July 21, 1970 W. M. SHARPLESS 3,521,203

MAGNETIC MOUNTING FOR PILL-TYPE DIODES

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FIG. 1

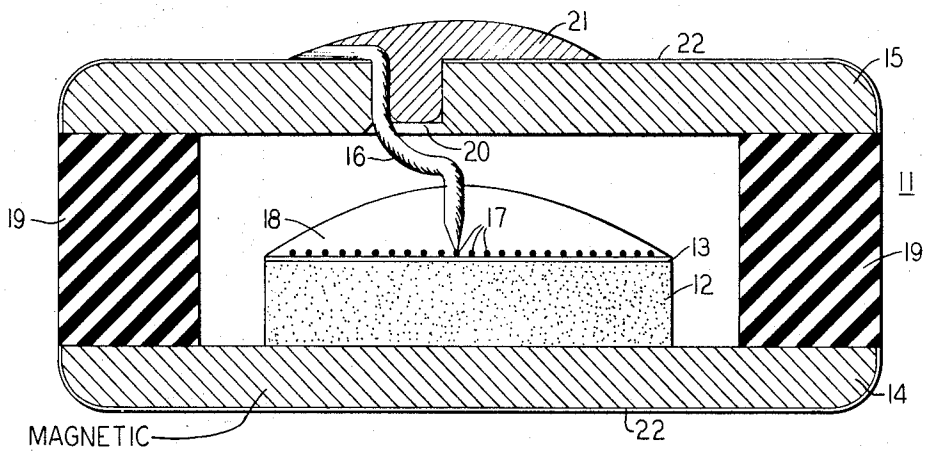



FIG. 2

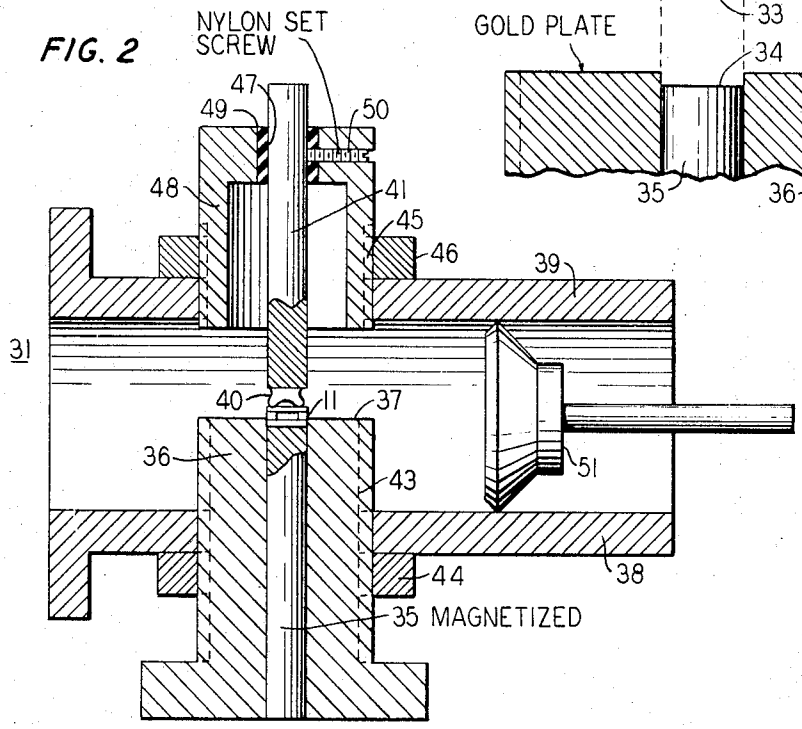



FIG. 3




INVENTOR
W. M. SHARPLESS
BY Ray M. Porter Jr.
ATTORNEY

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# MAGNETIC MOUNTING FOR PILL-TYPE DIODES

William M. Sharpless, Fair Haven, N.J., assignor to Bell Telephone Laboratories, Incorporated, Murray Hill and Berkeley Heights, N.J., a corporation of New York

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## ABSTRACT OF THE DISCLOSURE

A pill-type diode is disclosed suitable for magnetic mounting within a waveguide. The end layers of the cylindrical pill, constituting the diode's terminals, are made of a magnetic material and are conductively bounded. The pill is secured within the guide by compression between two coaxial conducting rods inserted through opposite walls of the waveguide. One of the rods is magnetized so that the pill is held magnetically during the mounting process.

## BACKGROUND OF THE INVENTION

This invention relates to electromagnetic wave devices and, more specifically, to devices for mounting miniaturized diodes within waveguides.

Many characteristics of asymmetrically conducting devices such as crystal diodes have made their use desirable in the high frequency range of the electromagnetic wave spectrum. In U.S. Pats. 2,436,830 and 2,438,521 granted to applicant on Mar. 2, 1948 and Mar 30, 1948, respectively, there are disclosed various techniques for utilizing such devices. Particularly useful are diodes mounted in piston-tuned sections of a waveguide where they function, for example, as oscillators or detectors.

In the centimeter wave or longer microwave region a diode encased in a coaxial cartridge and located in the path of the propagating wave energy is generally satisfactory. Conventionally, the diode is encased in a cylindrical ceramic package approximately ¼ inch or more in length with end caps serving as the diode's electric terminals. For low frequency mounting, two spring contacts are soldered on the ends of wires and the diode is inserted between the spring contacts, each of which grips an end cap circumferentially. At the higher frequencies, where coaxial line and waveguide mounts are required, structural and electrical contact is usually made with pairs of jaw-spring fingers or mechanical chucks which grip the end caps of the cylindrical cartridge circumferentially. Using this mechanism, a diode can be inserted into a waveguide attached to one of these jaw-spring structures, and the mating required to complete the mount is accomplished within the guide. Removal is effected in a reverse manner.

At the higher frequencies, miniature pill-type diodes are more desirable than larger cartridge diodes since they exhibit greatly reduced inductance and capacitance. The need, therefore, arises to mount these miniature diodes within miniature sized waveguides. Pill-type diodes are cylindrical in shape but their axial length is small compared with the diameter of a cross section. A diode of this type might have an axial length of 0.025 inch and a diameter of 0.070 inch which is approximately the size of the head of a common household pin. In order to mount this tiny diode according to conventional technology, it would require machining a pair of chucks in many cases larger than the diode itself, adding undesirable inductance and capacity, and each capable of circumferentially gripping the small pill while avoiding electrical contact between themselves. This mounting technique would also required providing the pill diode with two electrically conductive end caps which extend axially on the pill's cylindrical surface far enough to be gripped solidly by the chucks, while each end cap remains electrically distinct.



An alternative means of mounting small diodes within a waveguide structure is desirable in order to avoid these undesirable mechanical and high frequency electrical features.

## SUMMARY OF THE INVENTION

In accordance with the present invention, a pill-type diode is constructed which can be mounted within a conductively bounded waveguide using a magnetic holder. The use of a magnetic mount eliminates the difficult problems involved in adapting conventional mounting techniques to a pill diode the size of a pin head. At least one end surface of the cylindrical pill is made of a magnetic material. As used herein a magnetic material is one such as a ferromagnetic substance which is attracted by a magnetic field such as is produced by a conventional magnet or magnetized material, and a magnetized material is one which has the properties of a magnet and sets up a magnetic field which attracts magnetic materials.

In addition to its magnetic properties, the end surface must afford good external electrical contact since the end surfaces of the pill constitute the terminals of the diode. This combination of properties is provided by using as an end layer of the cylindrical pill an iron alloy having good electrical conductivity and bonding a high conductivity material to its outer surface. The pill is a cylindrical sandwich having a conductively bounded iron alloy bottom end layer, a semiconductor diode bonded to the bottom end layer, and a conductively bounded top end layer. For the embodiment selected, the top and bottom ends are both made of the same magnetic material.

The pill diode constructed in accordance with the present invention has an outer casing which provides good electrical conductivity and a magnetic surface, thus permitting the pill to be supported by a magnetized holder. The mounting device magnetically provides structural connection between one end of the pill and a surface of a removable member of the mount. The pill may therefore be positioned within or removed from any inaccessible location into which the removable member may be inserted.

Magnetic attraction between the diode and the removable mounting member causes the pill to remain fixed in place on the surface of this member during the mounting process. The removable member with the pill affixed is inserted into the desired location which may be, for example, a waveguide section. A second member of the mounting mechanism, inserted from the opposite direction, provides pressure to the second end of the pill by means of a spring, causing the pill to be firmly compressed between the two members of the mount.

Electrical connections to the diode are made simultaneously with the structural support. The opposing ends of the pill constitute the two diode terminals and the mounting members act as conductors. For effective electrical contact, the mating surfaces of the rods should be plated with a low resistance material such as gold.

It is one object of the present invention to provide a pill-type diode which can be mounted in an inaccessible location. It is further desirable to provide a device which facilitates easy mounting and removal of a pill-type electronic component, such as a diode, within a waveguide section.

These objects are accomplished by packaging a diode so that it can be magnetically attached to a movable structure. Thus supported, the diode is placed in a desired position where it is firmly fixed by compression. In addition to mounting diodes, magnetic mounting can, of course,

be employed to hold other types of miniature electronic components.

## BRIEF DESCRIPTION OF THE DRAWINGS

The above-mentioned and other objects and features of the invention will become more apparent by reference to the following description taken in conjunction with the accompanying drawings in which like numbers are used to designate identical elements throughout.

In the drawing:

FIG. 1 is a cross-sectional view of a pill-type diode suitable for mounting in a magnetic holder;

FIG. 2 is a plan view particularly in cross section of a piston-tuned waveguide section in which a pill-type diode is mounted in accordance with the present invention; and

FIG. 3 is an exploded view of the pill-type diode and the adjacent members of the mounting structure.

## DETAILED DESCRIPTION

Referring to FIG. 1, there is shown, by way of example a diode suitable for mounting in a waveguide using a magnetic holder. The design of this diode is such that the lead inductance and barrier capacity have been reduced to a minimum while maintaining the high efficiency characteristics of a Schottky barrier rectifier. This diode is expected to show low conversion loss and noise ratios at frequencies well above "X" band.

The complete diode package **11** is about 0.070 inch in diameter and approximately 0.025 inch high. The semiconductor material is N-type epitaxial gallium-arsenide of the polka-dot type composed of substrate **12** and epitaxial layer **13**.

Substrate **12** is soldered or otherwise affixed to lower disc **14** as shown. Disc **14** is made of Kovar, an iron alloy containing nickel, cobalt, and maganese. As is well known in the art, Kovar is a magnetic material and a good electrical conductor, and its thermal expansion is covariant with glass. Thus Kovar is an excellent material for casings of small semiconductor devices especially where glass or quartz are used as insulators.

Point **16** is electrolytically pointed 0.0005 inch round phospho-bronze wire which is gold-plated. This point makes a firm low resistance contact to one of the numerous four micron diameter gold dots **17** previously disposed on the 0.5 micron thick epitaxial surface **13**. After the desired contact is made, the point is locked in place with a layer of low loss epoxy cement **18**. The finished ruggedized diode, bonded to disc **14**, is about 0.012 inch high. A second Kovar disc **15** is mounted as shown insulated by quartz spacer **19**. Point **16** extends through off center hole **20** in disc **15** and is affixed to the exterior of disc **15** by solder **21**. Discs **14** and **15** are the diode terminal and their exterior surfaces are plated with thin films of gold **22** which prevents corrosion of the Kovar surface and provides low resistance low loss contacts.

Referring to FIGS. 2 and 3, there is shown by way of example, a diode mounting assembly within a piston-tuned conductively bounded waveguide section **31**. As described above, the end surfaces **32** and **33** of diode package **11** are made of a magnetic material. The pill will be held in place when end **33** of package **11** is positioned on corresponding end **34** of magnetized rod **35**. Rod **35** has a diameter slightly larger than the diameter of diod package **11** and is mounted tightly in an axial hole in the center of matching probe **36**. Rod **35** is affixed to probe **36** depressed slightly from surface **37** of probe **36**. Diode package **11** is placed in the depression so that end **33** of package **11** is in contact with end **34** of magnetized rod **35**. By means of external threading **43**, matching probe **36** is inserted through lower broad waveguide wall **38** with package **11** attached. Pressure is applied to opposite end **32** of diode package **11** by small metal contact spring **40** located on the end of a second cylindrical rod **41**. Rod **41** and spring **40** are not magnetized. Rod **41** passes through cylindrical hole **47** in the wall of output trap **48** which is mounted in upper broad waveguide wall **39**. Rod **41** is insulated electrically from output trap **48** by a layer of insulation **49**, such as Teflon, which is attached to the cylindrical wall of hole **47**. Axial movement of rod **41** is prevented by set screw **50**, made of insulating material such as nylon, positioned as shown.

As was described above, ends **32** and **33** of diode package **11** constitute the electrical terminals of the diode are plated with a layer of high conductivity material. For good electrical contact, spring **40** and end **34** of rod **35** should likewise be plated with a high conductivity material. Gold is a suitable material for this purpose, and will provide gold contact at both terminal connections. Electrical connection of the diode to an external circuit is provided through rod **41** and through the waveguide walls via probe **36**. The conduction path from the diode package **11** to waveguide wall **38** is improved by gold plating surface **37** of probe **36** as well as end **34** of rod **35**.

Waveguide section **31** may be tuned by adjustment of piston **51** as is well known in the art. Impedance matching can be achieved by experimentally advancing and retracting probe **36** by means of threading **43** and correspondingly threaded locking nut **44**. Advancing and retracting trap **48** by means of threading **45** and correspondingly threaded locking nut **46** will further improve matching. A very broad-band, low standing wave ratio match to the diode is accomplished by adjusting the position of both trap **48** and probe **36**, together with piston **51**.

One advantage of the diode configuration described above is that the diode package is structurally symmetrical. Since each end is made of Kovar, both ends have magnetic properties. Therefore, the polarity may be reversed when desired and the pill may be mounted with either end in contact with the magnetized rod when used as an unbalanced single diode detector. For use as a balanced detector, the structural symmetry is especially desirable as either of the pill diodes may be reversed with respect to the other without altering the mounting structure. Thus the need for providing means of electrically reversing the direction of current flow by using one P and one N type diode or by employing complicated external circuitry to do the compensating is eliminated.

While the invention is shown with diode package **11** electrically connected to waveguide wall **38**, it is to be clearly understood that diode package **11** could be isolated from the waveguide wall and the necessary external connections provided by additional circuitry. Further, if it is desired to electrically DC isolate diode package **11** from rod **35**, probe **36**, and waveguide wall **38**, a thin layer of dielectric material such as mica may be substituted for gold layer **37**. Without affecting the magnetic attraction the dielectric material would allow only a high frequency capacitive coupling to waveguide wall **38** without providing a DC current path.

Although the invention has been described as a diode mounting for a piston tuned waveguide section, it is to be clearly understood that this mounting device is adaptable to any structure in which a pill-type electronic component, diode or otherwise, is internally mounted. A transistor, for example, could be mounted with a first terminal connected to probe **36** and the other two terminals connected individually to two discrete conductive paths associated with rod **41**.

In all cases it is to be understood that the above-described arrangements are merely illustrative of a small number of the many possible applications of the principles of the invention. Numerous and varied other arrangements in accordance with these principles may readily be devised by those skilled in the art wihtout departing from the spirit and scope of the invention.

What is claimed is:

**1.** Apparatus for mounting an electronic component comprising in combination:

a cylindrical package containing said component includ-

ing a plurality of terminals of said component on the exterior of said package, at least one end surface of said package being of a magnetic material;

a magnetized structural member for magnetically attracting said one magnetic end surface of said package;

a nonmagnetized structural member mounted coaxially with said magnetized member for compressing said package axially between said magnetized and nonmagnetized members providing structural support of said package;

means for making electrical contact between said plurality of terminals and an external circuit through at least one of said members.

**2.** In combination, a conductively bounded waveguide;

a semiconductor diode;

a cylindrical package in which said diode is held including two conductively bounded ends of said package connected as electrical terminals of said diode, at least one of said ends being of a magnetic material;

a magnetized rod magnetically attracting said one magnetic end of said package and having means for making electrical connection with said one magnetic terminal end of said package, said magnetized rod being inserted through and secured to a wall of said waveguide and said diode being magnetically attached axially thereto;

a nonmagnetized rod inserted coaxially with said magnetized rod through and secured to an opposite wall of said waveguide; and

means for maintaining rigid contact between said nonmagnetized rod and said package, and for making electrical contact with a second terminal end of said package.

**3.** A combination as claimed in claim **2** wherein said magnetized rod is of slightly larger diameter than said package and said magnetized rod is mounted within a probe with its end depressed slightly from the surface of said probe so that said package fits into the depression when magnetically attracted to said magnetized rod, and wherein said means for maintaining rigid contact and for making electrical contact is a conductive spring located



on the end of said nonmagnetized rod so that said spring is pressed against said second terminal end of said package when said nonmagnetized rod is inserted through and secured to said opposite wall.

**4.** In a waveguide,

a first mechanical element capable of conducting electrical signals;

a pill sized electronic component within a package;

means for magnetically holding said package to an extremity of said first element, said first element being inserted through a wall of said waveguide and secured thereto such that said extremity projects into said waveguide;

a second mechanical element capable of conducting electrical signals, said second element being inserted through a wall of said waveguide and secured thereto such that said second element and said first element provide axial structural support of said package and make electrical contact through said component.


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