

Description

[0001] The present invention relates to a load structure for an antenna, specifically a planar load realisation for an antenna for a wireless communication system, such as a telecommunication system, a wireless local area network system or any other wireless communication system in which antennas are used for transmitting and receiving signals.

[0002] Some antenna concepts require a loading of the antenna structure in order to improve the antenna radiation efficiency. Hereby, a complex load (impedance) placed between the antenna or antenna connection and a feeding connection (e.g. transmission line or cable) is suggested. The load, which is connected to the antenna is typically realised by one or more load resistors, capacitors, inductors or by a load circuit formed by series and/or parallel combinations thereof.

[0003] The object of the present invention is to propose a load structure for an antenna which simplifies a load design and improves the performance and reliability of the antenna itself.

[0004] This object is achieved according to a load structure for an antenna as claimed in the independent claim.

[0005] For solving the above object, the present invention proposes in particular a load structure for an antenna which comprises a substrate. One face is adapted to be connected to a feeding connection and the other face is adapted to be connected to an antenna or antenna connection. A first metal structure is located on the first face and a second metal structure is located on the other face, whereby the first metal structure is electrically connected to the second metal structure and the first and/or the second metal structure comprise at least one load element.

[0006] The invention is based on the insight, that the size of a load structure should be very small compared to the signal wavelength transmitted or received via the antenna. In particular, the physical size of a load should not exceed about a tenth of the respective wavelength. Thus, only small size discreet elements like SMD's (Surface Mounting Devices) can be used to construct a load. The placement of these elements has to be done very precisely as the performance of the antenna circuit, i.e. at least the antenna including its load, depends strongly on a geometrically correct assembly of its components.

[0007] Applications in the upper MHz to GHz frequency range often require a three-dimensional assembly of the discreet devices for implementing an antenna load circuit. As the devices can only be interconnected via their contact surfaces, a respective assembly is very difficult to realise. A load design is particularly complicated as the contact surfaces are typically located at opposite sides on most devices thereby imposing a lot of layout restrictions. To obtain the required mechanical stability of a load set-up, each device is usually stucked to a substrate or neighbouring device with a non-conductive res-

in that needs a special curing treatment before providing the required mechanical support. A three-dimensional load assembly is therefore prone to misalignment. Further, as the contact surfaces are bordering each other, short circuits are frequently formed when interconnecting the contact surfaces by means of soldering or with a conductive resin. Both, misalignment and short circuit behaviour result in a bad and unreliable performance of an antenna circuit assembly.

[0008] The assembly of an antenna circuit is usually accomplished by automatic component mounting machines, which cannot handle components, i.e. discreet devices or elements, respectively, below a certain size. This sets a practical limit to the minimal physical dimensions of workable discreet devices. But when the size of a discreet element exceeds about a tenth of a signal wavelength, effects originating from a wave propagation inside of the device have to be considered when designing a load. These effects, which modify the intended characteristic of the device are referred to as distributed effects. They considerably complicate a load design and/or degrade the performance of the antenna.

[0009] A load structure according to the present invention enables a substantially planar load structure design, as the one or more load elements are mounted directly on a face of the substrate. The load structure can be realised on different types of substrates. The substrate can be chosen based on the one hand for its usability for the requested frequency range, for example ceramic substrate, printed circuit board PCB, RT-duroid, on the other hand to be small in size to fit into the geometry of the antenna and to increase the antenna performance.

[0010] Advantageous embodiments of the present invention are the subject of other claims.

[0011] For an easy to manufacture planar load structure, the load element is preferably formed by ceramic or LTCC (Low Temperature Co-fired Ceramic) type of thinfilm and/or thickfilm technologies, as the respective technologies are well developed for implementing flat device structures of small physical dimensions directly on a surface of the substrate and can further easily be combined.

[0012] For realising an impedance of small dimensions, the load is preferably formed by a semiconductor structure. Particularly for very high frequency applications a complex impedance can economically be formed by an integrated circuit formed in a silicon or GaAs (Gallium Arsenide) substrate. Using semiconductor structures for constructing a load additionally offers the capability to implement the load in form of an active element like for instance a diode or transistor or to add respective active elements to the load for realising e.g. amplifier or rectifier circuits.

[0013] In a great number of applications the load for an antenna has to comprise a resistive component so that in this case at least one load element is a resistor formed in said first and/or said second metal structure.

Of course also a capacitor and or inductor may be as a load or part of a load circuit to achieve an improved antenna efficiency.

[0014] Further, the properties of strip lines like e.g. a microstrip or a triplate line can be used to form a load. The electrical properties of a strip line for a desired frequency range can be easily determined through its design.

[0015] For applications in the upper MHz and lower GHz range where a tenth of the signal wavelength does not exceed the dimensions of a Surface Mounting Device, the loading element may further be realised by using Surface Mounting Devices.

[0016] To avoid any distributed effects, the electrical connection between the first and the second metal structure must not be longer than about a tenth of a signal wavelength transmitted over it. This is best achieved by electrically connecting the first and second metal structure to each other by via holes in the substrate or by at least one metal edge wrap around bridging the substrate or a combination of both connecting types.

[0017] To enable a fast and easy bonding of a connector on the load structure, the second metal structure extends in a recess formed by the other face of the substrate thus allowing inserting the connector into the recess like a plug.

[0018] In the following description, an antenna load structure according to the present invention is explained in more detail with respect to special embodiments and in relation to the enclosed Figures 1 to 4, in which

Figure 1a shows an antenna load structure according to the present invention connected to an antenna and a feeding connection,

Figure 1b shows an antenna load structure according to the present invention connected to an antenna connection and a feeding connection,

Figure 2 shows a cross section view of an embodiment of a load structure according to the present invention,

Figure 3 shows a top view of the load structure shown in Figure 2, and

Figure 4 shows a planar load structure lay out example.

[0019] The application of a load structure 1 according to the present invention in a loaded antenna structure 2 with a bond to a feeding connection 4 or connector 4, respectively, is shown in Figure 1a. The loaded antenna structure 2' of Figure 1b differs from this only in that the antenna 3 is not directly connected to the load structure 1 but indirectly via the antenna connection 3a. The connector 4 serves as a transmission (feeding) line to an

RF circuit adapted to receive and or transmit electrical signals from or to, respectively, the antenna load structure 2. The load structure 1 connects the antenna 3 with the connector 4. The antenna 3 is bonded to a first metal structure on the first face of the load structure 1 and the connector 4 is bonded to a second metal structure on the second face of the load structure 1. Type and physical form of the antenna are determined by radiation characteristic considerations and have no influence on the load structure according to the present invention. In particular, the proposed load structure 1 is not restricted to a cone-shaped antenna 3 like shown in Figure 1 but may also be used with other types, e.g. a rode-like, patch-like or helix-like type of antenna.

[0020] The cross-sectional view shown in Figure 2 gives a detailed representation of a load structure 1 according to the present invention. The core of the load structure is formed by a substrate 5. The thickness of the substrate 5, i.e. its extension in the direction from the connector 4 to the antenna 3 in Figure 1, is about a tenth or less of a signal wavelength propagating between the antenna 3 and the connector 4.

[0021] A first metal structure 7 and 8 is formed on the first face of the substrate 5, which in Figure 2 is shown at the substrate bottom. In the illustrated embodiment, the wiring part 7 of the first metal structure consists of several sections each of which serves a different purpose as for instance providing a contact tongue for a load, a contact area for the connector 4 or the like. All sections belonging to the wiring part 7 are hatched with the same pattern. The load elements 8 each are placed between a first and a second section of the wiring part 7. A second metal structure 6 is formed on the opposite second face of the substrate 5.

[0022] The antenna 3 is bonded to the second metal structure 6 while the connector 4 is bonded to a wiring part 7 of the first metal structure on the opposite face of the substrate 5. Soldering or an epoxy type of mounting procedure, whereby the antenna 3 maybe fixed by a different bonding technique than the connector 4, typically accomplishes bonding of the antenna 3 and the connector 4 at the respective dedicated position. Accordingly, a suitable bonding layer 10 is present on both metal structures.

[0023] The electrical connection between the first and second metal structure, which connects the load elements 8 to the antenna 3, is preferably formed by conductive material spanning between the first and the second face of the substrate. In a preferred embodiment of the present invention shown in Figure 2, the first metal structure is electrically connected to the second metal structure 6 by means of one or more conductive feed-throughs 9 extending through via holes in the substrate 5. Alternatively, a so called 'edge wrap around' can be used. An edge wrap around is a conductive material as for instance a strip, foil, wire or the like, which bridges an edge, i.e. one of the surfaces extending between the first and second face of the substrate, to connect the

first metal structure 7 and 8 with the second metal structure 6. A combination of an electrical connection by via holes and by edge around elements is further possible.

[0024] To simplify a fastening of the connector 4 on the load structure 1 a fixture is formed in a further preferred embodiment of the present invention by a recess 11 on the first face of the substrate. The surface of the recess is preferably covered by the wiring part 7 of the first metal structure. For bonding, the connector 4 is fed into the recess, which may be prepared with a conductive resin layer 10 or solder layer 10. Compared to planar contact areas for bonding to the connector 4, the recess type fixture requires no sophisticated alignment equipment for attaching the connector.

[0025] In Figure 3 the first face of a load structure according to a special embodiment of the present invention is shown. The circular shape of the substrate 5 is adapted for an attachment to a cone-shaped antenna geometry like that shown in the cross-sectional view of Figure 1. The wiring part 7 comprises several segments, in particular a metalised groove 11 or recess 11, respectively, with a circularly shaped base located in the centre of the substrate 5 from which four contact tongues extend to each form an electrical connection to a respective load element 8 arranged around the groove. Each load element 8 is further connected to a feed-through 9 providing a wired connection from the first to the second metal structure.

[0026] The shape of the substrate must not necessarily follow an antenna's geometry, nor the geometry of the fixture groove 11. In the example shown in Figure 4, a square shaped substrate 5 is used for a cone-shaped antenna geometry and a polygon-shaped metal-plating around the groove 11. Different to the embodiment shown in Figure 3, the electrical connection between the first and second metal structure is in this embodiment realised by so called 'edge wrap arounds' 12 which interconnect a contact pad 13 of the first metal structure with a contact pad of the second metal structure on the opposite face of the substrate 5. Each edge wrap around hereto extends over a part of a side surface located between the first and second face of the substrate 5.

[0027] Both metal structures 6 and 7 are implemented in a planar technology. When using only one load element 8 per location provided on the wiring part 7 of a first metal structure, also SMD's can be used without impairing the planar character of the load structure 1. Using SMD's in the first metal structure is possible for frequencies up to the lower GHz range. A more complex load layout comprising a combination of different types of load elements is implemented by providing sufficient locations of the wiring part 7 of the first metal structure so that only one SMD has to be attached at one location provided for not to impair the planar character of the load structure 1.

[0028] Particularly for higher frequencies, planar technologies for manufacturing the load elements have to be applied. The preferred technologies are the thin-

film and thickfilm technology, particularly manufactured based on the Low Temperature Co-fired Ceramic (LTCC) technology. In thinfilm technology structures for forming devices are manufactured by one or more depositions of thin layers of suited materials like e.g. metals, isolators, semiconductors or organic type of materials. For making a resistor, usually a high resistive material is deposited between two metallic layers serving as contact strips. A capacitor is typically realised as a vertical sequence of two metallic layers sandwiching an isolating layer. The also generally known thickfilm technology is not very different from that except that pastes are applied to the substrate surface instead of depositing film.

[0029] In many applications the antenna performance requirements are simply achieved by a resistive type of load. For non resistive load designs capacitors and/or inductors may be used instead or additionally. But also semiconductor based structures, particularly active elements like e.g. diodes or transistors may be used. Besides using the resistive and reactive parts of these elements impedance, also their amplifying or rectifying properties may advantageously be employed. For a perfect impedance matching, a combination of different electric and/or electronic components is typically required.

[0030] As an alternative or in addition to discreet electric or electronic devices also distributed planar transmission type of loads, particularly strip lines, particularly microstrip or triplate lines may be used to form a load. The planar structure of a strip line advantageously allows to integrate a respectively formed load in the planar structure of the first or second metal structure. The electrical properties of a strip line for a desired frequency range are for a given dielectric easily engineered by its geometric dimensions.

[0031] Particularly when a respective combination of elements comprises a multitude of components, the load is preferably implemented in form of an integrated circuit. As manufacturing technologies are farthest developed for silicon and GaAs integrated technologies, the preferred base material for a respective integrated circuit is silicon or GaAs or a hybrid of both. Due to the higher mobility of charge carriers in GaAs, this material is the first choice for ultra high frequency applications and even semiconductor elements like diodes or transistors can be implemented into the load. A respective integrated circuit may further be designed to not only form a load but to serve in addition as an amplifier.

[0032] The design of a load structure is primarily orientated on improving an antenna's radiation performance which in some cases may best be achieved by a combination of the above mentioned types of load elements. Further, it is to be noted, that the load elements 8 must not necessarily be an integral part of the first metal structure opposite the second face supporting the antenna or the antenna connector but may also be an integral part of the second metal structure or of both metal structures.

Claims

1. Load structure for an antenna (3), comprising
 - a substrate (5) with a first face adapted to be connected to a feeding connection (4) and a second face adapted to be connected to an antenna (3) or an antenna connection (3a), and
 - a first metal structure (7, 8) on said first face and a second metal structure (6) on said second face, said first and said second metal structure being electrically connected to each other,
 whereby said first (7, 8) and/or said second metal structure (6) comprise at least one load element (8).
2. Load structure according to claim 1, **characterised in that** said load element is formed by a thinfilm structure.
3. Load structure according to claim 1 or 2, **characterised in that** said load element (8) is formed by a thickfilm structure.
4. Load structure according to claim 1, 2 or 3, **characterised in that** said load element (8) is formed by a semiconductor structure.
5. Load structure according to claim 4, **characterised in that** said semiconductor structure is a silicon or GaAs based integrated circuit.
6. Load structure according to claim 4 or 5, **characterised in that** a diode forms said semiconductor structure or is part of said semiconductor structure.
7. Load structure according to one of the claims 4 to 6, **characterised in that** a transistor forms said semiconductor structure or is part of said semiconductor structure.
8. Load structure according to one of the claims 1 to 7, **characterised in that** said load element (8) is formed by a resistor.
9. Load structure according to one of the claims 1 to 8, **characterised in that** said load element (8) is formed by a capacitor and/or inductor.
10. Load structure according to one of the claims 1 to 9, **characterised in that** said load element (8) is formed by a stripline.
11. Load structure according to one of the claims 1 to 9, **characterised in that** said load element (8) is a Surface Mounting Device.
12. Load structure according to one of the claims 1 to 11, **characterised in that** said first (7, 8) and said second (6) metal structure are electrically connected to each other by via holes (9) in the substrate (5).
13. Load structure according to one of the claims 1 to 12, **characterised in that** said first (7, 8) and said second (6) metal structure are electrically connected to each other by at least one metal edge wrap around (12) bridging the substrate (5).
14. Load structure according to one of the claims 1 to 13, **characterised in that** said second metal structure (6) extends in a recess (11) formed by the second face of the substrate (5).

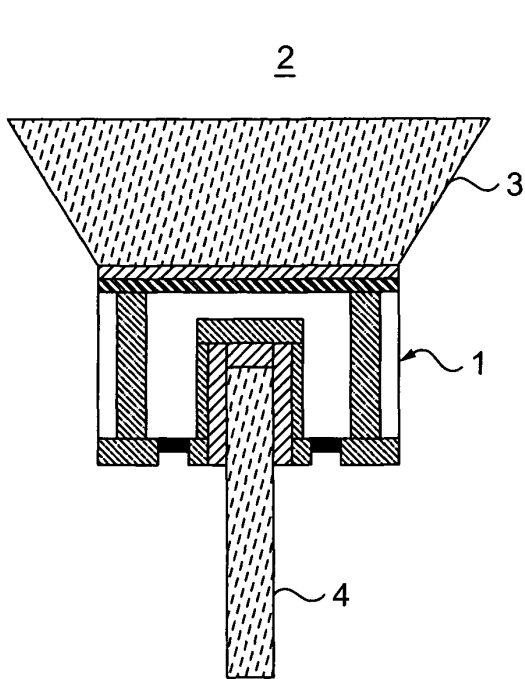


Figure 1a

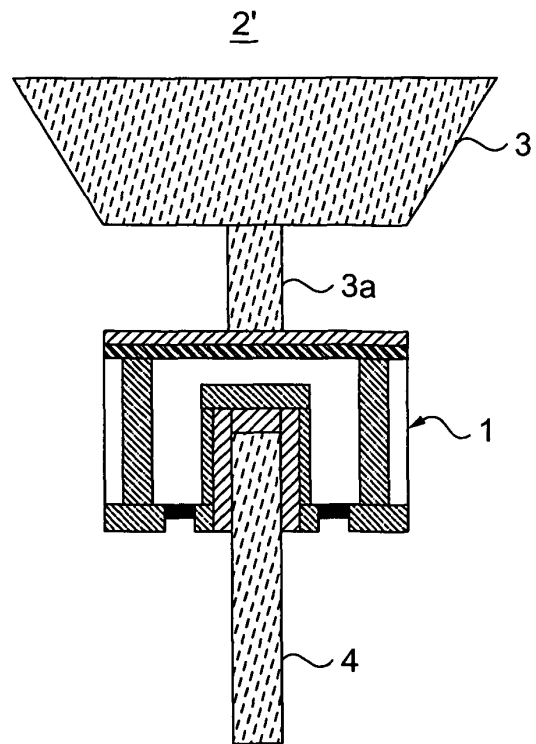


Figure 1b

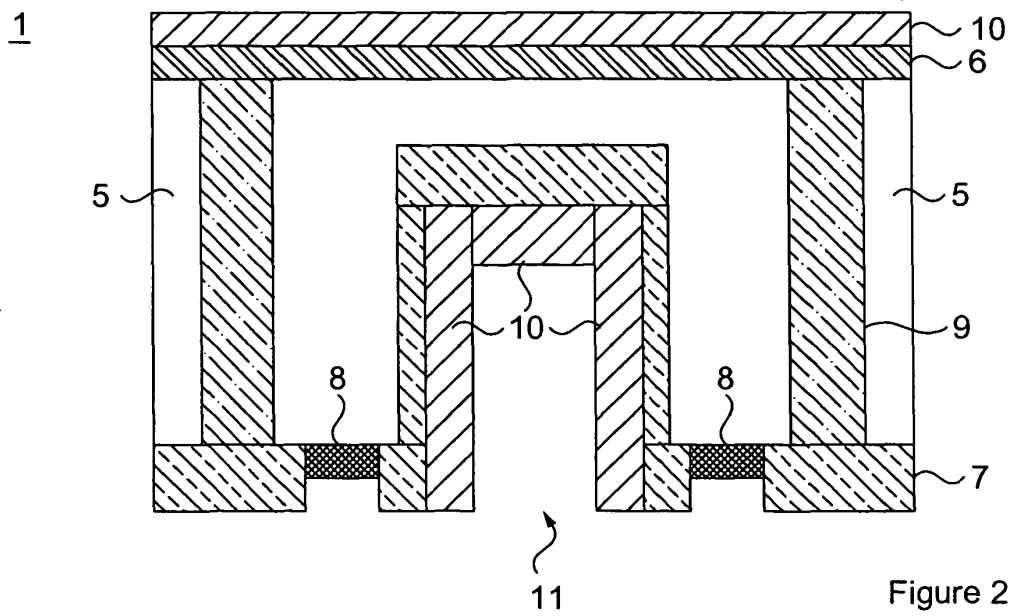


Figure 2

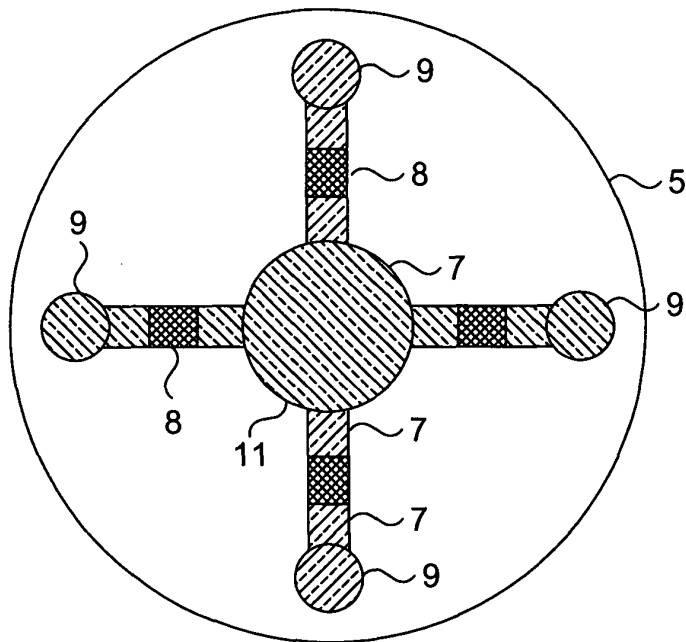


Figure 3

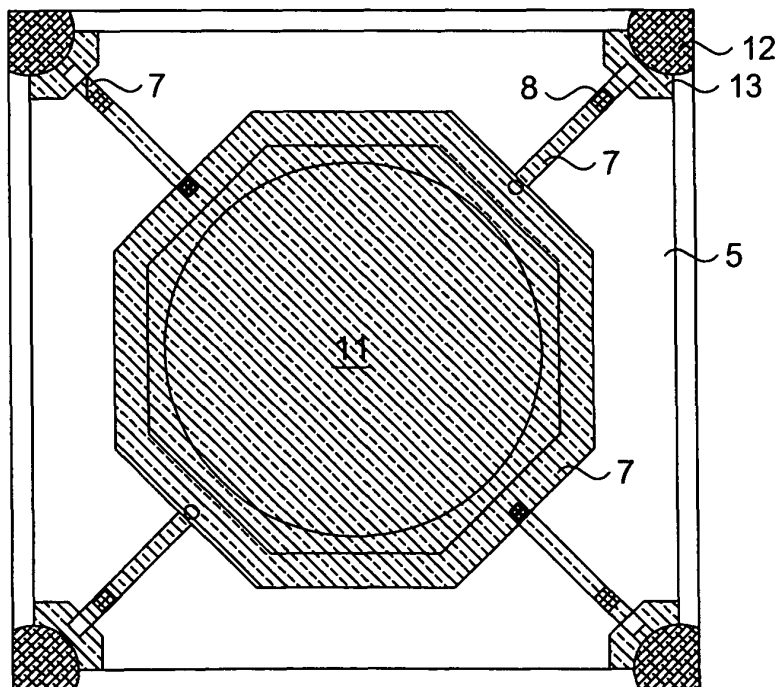


Figure 4



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Application Number
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The present search report has been drawn up for all claims			
Place of search MUNICH		Date of completion of the search 26 May 2004	Examiner Jäschke, H
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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