 1 in which the metal member is arranged to extend to and to make good electrical contact with a member external of the circuit assembly, which member in use is at a reference potential.

11. A circuit assembly as claimed in claim 1 having a metal member provided with recesses in which the discrete devices of the circuit assembly at least partially extend.

12. A circuit assembly as claimed in claim 1 in which the metal member is arranged to be used as the return lead for power lines of the circuit assembly.

13. A circuit assembly as claimed in claim 1 in which at least one discrete device comprises a semiconductor wafer.

14. A circuit assembly as claimed in claim 13 in which the semiconductor device has the device contacts on one major wafer face and the device is mounted on the substrate member with the contact-bearing wafer face supported by mounting pillars between the device contacts and the conductors on the substrate member.

40

45

50

55

60

65

70

75