7-10-2001

RFID Transponders with Paste Antennas and Flip-Chip Attachment

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US006259408B1

(12) **United States Patent**
Brady et al.

(10) **Patent No.: US 6,259,408 B1**
(45) **Date of Patent: Jul. 10, 2001**

(54) **RFID TRANSPONDERS WITH PASTE ANTENNAS AND FLIP-CHIP ATTACHMENT**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/443,621**

(22) Filed: **Nov. 19, 1999**

(51) **Int. Cl.**[7] **H01Q 1/38**

(52) **U.S. Cl.** .... **343/700 MS**; 343/795; 361/737

(58) **Field of Search** .... 343/700 MS, 793, 343/795, 873; 361/728, 736, 737, 793, 794, 795

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(57) **ABSTRACT**

A radio frequency transponder is provided which comprises a substrate layer, a radio frequency integrated circuit affixed to said substrate layer; and an antenna provided on said substrate layer in electrical connection with said radio frequency integrated circuit. The antenna is comprised of a conductive paste material having a resistivity of approximately 20 $\mu\Omega$-cm., which is greater than the resistivity of a conventional etched copper antenna, but still sufficiently low to provide a radio frequency transponder having acceptable read range. The substrate layer further comprises a flexible organic material. The radio frequency integrated circuit is disposed in a flip-chip configuration facing downward toward said substrate layer, with electrical contacts aligned with the antenna.

24 Claims, 4 Drawing Sheets

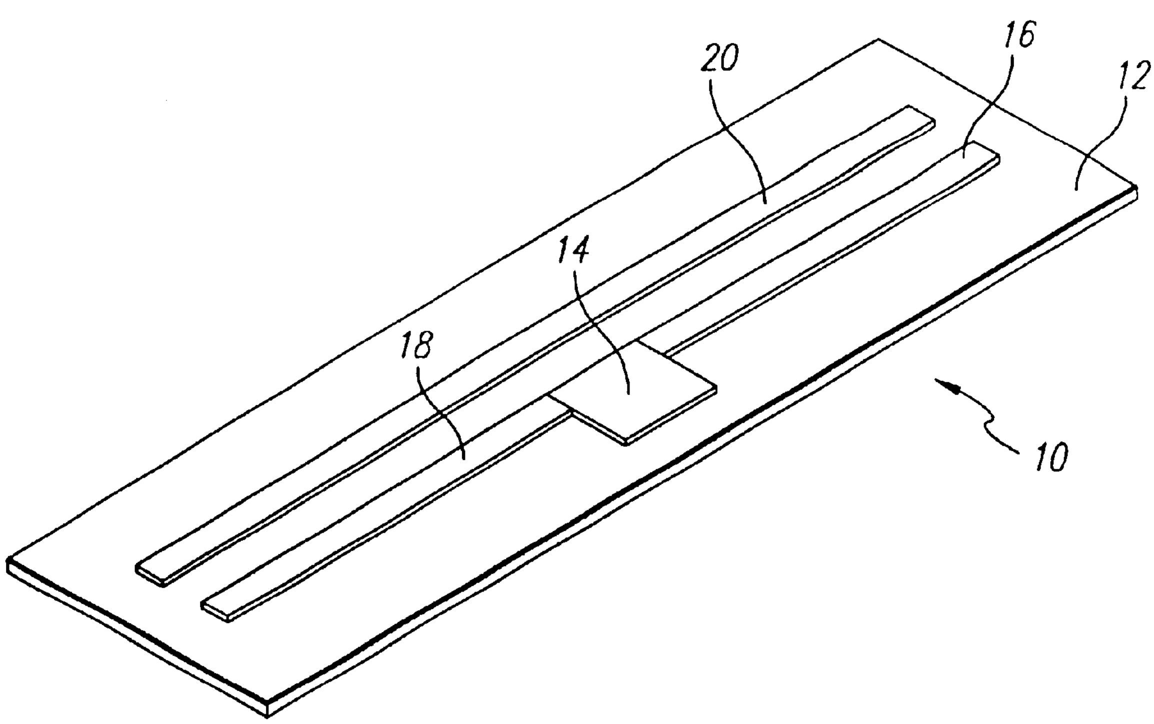


FIG. 1

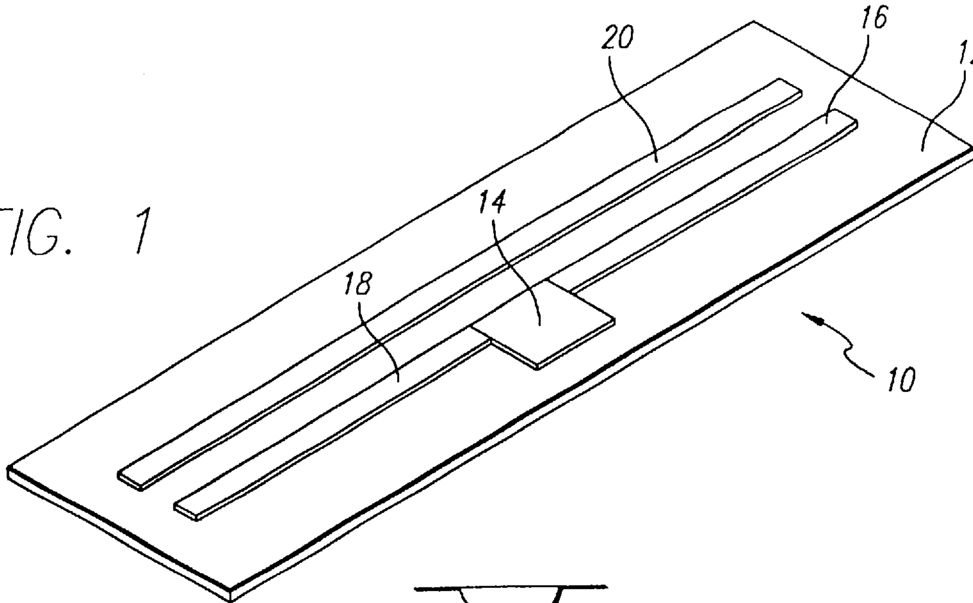


FIG. 2

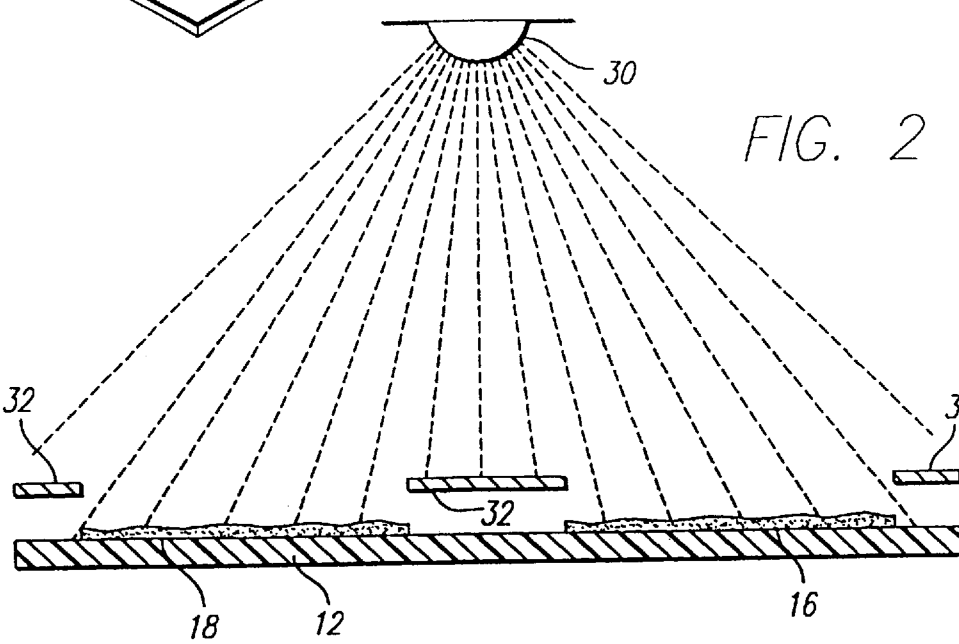
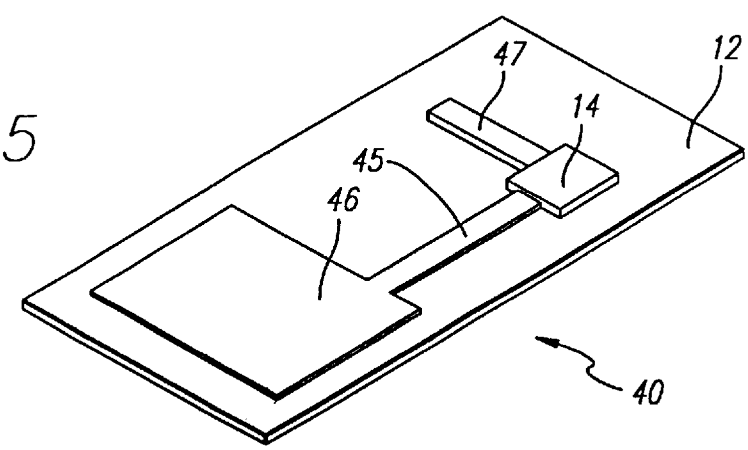


FIG. 5



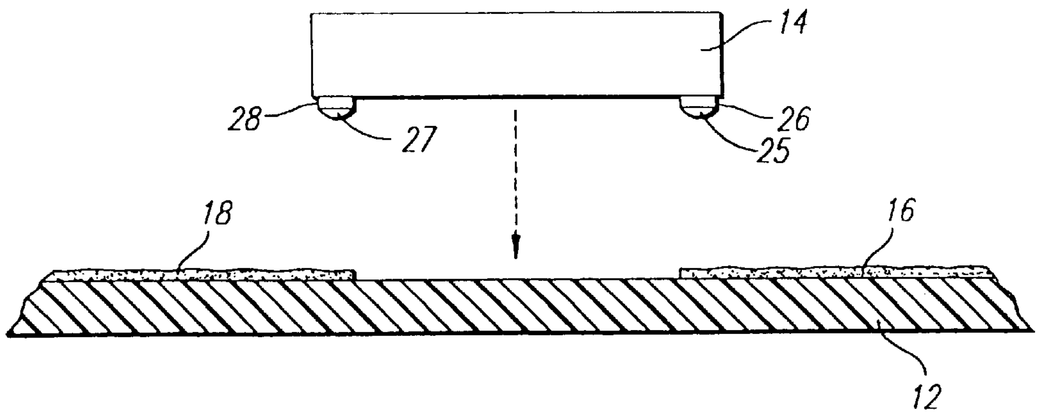


FIG. 3A

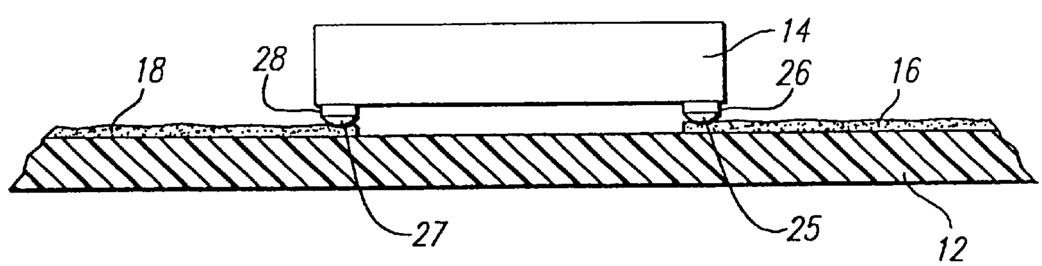


FIG. 3B

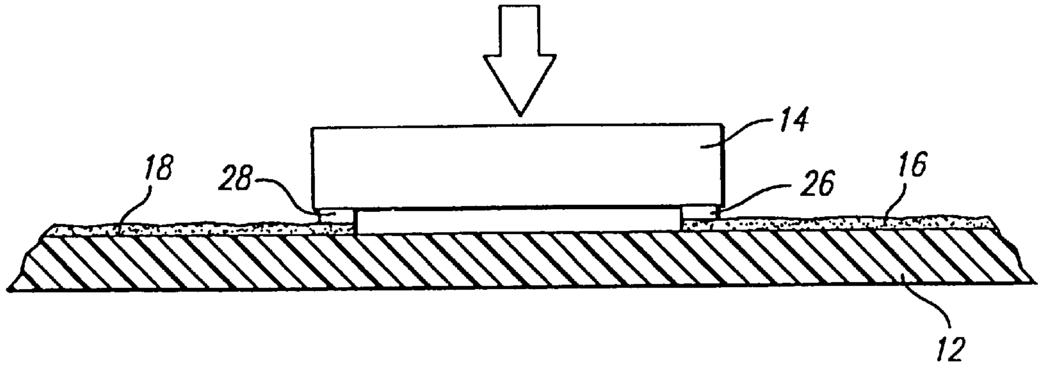


FIG. 3C

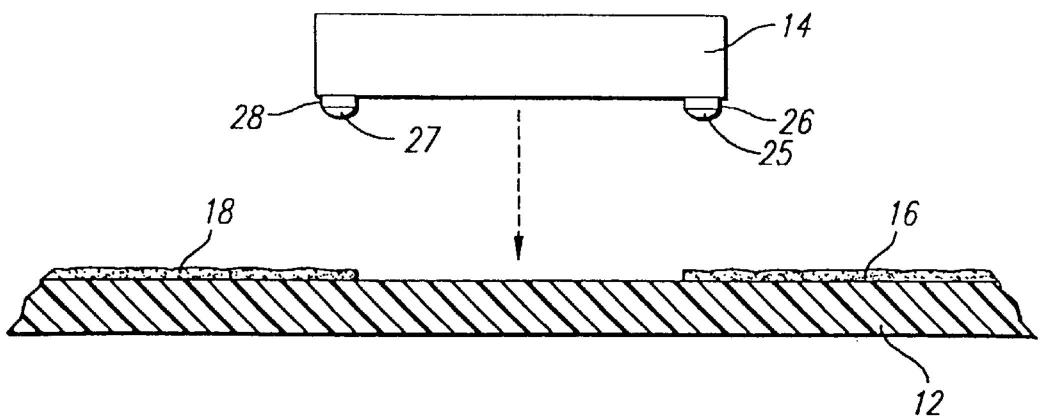


FIG. 4A

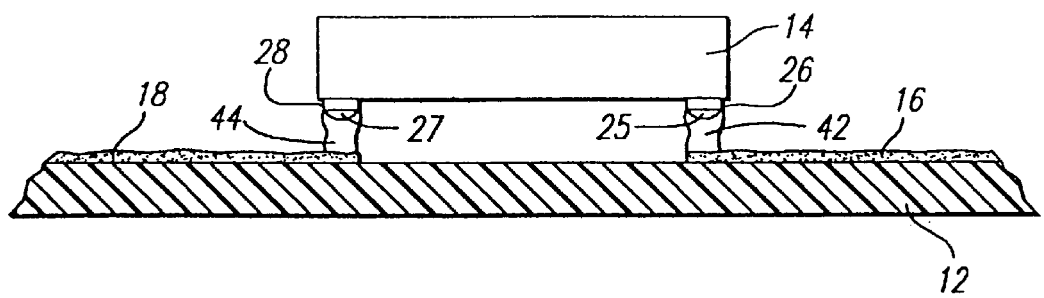


FIG. 4B

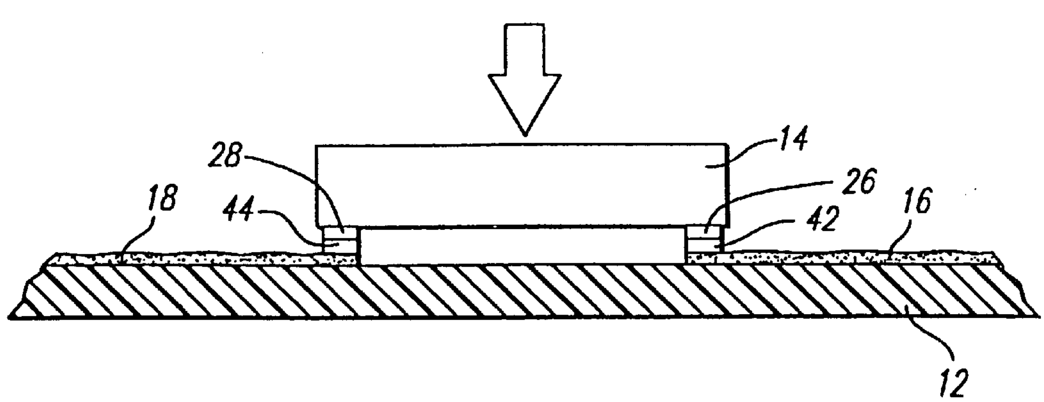


FIG. 4C

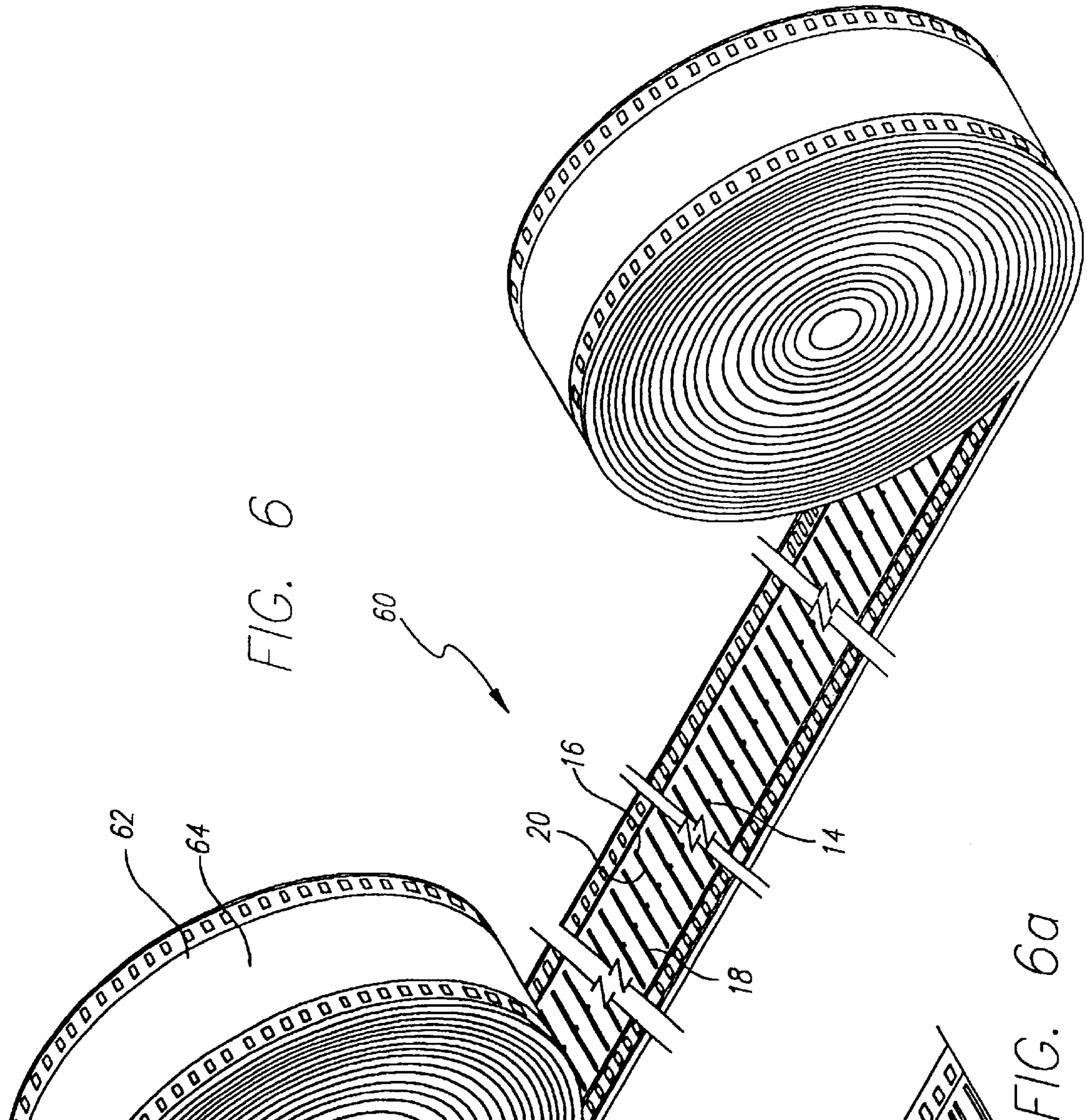


FIG. 6

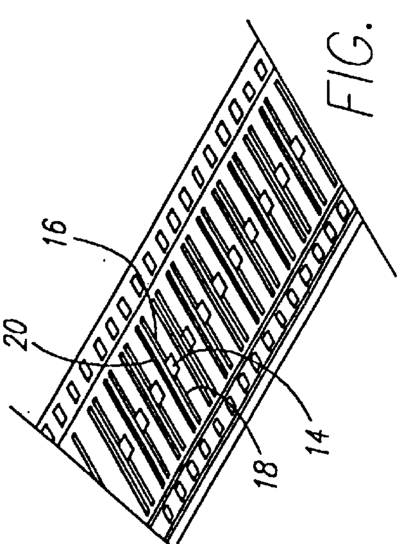


FIG. 6a

RFID TRANSPONDERS WITH PASTE ANTENNAS AND FLIP-CHIP ATTACHMENT

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates generally to radio frequency systems such as radio frequency identification (RFID) systems, and more specifically to RFID transponders having patterned metal used to form an antenna fabricated of a screened conductive paste.

2. Description of Related Art

In the automatic data identification industry, the use of RFID transponders (also known as RFID tags) has grown in prominence as a way to track data regarding an object to which an RFID transponder is affixed. An RFID transponder generally includes a semiconductor integrated circuit having a memory in which information may be stored. An RFID interrogator containing a transmitter-receiver unit is used to query an RFID transponder that may be at a distance from the interrogator. The RFID transponder detects the interrogating signal and transmits a response signal containing encoded data back to the interrogator. RFID systems are used in applications such as inventory management, security access, personnel identification, automotive toll collection, and vehicle identification, to name just a few.

Such RFID systems provide certain advantages over conventional optical indicia recognition systems (e.g., bar code symbols). For example, the RFID transponders have a memory capacity of several kilobytes or more, which is substantially greater than the maximum amount of data that may be contained in a typical one-dimensional bar code symbol. The RFID memory may be re-written with new or additional data, which would not be possible with a printed bar code symbol. Moreover, RFID transponders may be readable at a distance without requiring a direct line-of-sight view by the interrogator, unlike bar code symbols that must be within a direct line-of-sight and which may be entirely unreadable if the symbol is obscured or damaged. An additional advantage of RFID systems is that the interrogator may read several RFID transponders at one time.

Conventional RFID transponders are fabricated using a direct chip attach (DCA) process in which an integrated circuit chip is interconnected on a substrate such as a printed circuit board or an organic flexible substrate such as polyimide or Mylar. The chip is electrically connected to metallic traces formed on the substrate using various techniques, such as wire bonding, tape automated bonding or solder bumping. The metallic traces are generally formed using a photolithographic process in which a desired pattern is selectively etched into a copper layer laminated onto the substrate. Signal delay to and from the chip is thereby minimized because the distance between the chip and the metallic traces of the substrate is kept to a minimum due to the elimination of the chip package and corresponding internal interconnects. The DCA process is a generally cost-effective packaging technique since the chip is assembled directly onto the substrate without enclosing the chip in a separate package; however, the photolithographic process used to form the metallic traces is most expensive part of the process. There is great commercial interest in reducing the cost of RFID transponders to make the technology more price competitive with other automatic data identification technologies, such as bar code symbology.

Accordingly, it would be desirable to provide a more cost-effective process for fabricating RFID transponders. It would be further desirable to provide an alternative way to fabricate metallic traces on a substrate.

SUMMARY OF THE INVENTION

In accordance with the teachings of the present invention, a radio frequency transponder is provided which comprises a substrate layer, a radio frequency integrated circuit affixed to said substrate layer; and an antenna provided on said substrate layer in electrical connection with said radio frequency integrated circuit. The antenna is comprised of a conductive paste material having a resistivity of approximately 20 $\mu\Omega$-cm., which is greater than the resistivity of a conventional etched copper antenna, but still sufficiently low to provide a radio frequency transponder having acceptable read range. The substrate layer further comprises a flexible organic material. The radio frequency integrated circuit is disposed in a flip-chip configuration facing downward toward said substrate layer, with electrical contacts aligned with the antenna.

To fabricate the radio frequency transponder, a desired antenna pattern is screened onto the substrate layer using the conductive paste material. The conductive paste material further comprises silver particles loaded into a polymer binder with a solvent. The conductive paste material is extruded onto the substrate layer through a screening mask. Then, the patterned conductive paste is soft baked by driving the solvent out of the conductive paste to leave the silver particles in a polymer matrix. The radio frequency integrated circuit is optically aligned to the antenna pattern and bonded to the substrate layer using a conductive adhesive by applying heat and pressure between the radio frequency integrated circuit and the substrate layer for a predetermined period of time. The bond pressure and temperature thereby causes the conductive paste to become fully cured.

A more complete understanding of the RFID transponders with conductive paste antennas and flip-chip attachment will be afforded to those skilled in the art, as well as a realization of additional advantages and objects thereof, by a consideration of the following detailed description of the preferred embodiment. Reference will be made to the appended sheets of drawings that will first be described briefly.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an isometric view of an RFID transponder having a conductive paste dipole antenna fabricated in accordance with the present invention;

FIG. **2** is a side sectional view of a substrate having a conductive paste dipole antenna screened thereon;

FIGS. **3A–3C** illustrate a side sectional view of the RFID transponder of FIG. **1** through various stages of fabrication;

FIGS. **4A–4C** illustrate a side sectional view of the RFID transponder of FIG. **1** through various alternative stages of fabrication;

FIG. **5** is a perspective view of an alternative embodiment of an RFID transponder having a conductive paste patch antenna fabricated in accordance with the present invention;

FIG. **6** is an isometric view of a manufacturing process used to fabricate the RFID transponders of FIG. **1** onto a roll of flexible tape; and

FIG. **6A** is an enlarged portion of the flexible tape of FIG. **6**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention satisfies the need for a cost-effective process for fabricating RFID transponders. In the detailed description that follows, like element numerals are used to describe like elements illustrated in one or more of the figures.