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ENCAPSULATED DIODE AND PROTECTIVE RESISTANCE

The present invention relates to a device including an encapsulated arrangement of diode and protective resistance used especially for high-frequency signals. The device may be used, for example, in a tuner circuit of a television receiver.

Fig. 7 shows an input stage of a typical tuner circuit 1 of a television receiver, in which a variable-capacitance diode 2 and a switching diode 3 are used. In order to protect those diodes 2 and 3 from an accidental failure due to overvoltages, resistances 4a and 4b (usually of 50-100 kΩ) are normally provided for the respective diodes 2 and 3. In the figure, C_1, C_2, C_3, and C_4 are blocking capacitors, L_1, L_2 and L_3 are tuning coils, numeral 5 denotes a dual gate MOS FET for RF amplification, numeral 6 denotes a bias resistance and C_5 is a bypass capacitor.

Conventionally, discrete parts are used in constructing such a circuit, and the protection resistance 4a and 4b have been also provided separately: the resistance 4a and 4b are connected at one end to the diodes 2 and 3 and at the other end to the voltage input terminals 7 and 8. In this case,

there must be some length of the lead between the diode 2, 3 and the resistance 4a, 4b, and the problem is the stray capacitance 9 and 10 due to the lead, which may cause unintentional influences on the tuner characteristics.

Therefore, an object of the present invention is to provide a diode device with very small stray capacitance and suitable for high-frequency use.

Another object of the present invention is to provide a unit part in which a diode and its protection resistance are integrally combined.

According to one aspect of this invention, a diode device for a high-frequency circuit comprising: a variable-capacitance diode; a resistance connected to a terminal of the diode for protecting the diode from an overvoltage; a resin package for encapsulating the diode and the resistance; and a plurality of terminal members each being partially embedded in the resin package for making connection to the terminals of the diode and resistance.

According to another aspect of this invention, a diode device for a high-frequency circuit comprising: a diode formed by a semiconductor substrate and a semiconductor region having a conductivity type

opposite to the substrate and embedded in the substrate; a resistance for protecting the diode from an overvoltage and placed on the substrate on an insulation layer through which a hole is formed to establish contact between the resistance and the substrate; a first and a second terminal member connected to the terminals of the diode; a third terminal member connected to the resistance; and a resin package for encapsulating the diode and the resistance and for partially embedding the terminal members.

Since a diode and its protection resistance are integrated and molded into a unit part in the above features, the lead between them is very short, yielding negligible stray capacitance and giving high adaptability to high-frequency use. The unit device is also advantageous in handling and in manufacturing application circuits such as a television tuner.

BRIEF DESCRIPTION OF THE ATTACHED DRAWINGS

These and other objects and features of this invention will become clear from the following description taken in conjunction with the preferred embodiments with reference to the accompanied drawings in which:

Fig. 1a is an illustrative plan view of a diode device embodying the feature of the present invention,

Fig. 1b is a cross-sectional view taken along the line B-B of Fig. 1a,

Fig. 2 is a perspective view of the diode device,

Fig. 3 is the circuit diagram of the diode device,

Fig. 4 is a cross-sectional view of the main part of the diode device,

Fig. 5 is an illustrative plan view of the second embodiment of the present invention,

Fig. 6 is an illustrative plan view of the third embodiment of the present invention, and

Fig. 7 is a circuit diagram of a tuner of a VHF television receiver.

The device shown in Figs. 1a, 1b, and 2 is the first embodiment of the present invention in which a protection resistance 4′ is placed on a diode chip 12 which is mounted on one 11 of the three pins 11, 13 and 14 of the device. As shown in Fig. 3, the pin 11 is used for the cathode of the diode 12, another pin 13 is connected to the anode via an inner lead wire 16, and the third pin 14 is to the resistance 4′ via another inner lead wire 17, all of which are molded and fixed with resin 15. The pins 11, 13 and 14 are made from a leadframe and separated after molding.

The diode chip 12 integrated with the protection resistance 4′ is constructed as shown in Fig. 4. The diode 12 is formed by an N-type silicon substrate 18 and a P-type region 19 embedded in it. Then an insulation layer 21 is formed covering the N-type substrate surface with a through hole for a polysilicon layer doped with impurities (the resistance) 4′ to reach the substrate 18. On the P-type region (anode of the diode) 19 is placed a metal (preferably, but not limited to, aluminum) terminal 22, and on the polysilicon layer (resistance) 4′ is placed another metal terminal 23. The back of the N-type silicon substrate 18 is coated with a vapor-plated gold 24, which contacts the cathode pin 11. The metal terminals 22 and 23 are bonded with the wires 16 and 17 to connect to the other two pins 13 and 14. The molding resin is preferred to be chosen from those having less high-frequency dielectric loss.

Fig. 5 shows the second embodiment of the present

invention, in which the resistance 4' is formed, independent from the the diode 12, on the third pin 14. The resistance 4' may be formed by vapor plating on the pin 14, or otherwise. The third embodiment is shown in Fig. 6, in which the connection wire 17 between the diode 12 and the third pin 14 is formed by a high-resistance wire to work as the protection resistance.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims, the invention may be practiced other than as specifically described.

CLAIMS:

1. A diode device for a high-frequency circuit comprising:

a variable-capacitance diode;

a resistance connected to a terminal of the diode for protecting the diode from an overvoltage;

a resin package for encapsulating the diode and the resistance; and

a plurality of terminal members each being partially embedded in the resin package for making connection to the terminals of the diode and the resistance.

2. The diode device according to claim 1, wherein the terminal members are pins made from a leadframe, and wires connecting the diode and the resistance to the pins are encapsulated in the resin package.

3. The diode device according to claim 2, wherein the resistance is mounted on one of the pins.

4. The diode device according to claim 2, wherein the wire connecting the diode and one of the pins is formed by a high-resistance wire acting as the resistance.

5. The diode device according to claim 1, where the resistance is integrally formed on a semiconductor substrate of the diode.

6. A diode device for a high-frequency circuit comprising:

a diode formed by a semiconductor substrate and a semiconductor region having a conductivity type opposite to the substrate and embedded in the substrate;

a resistance for protecting the diode from an overvoltage and placed on the substrate on an insulation layer through which a hole is formed to establish contact between the resistance and the substrate;

a first and a second terminal member connected to the terminals of the diode;

a third terminal member connected to the resistance; and

a resin package for encapsulating the diode and the resistance and for partially embedding the terminal members.

7. A tuner for high-frequency signals comprising a diode device according to any of the preceding claims.

8. A diode device substantially as described herewith with reference to any of Figs. 1 to 6 of the drawings.