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Method for Forming an Antenna and A Radio Frequency Transponder

Dr.Ravi Saraf
University of Nebraska-Lincoln, rsaraf2@unl.edu

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Brady et al.

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(54) **METHOD FOR FORMING AN ANTENNA AND A RADIO FREQUENCY TRANSPONDER**

(75) Inventors: **Michael John Brady**, Brewster, NY (US); **Ravi Saraf**, Blacksburg, VA (US); **Judy Rubino**, Ossining, NY (US)

(73) Assignee: **International Business Machines Corporation**, Armonk, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 84 days.

(21) Appl. No.: **09/883,433**

(22) Filed: **Jun. 18, 2001**

(65) **Prior Publication Data**

US 2001/0030628 A1 Oct. 18, 2001

Related U.S. Application Data

(63) Continuation of application No. 09/435,172, filed on Nov. 5, 1999, now Pat. No. 6,271,793.

(51) **Int. Cl.**7 .... **H01Q 13/00**

(52) **U.S. Cl.** .... **29/600**; 29/840; 29/846; 343/700 R

(58) **Field of Search** .... 29/600, 840, 846, 29/847; 228/180.22, 180.21; 428/901; 343/700 R, 718

(56) **References Cited**

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5,403,649	A	*	4/1995	Morgan et al.	428/209
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Primary Examiner—Carl J. Arbes
Assistant Examiner—Tai Nguyen
(74) *Attorney, Agent, or Firm*—Ryan, Mason & Lewis, LLP; Louis J. Percello, Esq.

(57) **ABSTRACT**

A method is disclosed for forming an antenna and a radio frequency transponder. The method comprises the steps of (1) forming a paste comprising metal powder, polymeric material, and solvent; and (2) screening the paste through a screen onto a substrate. Additional steps couple electrical components to the paste and dry the paste.

8 Claims, 2 Drawing Sheets

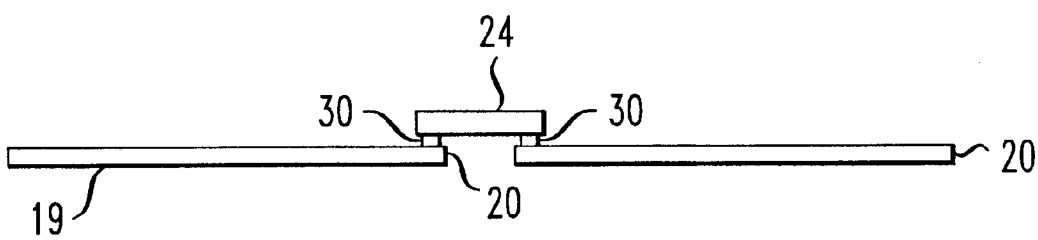


FIG. 1
PRIOR ART

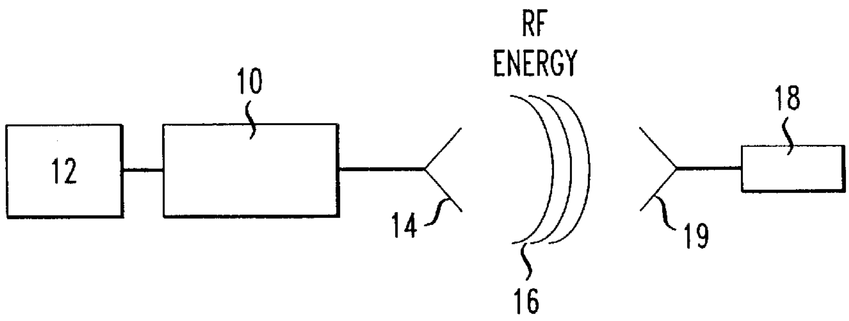


FIG. 2

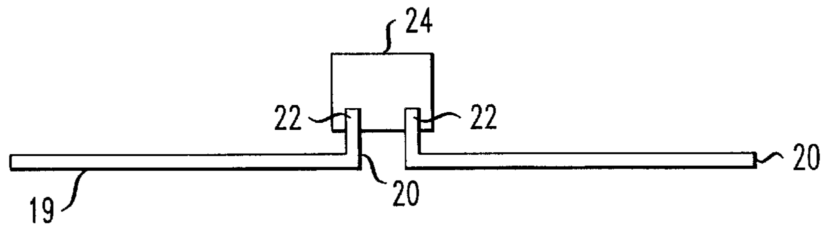


FIG. 3

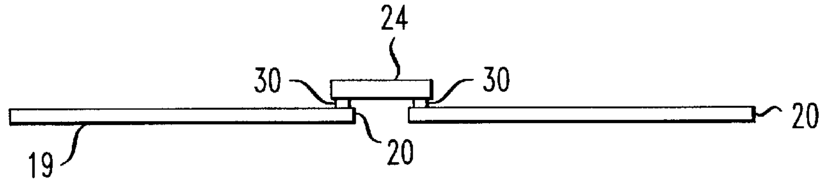


FIG. 4

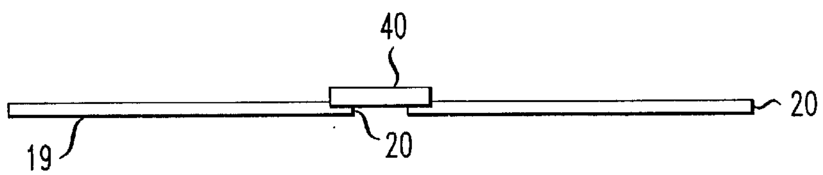


FIG. 5

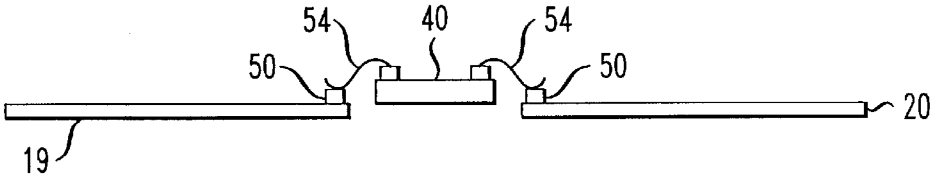


FIG. 6

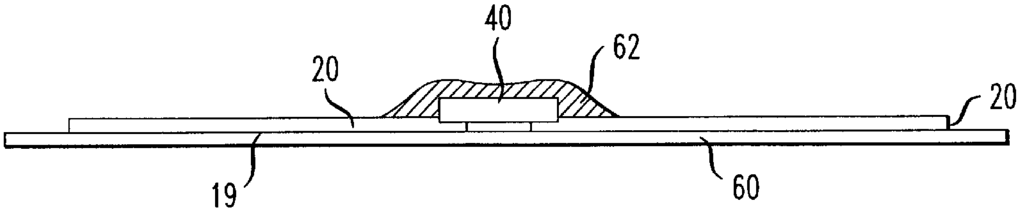


FIG. 7

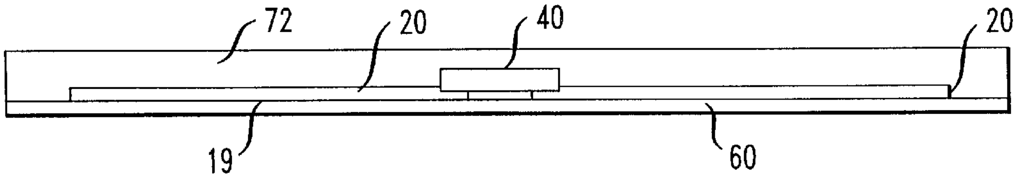
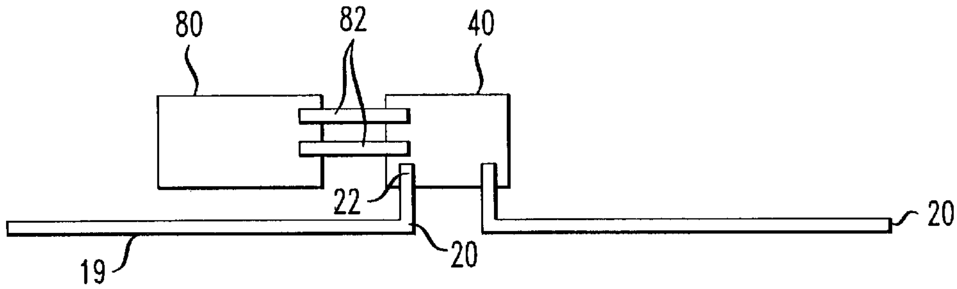


FIG. 8



METHOD FOR FORMING AN ANTENNA AND A RADIO FREQUENCY TRANSPONDER

This application is a continuation of Ser. No. 09/439,172 of U.S. Pat. No. 6,271,793, filed Nov. 5, 1999.

FIELD OF THE INVENTION

The field of the invention is the field of Radio Frequency (RF) transponders (RF Tags) which receive RF electromagnetic radiation from a base station and send information to the base station by modulating the load of an RF antenna.

BACKGROUND OF THE INVENTION

RF Tags can be used in a multiplicity of ways for locating and identifying accompanying objects, items, animals, and people, whether these objects, items, animals, and people are stationary or mobile, and transmitting information about the state of the of the objects, items, animals, and people. It has been known since the early 60's in U.S. Pat. No. 3,098,971 by R. M. Richardson, that electronic components on a transponder could be powered by radio frequency (RF) power sent by a "base station" at a carrier frequency and received by an antenna on the tag. The signal picked up by the tag antenna induces an alternating current in the antenna which can be rectified by an RF diode and the rectified current can be used for a power supply for the electronic components. The tag antenna loading is changed by something that was to be measured, for example a microphone resistance in the cited patent. The oscillating current induced in the tag antenna from the incoming RF energy would thus be changed, and the change in the oscillating current led to a change in the RF power radiated from the tag antenna. This change in the radiated power from the tag antenna could be picked up by the base station antenna and thus the microphone would in effect broadcast power without itself having a self contained power supply. In the cited patent, the antenna current also oscillates at a harmonic of the carrier frequency because the diode current contains a doubled frequency component, and this frequency can be picked up and sorted out from the carrier frequency much more easily than if it were merely reflected. Since this type of tag carries no power supply of its own, it is called a "passive" tag to distinguish it from an active tag containing a battery. The battery supplies energy to run the active tag electronics, but not to broadcast the information from the tag antenna. An active tag also changes the loading on the tag antenna for the purpose of transmitting information to the base station.

The "rebroadcast" or "reflection" of the incoming RF energy at the carrier frequency is conventionally called "back scattering", even though the tag broadcasts the energy in a pattern determined solely by the tag antenna and most of the energy may not be directed "back" to the transmitting antenna.

In the 70's, suggestions to use tags with logic and read/write memories were made. In this way, the tag could not only be used to measure some characteristic, for example the temperature of an animal in U.S. Pat. No. 4,075,632 to Baldwin et. al., but could also identify the animal. The antenna load was changed by use of a transistor. A transistor switch also changed the loading of the transponder in U.S. Pat. No. 4,786,907 by A. Koelle.

Prior art tags have used electronic logic and memory circuits and receiver circuits and modulator circuits for receiving information from the base station and for sending information from the tag to the base station.

The continuing march of semiconductor technology to smaller, faster, and less power hungry has allowed enormous increases of function and enormous drop of cost of such tags. Presently available research and development technology will also allow new function and different products in communications technology.

A fundamental problem with RF tags is that the cost of the tag must be reduced to a level small compared to the cost of the product to which the tag is attached, which would then allow many more tags to be used and so that high volume production can cut the costs even further. The cost of the tags is the cost of the semiconductor chip, the antenna, the substrate supporting the antenna and chip, and the attachment cost. The present invention lowers the cost and increases the function of the antenna attached to the substrate.

RELATED PATENTS AND APPLICATIONS

Related U.S. patents assigned to the assignee of the present invention include: U.S. Pat. No. 5,866,044, which is a continuation of application Ser. No. 08/2,339,609, filed Nov. 15, 1994 (now abandoned). Other U.S. patents include: U.S. Pat. Nos. 5,521,601; 5,528,222; 5,538,803; 5,550,547; 5,552,778; 5,554,974; 5,563,583; 5,565,847; 5,606,323; 5,635,693; 5,673,037; 5,680,106; 5,682,143; 5,729,201; 5,729,697; 5,736,929; 5,739,754; 5,767,789; 5,777,561; 5,786,626; 5,812,065; 5,821,859; 5,828,318; 5,831,532; 5,850,181; 5,874,902; 5,889,489; 5,909,176; and 5,912,632. U.S. patent applications assigned to the assignee of the present invention include: application Ser. No. 099/119,569, filed Jul. 20, 1998, which is a division of Ser. No. 08/734,492 (now U.S. Pat. No. 5,866,044. The above identified U.S. patents and U.S. patent applications are hereby incorporated by reference.

OBJECTS OF THE INVENTION

It is an object of the invention to produce an RF transponder comprising components which can be made at low cost. It is a further object of the invention to provide an RF transponder comprising a flexible antenna and substrate. It is a further object of the invention to provide an RF transponder which can be made by screen printing techniques. It is a further object of the invention to provide an RF transponder having enhanced environmental resistance. It is a further object of the invention to provide an RF transponder in a thin package. It is a further object of the invention to provide an RF transponder antenna which may easily be electrically connected to a semiconductor chip.

SUMMARY OF THE INVENTION

The present invention is an RF antenna made from a composite material, wherein the composite material preferably comprises electrically conducting particles in a matrix, and wherein the electrically conducting particles have such a high density that the electrical conductivity of the composite material is large enough for the antenna to receive RF signals sufficient to activate the RF tag.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a sketch of a prior art RFID tag and base station.

FIG. **2** is a sketch of a plan view of an embodiment of the invention.

FIG. **3** is a sketch of an elevation view of an embodiment of the invention.

FIG. **4** is a sketch of an elevation view of an embodiment of the invention.

FIG. **5** is a sketch of an elevation view of an embodiment of the invention.

FIG. **6** is a sketch of an elevation view of an embodiment of the invention.

FIG. **7** is a sketch of an elevation view of an embodiment of the invention.

FIG. **8** is a sketch of a plan view of an embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

FIG. **2** shows a plan view of the apparatus of the invention. Electrical circuitry **24** is connected to an antenna **19**, which is made of a material **20** which is a composite material, preferably a composite of a large number of small electrically conducting particles in a matrix. The composite material is connected to electrical circuitry **24** at points **22**. Composite material **20** is most preferably silver powder mixed in a thermoplastic matrix. Composite material's **20** matrix is preferably an elastomeric polymer and/or a thermoplastic material. The antenna **19** is preferably made by screening a paste of metal powder, polymer material, and solvent through a screen on to a substrate (shown later). While the paste is still wet, the electrical circuitry **24** is preferably mechanically and electrically bonded to the material **20** of the invention by contacting electrical contacts of the electrical circuitry **24** with the wet paste, and then driving off the solvent and/or curing the polymer matrix material. Surprisingly, material **20** of the invention may have sufficiently low electrical resistance that the apparatus of FIG. **2** works as an RFID tag with only slightly reduced read distance from an RFID tag with an antenna made from conventional copper. Conventional wisdom in the antenna art dictates that the antenna material has as low a resistivity as possible. The material **20** has preferably 30% by volume electrically conducting powder mixed in with the matrix material. With the most preferred material of the invention, the dried metal powder matrix material has a resistivity only 10 times that of solid copper which equals 1.7 micro-ohm-cm. It is important that the resistivity be as low as possible, preferably in the range from about 10 micro-ohm-cm to about 40 micro-ohm-cm. It is most preferable for the material to have a resistivity less than 20 micro-ohm-cm. Other conducting particle composite materials are preferably copper particles, copper particles covered with a silver film, and copper particles covered with a gold film. Other preferred composite materials **20** are composites of conducting polymers and elastomeric polymers.

With the material **20** of the invention, the steps of forming an antenna by stamping or etching solid metal electrical conductors, then joining the metal to the semiconductor chip are combined into the steps of screening paste and pressing the electrical circuit connections into the wet paste. This leads to an enormous decrease in the cost of the tags.

While FIGS. **1–8** show antennas as dipole antennas, all antennas as known in the art of RF communication are anticipated by the inventors, including but not limited to patch antennas, spiral antennas, horn antennas, reflector antennas, folded dipole antennas, and polarizing antennas.

FIG. **3** shows an elevation view of the apparatus of the invention. Material **20** is shown electrically contacting an electrically conducting material **30** which is electrical contact with electrical circuitry **24**. Electrical circuitry **24** is most preferably a single semiconductor chip. Electrically conducting material **30** may be a pad on the chip, a bump on the chip or another means as known in the art to make contact to a chip. Material **20** is most preferably screen printed on to a substrate (shown later). The formed antenna **19** may be stripped off the screen printed substrate after curing, or may most preferably be left on the substrate.

FIG. **4** shows the material **20** of the invention directly contacting electrical contacts of the a chip **40** so that the chip **40** is both mechanically connected to and electrically connected to the material **20** of the antenna **19**.

FIG. **5** shows the material **20** of the invention connected to an electrically conducting pad **50** which is wire bonded with wire **54** to chip **40** through a conducting pad or bump **52** on the chip **40**.

FIG. **6** shows the antenna of the invention supported by a substrate **60**, and also shows that the chip **40** is encapsulated with encapsulant **62**. The substrate **60** and the encapsulant **62** protect the chip from the environment. The substrate **60** is formed from epoxy-glass printed circuit board or from a polymer such as polyimide, polyethylene terphalate (PET), mylar, polyester, pollycarbonate, or other substrates as are known in the art. In particular, the substrate **60** and the material **20** of the antenna may be elastic so that the system is flexible.

FIG. **7** shows the material of the invention and the chip protected by the environment by a layer **72** which is sealed to substrate **60** and which covers material **20** and chip **40** completely. Material for layer **72** is advantageously EVA (Ethylene vinyl acetate), which adheres well with PET and is used extensively in the food industry.

FIG. **8** shows a plan view of the invention, where battery **80** is attached to chip **40** by electrical connections **82**. Electrical connections **82** are preferably made of the same material **20** as antenna **19**, and are bonded at the same time that chip **40** and material **20** are bonded together. A suitable battery is a thin film battery comprising MnO_2, Lithium foil, and a polymer electrolyte (PAN) with a thickness of 14 mils. The apparatus of the invention may also comprise a passive RFID tag.

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 otherwise than as specifically described.

We claim:

1. A method for forming an antenna and connecting the antenna with electrical circuitry, the method comprising the steps of:

forming a paste comprising metal powder, thermoplastic material, and solvent;

screening the paste through a screen onto a substrate, the step of screening forming at least the antenna and forming electrically conducting material;

while the paste is wet, contacting electrical contacts of electrical circuitry to the electrically conducting material formed from the paste; and

drying the paste.

2. The method of claim **1** wherein the step of drying the paste comprises the step of driving off the solvent.

3. The method of claim **1** wherein the step of drying the paste comprises the step of curing the thermoplastic material.

4. The method of claim **1** wherein the step of drying the paste comprises the steps of:

driving off the solvent; and

curing the thermoplastic material.

5. The method of claim **1** wherein the step of forming a paste comprising metal powder, thermoplastic material, and solvent comprises the step of forming a paste comprising metal powder, thermoplastic material, and solvent such that the metal powder occupies at least 30 percent by volume of the metal powder and thermoplastic material.

6. The method of claim **1** wherein the dried paste has a resistivity having a predetermined value low enough that radio frequency signals activate the electrical circuitry.

7. The method of claim **1** wherein the metal powder comprises one or more of silver, copper, copper coated with silver, or copper coated with gold.

8. The method of claim **1**, wherein the antenna and the electrical circuitry form a radio frequency transponder.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,662,430 B2

DATED : December 16, 2003

INVENTOR(S) : Brady et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

Column 1,

Line 1, replace "This application is a continuation of Ser. No. 09/439,172 of U.S. Pat. No. 6,271,793, filed Nov. 5, 1999" with -- This application is a continuation of U.S. Patent No. 6,271,793, filed November 5, 1999. --.

Signed and Sealed this

Twentieth Day of September, 2005

JON W. DUDAS

Director of the United States Patent and Trademark Office