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I, Caroline Snider, declare:

I am a professional translator specializing in translating Japanese to English.

I have over 6 years of experience reviewing and coordinating translations of thousands of technical, legal, and business documents from Japanese to English.

I certify that the following Japanese to English translation of the corresponding source text is a true, correct, and complete translation to the best of my knowledge and ability.

I hereby certify under penalty of perjury that the foregoing is true and correct. Executed this 8th day of December 2022 in the Queens county of the state of New York.

A handwritten signature in black ink, appearing to be 'C. Snider', written over a horizontal line.

Caroline Snider

Sworn to before me this
December 8, 2022

A handwritten signature in black ink, appearing to be 'Wendy Poon', written over a horizontal line.

Signature, Notary Public



Stamp, Notary Public

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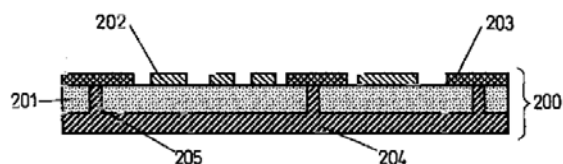
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**(54) (TITLE OF THE INVENTION) CIRCUIT SUBSTRATE, MODULE WITH EMBEDDED CIRCUIT COMPONENTS,
AND MANUFACTURING METHOD FOR THE SAME**

(57) (ABSTRACT)

(PROBLEM) Provide a circuit substrate wherein a shield blocks electromagnetic waves and also functions to establish an electrical connection to the ground pattern, thereby reducing the number of processes and reducing cost, and a manufacturing method for the same.

(MEANS FOR SOLVING) Circuit substrate comprising an electrically insulating substrate 201, a trace pattern 202 and ground pattern 203 formed on at least one of the main surfaces of the aforesaid electrically insulating substrate, or the interior of the same, and a shield 204 containing conductive powder and thermosetting resin, characterized in that the aforesaid shield 204 is formed on at least one of the main surfaces of the aforesaid electrically insulating substrate 201, or on the interior thereof, as well as in the interior of a through-hole 205 provided in the aforesaid electrically insulating substrate, and the aforesaid ground pattern 203 and the aforesaid shield 204 are electrically connected.



(SCOPE OF PATENT CLAIMS)

(CLAIM 1) Circuit substrate comprising an electrically insulating substrate upon which a trace pattern and a ground pattern have been formed, characterized in that:

A shield is formed on at least one of either the main surface or the interior of the aforesaid electrically insulating substrate, and the aforesaid shield is electrically connected to the aforesaid ground pattern via a connector component made of the same material as said shield.

(CLAIM 2) Circuit substrate set forth in claim 1, wherein:

The aforesaid shield includes conductive powder and thermosetting resin; and

The aforesaid connector component is formed integrally with the aforesaid shield by filling a through-hole formed in the aforesaid electrically insulating substrate with the aforesaid same material.

(CLAIM 3) Circuit substrate set forth in claim 1, wherein:

The aforesaid shield includes conductive powder and thermosetting resin; and

The aforesaid connector component is formed integrally with the aforesaid shield by means of the aforesaid same material around the perimeter of the aforesaid electrically insulating substrate.

(CLAIM 4) Circuit substrate comprising an electrically insulating substrate upon which a trace pattern and a ground pattern have been formed, characterized in that:

A shield containing magnetic powder and thermosetting resin is formed on at least one of either the main surface or the interior of the aforesaid electrically insulating substrate.

(CLAIM 5) Module with embedded circuit components comprising an electrically insulating substrate on which a trace pattern and a ground pattern have been formed, and circuit components disposed therein which are electrically connected to the aforesaid trace pattern, characterized in that:

A shield is formed on at least one of either the main surface or the interior of the aforesaid electrically insulating substrate, and the aforesaid shield is electrically connected to the aforesaid ground pattern via a connector component made of the same material as said shield.

(CLAIM 6) Module with embedded circuit components set forth in claim 5, wherein:

The aforesaid shield includes conductive powder and thermosetting resin; and

The aforesaid connector component is formed integrally with the aforesaid shield by filling a through-hole formed in the aforesaid electrically insulating substrate with the aforesaid same material.

(CLAIM 7) Module with embedded circuit components set forth in claim 5, wherein:

The aforesaid shield includes conductive powder and thermosetting resin; and

The aforesaid connector component is formed integrally with the aforesaid shield by means of the aforesaid same material around the perimeter of the aforesaid electrically insulating substrate.

(CLAIM 8) Module with embedded circuit components comprising an electrically insulating substrate on which a trace pattern and a ground pattern have been formed, and circuit components disposed therein which are electrically connected to the aforesaid trace pattern, characterized in that:

A shield containing magnetic powder and thermosetting resin is formed at least one of either the main surface or the interior of the aforesaid electrically insulating substrate.

(CLAIM 9) Circuit substrate set forth in any one of claims 1 through 3, wherein the aforesaid ground pattern is formed from

material containing conductive powder and thermosetting resin.

(CLAIM 10) Module with embedded circuit components set forth in any one of claims 5 through 7, wherein the aforesaid ground pattern is formed from material containing conductive powder and thermosetting resin.

(CLAIM 11) Circuit substrate set forth in claim 2 or 3, wherein the aforesaid conductive powder in the aforesaid shield contains one or more conductive components selected from the group of gold, silver, copper, nickel, and carbon.

(CLAIM 12) Module with embedded circuit components set forth in claim 6 or 7, wherein the aforesaid conductive powder in the aforesaid shield contains one or more conductive components selected from the group of gold, silver, copper, nickel, and carbon.

(CLAIM 13) Circuit substrate set forth in claim 2 or 3, wherein the aforesaid conductive powder in the aforesaid shield includes powder comprising magnetic powder whose surface is coated with gold, silver, or copper.

(CLAIM 14) Module with embedded circuit components set forth in claim 6 or 7, wherein the aforesaid conductive powder in the aforesaid shield includes powder comprising magnetic powder whose surface is coated with gold, silver, or copper.

(CLAIM 15) Circuit substrate set forth in any one of claims 2 through 4, wherein the aforesaid thermosetting resin in the aforesaid shield includes one or more types of thermosetting resin selected from the group of epoxy resin, phenolic resin, and cyanate resin.

(CLAIM 16) Module with embedded circuit components set forth in any one of claims 6 through 8, wherein the aforesaid thermosetting resin in the aforesaid shield includes one or more types of thermosetting resin selected from the group of epoxy resin, phenolic resin, and cyanate resin.

(CLAIM 17) Circuit substrate set forth in any one of claims 1 through 4, wherein the aforesaid shield is formed into a closed loop shape around the aforesaid trace pattern.

(CLAIM 18) Module with embedded circuit components set forth in any one of claims 5 through 8, wherein the aforesaid shield is formed into a closed loop shape around the aforesaid trace pattern.

(CLAIM 19) Circuit substrate set forth in claim 4, wherein the aforesaid magnetic powder in the aforesaid shield is a soft magnetic material.

(CLAIM 20) Module with embedded circuit components set forth in claim 8, wherein the aforesaid magnetic powder in the aforesaid shield is a soft magnetic material.

(CLAIM 21) Manufacturing method for circuit substrate characterized in that it includes:

A process in which a through-hole is formed in an electrically insulating substrate;

A process in which a trace pattern and a ground pattern are formed on the aforesaid electrically insulating substrate;

A process in which a conductive resin mixture containing conductive powder and thermosetting resin is formed into a sheet shape;

A process in which the aforesaid conductive resin mixture is molded into the shape of a shield and filled into the aforesaid through-hole by superimposing and applying pressure to the aforesaid electrically insulating substrate and the aforesaid conductive resin mixture; and

A process in which the aforesaid molded conductive resin mixture is heated, thereby forming the aforesaid shield by hardening the aforesaid thermosetting resin, as well as establishing an electrical connection between the aforesaid ground pattern and the aforesaid shield via the aforesaid through-hole, and bonding the aforesaid shield to the aforesaid electrically insulating substrate.

(CLAIM 22) Manufacturing method for circuit substrate characterized in that it includes:

A process in which a trace pattern and a ground pattern are formed on an electrically insulating substrate;

A process in which a conductive resin mixture containing conductive powder and thermosetting resin is formed into a sheet shape;

A process in which the aforesaid conductive resin mixture is molded into the shape of a shield and brought into contact with the aforesaid ground pattern by superimposing and applying pressure to the aforesaid electrically insulating substrate and the aforesaid conductive resin mixture; and

A process in which the aforesaid molded conductive resin mixture is heated, thereby forming the aforesaid shield by hardening the aforesaid thermosetting resin, as well as establishing an electrical connection between the aforesaid ground pattern and the aforesaid shield, and bonding the aforesaid shield to the aforesaid electrically insulating substrate.

(CLAIM 23) Manufacturing method for circuit substrate characterized in that it includes:

A process in which a trace pattern and a ground pattern are formed on an electrically insulating substrate;

A process in which a magnetic resin mixture containing magnetic powder and thermosetting resin is formed into a sheet shape;

A process in which the aforesaid magnetic resin mixture is molded into the shape of a shield by superimposing and applying pressure to the aforesaid electrically insulating substrate and the aforesaid magnetic resin mixture; and

A process in which the aforesaid molded magnetic resin mixture is heated, thereby forming the aforesaid shield by hardening the aforesaid thermosetting resin, as well as establishing a bond to the aforesaid electrically insulating substrate.

(CLAIM 24) Manufacturing method for circuit substrate characterized in that it includes:

A process in which a trace pattern is formed on an electrically insulating substrate;

A process in which a groove serving as the mold for the ground pattern is formed in the aforesaid electrically insulating substrate;

A process in which a conductive resin mixture containing conductive powder and thermosetting resin is formed into a sheet shape;

A process in which the aforesaid conductive resin mixture is molded into the shape of a shield and filled into the aforesaid groove by superimposing and applying pressure to the aforesaid electrically insulating substrate and the aforesaid conductive resin mixture; and

A process in which the aforesaid molded conductive resin mixture is heated, thereby integrally forming the aforesaid shield and the aforesaid ground pattern by hardening the aforesaid thermosetting resin, as well as establishing a bond to the aforesaid electrically insulating substrate.

(CLAIM 25) Manufacturing method for module with embedded circuit components, characterized in that it includes:

A process in which a thermosetting resin mixture containing inorganic filler and thermosetting resin is machined into a sheet shape;

A process in which a trace pattern and a ground pattern are formed;

A process in which circuit components are mounted on the aforesaid formed pattern;

A process in which an electrically insulated substrate in which the aforesaid circuit components are embedded is formed by superimposing and applying pressure to the aforesaid thermosetting resin mixture and the aforesaid pattern on which the aforesaid circuit components have been mounted;

A process in which a through-hole is formed in the aforesaid electrically insulating substrate;

A process in which a conductive resin mixture containing conductive powder and thermosetting resin is formed into a sheet shape;

A process in which the aforesaid conductive resin mixture is molded into the shape of a shield and filled into the aforesaid through-hole by superimposing and applying pressure to the aforesaid electrically insulating substrate and the aforesaid conductive resin mixture; and

A process in which the aforesaid molded conductive resin mixture is heated, thereby forming the aforesaid shield by hardening the aforesaid thermosetting resin, as well as establishing an electrical connection between the aforesaid ground pattern and the aforesaid shield, and bonding the aforesaid shield to the aforesaid electrically insulating substrate.

(CLAIM 26) Manufacturing method for module with embedded circuit components, characterized in that it includes:

A process in which a thermosetting resin mixture containing inorganic filler and thermosetting resin is machined into a sheet shape;

A process in which a trace pattern and a ground pattern are formed;

A process in which circuit components are mounted on the aforesaid formed pattern;

A process in which an electrically insulated substrate in which the aforesaid circuit components are embedded is formed by superimposing and applying pressure to the aforesaid thermosetting resin mixture and the aforesaid pattern on which the aforesaid circuit components have been mounted;

A process in which a conductive resin mixture containing conductive powder and thermosetting resin is formed into a sheet shape;

A process in which the aforesaid conductive resin mixture is molded into the shape of a shield and brought into contact with the aforesaid ground pattern by superimposing and applying pressure to the aforesaid electrically insulating substrate and the aforesaid conductive resin mixture; and

A process in which the aforesaid molded conductive resin mixture is heated, thereby forming the aforesaid shield by hardening the aforesaid thermosetting resin, as well as establishing an electrical connection between the aforesaid ground pattern and the aforesaid shield, and bonding the aforesaid shield to the aforesaid electrically insulating substrate.

(CLAIM 27) Manufacturing method for module with embedded circuit components, characterized in that it includes:

A process in which a thermosetting resin mixture containing inorganic filler and thermosetting resin is machined into a sheet shape;

A process in which a trace pattern and a ground pattern are formed;

A process in which circuit components are mounted on the aforesaid formed pattern;

A process in which an electrically insulated substrate in which the aforesaid circuit components are embedded is formed by superimposing and applying pressure to the aforesaid thermosetting resin mixture and the aforesaid pattern on which the aforesaid circuit components have been mounted;

A process in which a magnetic resin mixture containing magnetic powder and thermosetting resin is formed into a sheet shape;

A process in which the aforesaid magnetic resin mixture is molded into the shape of a shield by superimposing and applying pressure to the aforesaid electrically insulating substrate and the aforesaid magnetic resin mixture; and

A process in which the aforesaid molded magnetic resin mixture is heated, thereby forming the aforesaid shield by hardening the aforesaid thermosetting resin, as well as establishing a bond to the aforesaid electrically insulating substrate.

(CLAIM 28) Manufacturing method for module with embedded circuit components, characterized in that it includes:

A process in which a thermosetting resin mixture containing inorganic filler and thermosetting resin is machined into a sheet shape;

A process in which a trace pattern is formed;

A process in which circuit components are mounted on the aforesaid formed pattern;

A process in which an electrically insulated substrate in which the aforesaid circuit components are embedded is formed by superimposing and applying pressure to the aforesaid thermosetting resin mixture and the aforesaid pattern on which the aforesaid circuit components have been mounted;

A process in which a groove serving as the mold for the ground pattern is formed on the aforesaid electrically insulating substrate;

A process in which a conductive resin mixture containing conductive powder and thermosetting resin is formed into a sheet shape;

A process in which the aforesaid conductive resin mixture is molded into the shape of a shield and filled into the aforesaid groove by superimposing and applying pressure to the aforesaid electrically insulating substrate and the aforesaid conductive resin mixture; and

A process in which the aforesaid molded conductive resin mixture is heated, thereby forming the aforesaid shield and the aforesaid ground pattern by hardening the aforesaid thermosetting resin, as well as establishing a bond to the aforesaid electrically insulating substrate.

(DETAILED DESCRIPTION OF THE INVENTION)

(0001)

(TECHNICAL FIELD OF THE INVENTION) The present invention relates to a circuit substrate and a module with embedded circuit components, in which circuit components are arrayed in the interior of a substrate, and a manufacturing method for the same.

(0002)

(PRIOR ART) At present, electronic components such as semiconductor elements are driven at an increasingly rapid speed, which renders these components highly susceptible to the influence of high-frequency noise, raising the risk of malfunction. For this reason, circuit substrates mounted with electrical components such as IC that are driven at a high frequency are commonly equipped with a shield layer to block electromagnetic waves generated by electronic components and trace patterns, as well as electromagnetic waves from the exterior.

(0003) A metal case, resin molded layer, or the like covering the substrate body can be used as this shield layer.

(0004) Furthermore, as a result of the growing demand for electronic components with improved performance and greater compactness in recent years, demand is growing for circuit components with greater density and functionality. This in turn has created demand for modules with embedded circuit components in which the circuit components are embedded onto circuit substrates capable of accommodating circuit components in a more dense and functional manner. These modules with embedded circuit components also require a shield layer.

(0005)

(PROBLEM TO BE SOLVED BY THE INVENTION) As described above, because a metal case or resin mold layer was used as the shield layer prior to now, it was necessary to fit the substrate with mounted electronic components into the case or else to mold the case from resin, which increased the complexity of the manufacturing process, thereby increasing cost.

(0006) The present invention was devised in view of the above considerations, having as its objective to provide, at low cost, a circuit substrate and module with embedded circuit components that have shield effect.

(0007)

(MEANS FOR SOLVING THE PROBLEM) To achieve the objective set forth above, the present invention is configured as follows.

(0008) Namely, the circuit substrate of the present invention is a circuit substrate comprising an electrically insulating substrate on which a trace pattern and a ground pattern have been formed, wherein a shield is formed on at least one of either the main surface or the interior of the aforesaid electrically insulating substrate, and the aforesaid shield is electrically connected to the aforesaid ground pattern by means of a connector component made of the same material as said shield.

(0009) According to the present invention, the fact that the shield is electrically connected to the ground pattern means that the potential of the shield remains stable, and the shield does not act as an antenna in the event that it is separated from the ground pattern, and furthermore the fact that the connector component that establishes an electrical connection to the ground pattern is made of the same material as the shield means that fewer manufacturing processes are needed and connection resistance is lower than when establishing a connection between a shield and a ground pattern made of different materials, thereby improving connection reliability, which makes it possible to create a more stable circuit substrate and reduce the cost thereof.

(0010)

(EMBODIMENT OF THE INVENTION) The invention in claim 1 of the present invention is a circuit substrate comprising an electrically insulating substrate upon which a trace pattern and a ground pattern have been formed, wherein: a shield is formed on at least one of either the main surface or the interior of the aforesaid electrically insulating substrate, and the aforesaid shield is electrically connected to the aforesaid ground pattern via a connector component made of the same material as said shield. Consequently, the shield not only blocks electromagnetic waves but also establishes an electrical connection to the ground pattern, thereby stabilizing the circuit substrate and reducing both the number of manufacturing processes as well as cost.

(0011) The invention set forth in claim 2 is the invention set forth in claim 1, wherein: the aforesaid shield includes conductive powder and thermosetting resin; and the aforesaid

connector component is formed integrally with the aforesaid shield by filling a through-hole formed in the aforesaid electrically insulating substrate with the aforesaid same material. Consequently, the shield, in addition to blocking electromagnetic waves, also establishes an electrical connection with the ground pattern via the through-hole, thereby stabilizing the circuit substrate and reducing both the number of manufacturing processes as well as cost.

(0012) The invention set forth in claim 3 is the invention set forth in claim 1, wherein: the aforesaid shield includes conductive powder and thermosetting resin; and the aforesaid connector component is formed integrally with the aforesaid shield by means of the aforesaid same material around the perimeter of the aforesaid electrically insulating substrate. Consequently, the shield, in addition to blocking electromagnetic waves, also establishes an electrical connection with the ground pattern via the perimeter of the electrically insulating substrate, thereby stabilizing the circuit substrate and reducing both the number of manufacturing processes as well as cost.

(0013) The invention set forth in claim 4 is a circuit substrate comprising an electrically insulating substrate upon which a trace pattern and a ground pattern have been formed, wherein: a shield containing magnetic powder and thermosetting resin is formed on at least one of either the main surface or the interior of the aforesaid electrically insulating substrate. Consequently, electromagnetic waves are absorbed by the shield, thereby stabilizing the circuit substrate and reducing both the number of manufacturing processes as well as cost.

(0014) The invention set forth in claim 5 is a module with embedded circuit components comprising an electrically insulating substrate on which a trace pattern and a ground pattern have been formed, and circuit components disposed therein which are electrically connected to the aforesaid trace pattern, wherein: a shield is formed on at least one of either the main surface or the interior of the aforesaid electrically insulating substrate, and the aforesaid shield is electrically connected to the aforesaid ground pattern via a connector component made of the same material as said shield. Consequently, the shield, in addition to blocking electromagnetic waves, also establishes an electrical connection to the ground pattern, thereby stabilizing the module with embedded circuit components and reducing both the number of manufacturing processes as well as cost.

(0015) The invention set forth in claim 6 is the module with embedded circuit components set forth in claim 5, wherein: the aforesaid shield includes conductive powder and thermosetting resin; and the aforesaid connector component is formed integrally with the aforesaid shield by filling a through-hole formed in the aforesaid electrically insulating substrate with the aforesaid same material. Consequently, the shield, in addition to blocking electromagnetic waves, also establishes an electrical connection to the ground pattern via the through-hole, thereby stabilizing the module with embedded circuit components and reducing both the number of manufacturing processes as well as cost.

(0016) The invention set forth in claim 7 is the module with embedded circuit components set forth in claim 5, wherein: the aforesaid shield includes conductive powder and thermosetting resin; and the aforesaid connector component is formed integrally with the aforesaid shield by means of the aforesaid same material around the perimeter of the aforesaid electrically insulating substrate. Consequently, the shield, in addition to blocking electromagnetic waves, also establishes an electrical connection to the ground pattern via the perimeter of the electrically insulating substrate, thereby stabilizing the module

with embedded circuit components and reducing both the number of manufacturing processes as well as cost.

(0017) The invention set forth in claim 8 is a module with embedded circuit components comprising an electrically insulating substrate on which a trace pattern and a ground pattern have been formed, and circuit components disposed therein which are electrically connected to the aforesaid trace pattern, wherein: a shield containing magnetic powder and thermosetting resin is formed at least one of either the main surface or the interior of the aforesaid electrically insulating substrate. Consequently, the shield absorbs electromagnetic waves, thereby stabilizing the module with embedded circuit components and reducing both the number of manufacturing processes as well as cost.

(0018) The invention set forth in claim 9 is the invention set forth in any one of claims 1 through 3, wherein the aforesaid ground pattern is formed from material containing conductive powder and thermosetting resin. Consequently, the ground pattern can be created in the same process as the shield, which helps reduce cost.

(0019) The invention set forth in claim 10 is the invention set forth in any one of claims 5 through 7, wherein the aforesaid ground pattern is formed from material containing conductive powder and thermosetting resin. Consequently, the ground pattern can be created in the same process as the shield, which helps reduce cost.

(0020) The invention set forth in claim 11 is the invention set forth in claim 2 or 3, wherein the aforesaid conductive powder in the aforesaid shield contains one or more conductive components selected from the group of gold, silver, copper, nickel, and carbon. Consequently, it is possible to form a shield with low electrical resistance, which improves its ability to block electromagnetic waves.

(0021) The invention set forth in claim 12 is the invention set forth in claim 6 or 7, wherein the aforesaid conductive powder in the aforesaid shield contains one or more conductive components selected from the group of gold, silver, copper, nickel, and carbon. Consequently, it is possible to form a shield with low electrical resistance, which improves its ability to block electromagnetic waves.

(0022) The invention set forth in claim 13 is the invention set forth in claim 2 or 3, wherein the aforesaid conductive powder in the aforesaid shield includes powder comprising magnetic powder whose surface is coated with gold, silver, or copper. Consequently, shielding ability is improved by electromagnetic wave absorption effect provided by the magnetic material.

(0023) The invention set forth in claim 14 is the invention set forth in claim 6 or 7, wherein the aforesaid conductive powder in the aforesaid shield includes powder comprising magnetic powder whose surface is coated with gold, silver, or copper. Consequently, shielding ability is improved by electromagnetic wave absorption effect provided by the magnetic material.

(0024) The invention set forth in claim 15 is the invention set forth in any one of claims 2 through 4, wherein the aforesaid thermosetting resin in the aforesaid shield includes one or more types of thermosetting resin selected from the group of epoxy resin, phenolic resin, and cyanate resin. Consequently, it is possible to improve the heat resistance and electrical insulation properties.

(0025) The invention set forth in claim 16 is the invention set forth in any one of claims 6 through 8, wherein the aforesaid thermosetting resin in the aforesaid shield includes one or more types of thermosetting resin selected from the group of epoxy resin, phenolic resin, and cyanate resin. Consequently, it is possible to improve the heat resistance and electrical insulation properties.

(0026) The invention set forth in claim 17 is the invention set forth in any one of claims 1 through 4, wherein the aforesaid shield is formed into a closed loop shape around the aforesaid trace pattern. Consequently, it is possible to extend the range of electromagnetic wave blocking.

(0027) The invention set forth in claim 18 is the invention set forth in any one of claims 5 through 8, wherein the aforesaid shield is formed into a closed loop shape around the aforesaid trace pattern. Consequently, it is possible to extend the range of electromagnetic wave blocking.

(0028) The invention set forth in claim 19 is the invention set forth in claim 4, wherein the aforesaid magnetic powder in the aforesaid shield is a soft magnetic material. Consequently, it is possible to achieve shielding effect uninfluenced by the magnetization of the magnetic material.

(0029) The invention set forth in claim 20 is the invention set forth in claim 8, wherein the aforesaid magnetic powder in the aforesaid shield is a soft magnetic material. Consequently, it is possible to achieve shielding effect uninfluenced by the magnetization of the magnetic material.

(0030) The invention set forth in claim 21 includes: a process in which a through-hole is formed in an electrically insulating substrate; a process in which a trace pattern and a ground pattern are formed on the aforesaid electrically insulating substrate; a process in which a conductive resin mixture containing conductive powder and thermosetting resin is formed into a sheet shape; a process in which the aforesaid conductive resin mixture is molded into the shape of a shield and filled into the aforesaid through-hole by superimposing and applying pressure to the aforesaid electrically insulating substrate and the aforesaid conductive resin mixture; and a process in which the aforesaid molded conductive resin mixture is heated, thereby forming the aforesaid shield by hardening the aforesaid thermosetting resin, as well as establishing an electrical connection between the aforesaid ground pattern and the aforesaid shield via the aforesaid through-hole, and bonding the aforesaid shield to the aforesaid electrically insulating substrate. Consequently, this facilitates the manufacture of the circuit substrate of the present invention, which has a shield that is electrically connected to a ground pattern via a through-hole.

(0031) The invention set forth in claim 22 includes: a process in which a trace pattern and a ground pattern are formed on an electrically insulating substrate; a process in which a conductive resin mixture containing conductive powder and thermosetting resin is formed into a sheet shape; a process in which the aforesaid conductive resin mixture is molded into the shape of a shield and brought into contact with the aforesaid ground pattern by superimposing and applying pressure to the aforesaid electrically insulating substrate and the aforesaid conductive resin mixture; and a process in which the aforesaid molded conductive resin mixture is heated, thereby forming the aforesaid shield by hardening the aforesaid thermosetting resin, as well as establishing an electrical connection between the aforesaid ground pattern and the aforesaid shield, and bonding the aforesaid shield to the aforesaid electrically insulating substrate. Consequently, this facilitates the manufacture of the circuit substrate of the present invention, which has a shield that is electrically connected to a ground pattern.

(0032) The invention set forth in claim 23 includes: a process in which a trace pattern and a ground pattern are formed on an electrically insulating substrate; a process in which a magnetic resin mixture containing magnetic powder and thermosetting resin is formed into a sheet shape; a process in which the aforesaid magnetic resin mixture is molded into the shape of a

shield by superimposing and applying pressure to the aforesaid electrically insulating substrate and the aforesaid magnetic resin mixture; and a process in which the aforesaid molded magnetic resin mixture is heated, thereby forming the aforesaid shield by hardening the aforesaid thermosetting resin, as well as establishing a bond to the aforesaid electrically insulating substrate. Consequently, this facilitates the manufacture of the circuit substrate of the present invention, which has a shield that absorbs electromagnetic waves.

(0033) The invention set forth in claim 24 includes: a process in which a trace pattern is formed on an electrically insulating substrate; a process in which a groove serving as the mold for the ground pattern is formed in the aforesaid electrically insulating substrate; a process in which a conductive resin mixture containing conductive powder and thermosetting resin is formed into a sheet shape; a process in which the aforesaid conductive resin mixture is molded into the shape of a shield and filled into the aforesaid groove by superimposing and applying pressure to the aforesaid electrically insulating substrate and the aforesaid conductive resin mixture; and a process in which the aforesaid molded conductive resin mixture is heated, thereby integrally forming the aforesaid shield and the aforesaid ground pattern by hardening the aforesaid thermosetting resin, as well as establishing a bond to the aforesaid electrically insulating substrate. Consequently, this makes it possible to manufacture the circuit substrate of the present invention in a manner that is both easy and inexpensive.

(0034) The invention set forth in claim 25 includes: a process in which a thermosetting resin mixture containing inorganic filler and thermosetting resin is machined into a sheet shape; a process in which a trace pattern and a ground pattern are formed; a process in which circuit components are mounted on the aforesaid formed pattern; a process in which an electrically insulated substrate in which the aforesaid circuit components are embedded is formed by superimposing and applying pressure to the aforesaid thermosetting resin mixture and the aforesaid pattern on which the aforesaid circuit components have been mounted; a process in which a through-hole is formed in the aforesaid electrically insulating substrate; a process in which a conductive resin mixture containing conductive powder and thermosetting resin is formed into a sheet shape; a process in which the aforesaid conductive resin mixture is molded into the shape of a shield and filled into the aforesaid through-hole by superimposing and applying pressure to the aforesaid electrically insulating substrate and the aforesaid conductive resin mixture; and a process in which the aforesaid molded conductive resin mixture is heated, thereby forming the aforesaid shield by hardening the aforesaid thermosetting resin, as well as establishing an electrical connection between the aforesaid ground pattern and the aforesaid shield, and bonding the aforesaid shield to the aforesaid electrically insulating substrate. Consequently, this facilitates the manufacture of the module with embedded circuit components of the present invention, which has a shield that is electrically connected to a ground pattern via a through-hole.

(0035) The invention set forth in claim 26 includes: a process in which a thermosetting resin mixture containing inorganic filler and thermosetting resin is machined into a sheet shape; a process in which a trace pattern and a ground pattern are formed; a process in which circuit components are mounted on the aforesaid formed pattern; a process in which an electrically insulated substrate in which the aforesaid circuit components are embedded is formed by superimposing and applying pressure to the aforesaid thermosetting resin mixture and the

aforesaid pattern on which the aforesaid circuit components have been mounted; a process in which a conductive resin mixture containing conductive powder and thermosetting resin is formed into a sheet shape; a process in which the aforesaid conductive resin mixture is molded into the shape of a shield and brought into contact with the aforesaid ground pattern by superimposing and applying pressure to the aforesaid electrically insulating substrate and the aforesaid conductive resin mixture; and a process in which the aforesaid molded conductive resin mixture is heated, thereby forming the aforesaid shield by hardening the aforesaid thermosetting resin, as well as establishing an electrical connection between the aforesaid ground pattern and the aforesaid shield, and bonding the aforesaid shield to the aforesaid electrically insulating substrate. Consequently, this facilitates the manufacture of the module with embedded circuit components of the present invention, which has a shield that is electrically connected to a ground pattern.

(0036) The invention set forth in claim 27 includes: a process in which a thermosetting resin mixture containing inorganic filler and thermosetting resin is machined into a sheet shape; a process in which a trace pattern and a ground pattern are formed; a process in which circuit components are mounted on the aforesaid formed pattern; a process in which an electrically insulated substrate in which the aforesaid circuit components are embedded is formed by superimposing and applying pressure to the aforesaid thermosetting resin mixture and the aforesaid pattern on which the aforesaid circuit components have been mounted; a process in which a magnetic resin mixture containing magnetic powder and thermosetting resin is formed into a sheet shape; a process in which the aforesaid magnetic resin mixture is molded into the shape of a shield by superimposing and applying pressure to the aforesaid electrically insulating substrate and the aforesaid magnetic resin mixture; and a process in which the aforesaid molded magnetic resin mixture is heated, thereby forming the aforesaid shield by hardening the aforesaid thermosetting resin, as well as establishing a bond to the aforesaid electrically insulating substrate. Consequently, this facilitates the manufacture of the module with embedded circuit components of the present invention, which has a shield that absorbs electromagnetic waves.

(0037) The invention set forth in claim 28 includes: a process in which a thermosetting resin mixture containing inorganic filler and thermosetting resin is machined into a sheet shape; a process in which a trace pattern is formed; a process in which circuit components are mounted on the aforesaid formed pattern; a process in which an electrically insulated substrate in which the aforesaid circuit components are embedded is formed by superimposing and applying pressure to the aforesaid thermosetting resin mixture and the aforesaid pattern on which the aforesaid circuit components have been mounted; a process in which a groove serving as the mold for the ground pattern is formed on the aforesaid electrically insulating substrate; a process in which a conductive resin mixture containing conductive powder and thermosetting resin is formed into a sheet shape; a process in which the aforesaid conductive resin mixture is molded into the shape of a shield and filled into the aforesaid groove by superimposing and applying pressure to the aforesaid electrically insulating substrate and the aforesaid conductive resin mixture; and a process in which the aforesaid molded conductive resin mixture is heated, thereby forming the aforesaid shield and the aforesaid ground pattern by hardening the aforesaid thermosetting resin, as well as establishing a bond to the

aforesaid electrically insulating substrate. Consequently, this makes it possible to manufacture the module with embedded circuit components of the present invention in a manner that is both easy and inexpensive.

(0038) (Embodiment 1) Embodiments of the present invention will be described below with reference to the drawings.

(0039) FIG. 1 is a cross-section of the circuit substrate 200 in one embodiment of the present invention. The circuit substrate 200 is furnished with an electrically insulating substrate 201 having a through-hole 205, on one of the main surfaces of which are formed a trace pattern 202 and a ground pattern 203, and on the other main surface of which is formed a shield 204.

(0040) For the electrically insulating substrate 201, it is acceptable to use any substrate that is electrically insulating, such as glass epoxy substrate, ceramic substrate, composite substrate made of inorganic filler and resin, etc.

(0041) If a composite substrate is used as the electrically insulating substrate, selecting inorganic filler and resin makes it easier to control the properties of the electrically insulating substrate 201 such as linear coefficient of expansion, thermal conductivity, inductivity, etc. Examples of inorganic fillers that may be used include , MgO, BN, AlN, , etc.

(0042) Using , BN, or AlN makes it possible to produce a substrate with higher thermal conductivity than conventional glass-epoxy substrate. Another advantage of is its low cost. An electrically insulating substrate made using has a linear coefficient of expansion that is closer to that of silicon semiconductor, which makes it possible to prevent cracking and the like due to temperature changes, and hence is preferred for use as a flip-chip substrate for the direct mounting of semiconductors. Furthermore, this also yields an electrically insulating substrate with low inductivity and a low specific gravity, which is preferred for use as a high-frequency substrate in cell phones and the like. Using BN makes it possible to lower the linear coefficient of expansion. Using MgO makes it possible to increase the linear coefficient of expansion of the electrically insulating substrate.

(0043) As resin, any thermosetting resin or photo-curing resin may be used, but using a heat-resistant resin such as epoxy resin, phenolic resin, or cyanate resin makes it possible to improve the heat resistance of the circuit substrate. Additionally, using resin with a low dielectric tangent such as fluorine resin or PRO resin improves the high-frequency characteristics of the circuit substrate. Additionally, dispersant, colorant, coupling agent, or mold release agent may also be included. Dispersant makes it possible to uniformly disperse the inorganic filler in the thermosetting resin. Colorant makes it possible to color the electrically insulating substrate, which can improve the heat dissipation qualities of the module with embedded circuit components. Coupling agent makes it possible to increase the strength of the bond between the thermosetting resin and the inorganic filler, which improves the insulating ability of the electrically insulating substrate. Mold release agent makes it possible to improve the ability of the mixture to be released from its die, which improves productivity.

(0044) Any electrically conductive material can be used for the trace pattern 202 and the ground pattern 203, such as metal foil, conductive resin composition, or a lead frame made by machining a metal plate. Using metal foil or a lead frame makes it easy to create a fine trace pattern and ground pattern by etching or the like. Additionally, using metal foil makes it possible to form a trace pattern by transfer of peel-away film or the like. Copper foil in particular is preferred due to its low cost and high electrical conductivity. Additionally, using peel-

away film makes it easier to handle the trace pattern.

(0045) Using conductive resin composition makes it possible to produce a trace pattern and ground pattern by screen printing or the like. If a conductive resin composition is used, using metallic powder of gold, silver, copper, nickel or the like or carbon powder makes it possible to form a trace pattern with low electrical resistance. Furthermore, for the resin, including at least one thermosetting resin selected from among epoxy resin, phenolic resin, and cyanate resin makes it possible to improve heat resistance.

(0046) Using a lead frame makes it possible to use a thicker metal, which provides lower electrical resistance. Doing so also makes it possible to use simple fabrication techniques such as fine etch patterning or stamping or the like. A plurality of patterns can be handled with one lead frame by connecting the respective trace pattern and ground pattern on the perimeter of the lead frame. Furthermore, by plating the surface of these trace patterns and ground patterns, it is possible to improve corrosion resistance and electrical conductivity.

(0047) The shield 204 is made of an electrically conductive material, which can be a mixture of conductive powder and resin, e.g. a mixture comprising metal powder such as gold, silver, copper, or nickel or carbon powder and thermosetting resin or photo-curing resin. Furthermore, using magnetic powder or the like whose surface is covered with a conductive component also provides shielding effect as a result of the absorption of electromagnetic waves due to magnetic loss from the magnet. Using a mixture of conductive powder and resin makes it easy to produce a shield with a complex shape, and also makes it possible to integrate the shield with the electrically conductive substrate during casting. Forming the shield 204 on both sides of the electrically insulating substrate makes it possible to expand the range of electromagnetic wave blocking.

(0048) The through-hole 205 can be formed in the electrically insulating substrate 201 by, for example, laser boring or machining with a drill. In particular, if the electrically insulating substrate 201 is made of inorganic filler and thermosetting resin or ceramic, the through-hole may alternately be formed by casting. Laser boring makes it possible to form a fine-pitch through-hole 205, and is preferred due to the lack of drill shavings. Laser boring can be facilitated by using a CO₂ laser or excimer laser. Drilling a through-hole provides the advantage of low cost, as this can be accomplished with basic equipment.

(0049) In the circuit substrate 20 shown in this embodiment 1, the shield 204 is molded integrally with the main surface of the electrically insulating substrate 201, and also extends into the through-hole 205, where it serves as a connector component. By this means, an electrical connection is established between the shield 204 and the ground pattern 203, which stabilizes the potential of the shield, resulting in more effective blocking of electromagnetic waves, which stabilizes the circuit. Additionally, connecting the shield 204 to the ground pattern

203 in the through-hole 205 shortens the length of the connection in comparison with a connection established on the perimeter of the insulating substrate 201.

(0050) It should be added that lower resistance values can be achieved by thus forming the shield 204 integrally in the through-hole 205 and in the main plane than, for example, by filling the through-hole with conductive material for the purpose of connecting the ground pattern 203 to the shield, or by forming the main plane of the shield separately after plating. This furthermore eliminates the need to perform plating or use other filler in the through-hole, thereby making it possible to reduce the number of parts and the number of processes needed to create the circuit substrate 200, which enables low-cost manufacture.

(0051) Note that, in this embodiment, the shield is electrically conductive, and hence also serves the function of ground pattern.

(0052) Although this embodiment was described by way of an example in which the trace pattern is not embedded in the electrically insulating substrate, the trace pattern may alternately be within the electrically insulating substrate.

(0053) Although this embodiment was described by way of an example in which the shield is not embedded in the electrically insulating substrate, the shield may alternately be within the electrically insulating substrate.

(0054) Although this embodiment was described by way of an example in which the shield was formed on the primary surface on one side, the same effect can be achieved by forming the shield on all sides of the electrically insulating substrate or around a designated trace pattern.

(0055) Although this embodiment was described by way of an example in which there was one layer for the trace pattern, the ground pattern, and the shield, each of these may alternately comprise a plurality of layers.

(0056) FIG. 2 is a process cross-section showing the manufacturing method for the circuit substrate 200 in this embodiment.

(0057) First, as shown in FIG. 2 (a), the electrically insulating substrate 201 is machined by cutting or the like into a sheet with the designated shape. Next, a plurality of through-holes 205 are formed. After forming the through-holes 205, the electrically insulating substrate and the copper foil 207 are aligned and superimposed, and the copper foil 207 is affixed to the main surface of the electrically insulating substrate 201 by means of adhesive. Next, as shown in FIG. 2 (b), the etching pattern 202 and the ground pattern 203 are formed by etching.

(0058) In parallel with the processes in FIG. 2 (a) and (b), a kneaded paste is formed by combining conductive powder with uncured thermosetting resin, and this kneaded paste is molded to a uniform thickness, forming a conductive resin mixture 206 in sheet form.

(0059) Below is a description of an example of how to produce the conductive resin mixture of the present invention containing conductive power and thermosetting resin.

(0060) First, a mixture in the form of a paste was produced by mixing Cu powder with a grain size of $\phi 1 \mu\text{m}$ as the conductive powder and liquid epoxy resin as the thermosetting resin until attaining a weight ratio of 90%, and then stirring with a stirring mixer for roughly 10 minutes. While stirring, a small amount of low-boiling-point butyl acetate was added to adjust viscosity. This mixture was molded over 70 μm thick polyethylene terephthalate film using a doctor blade in such a way as to achieve a thickness of 200 μm . After molding, the mixture was dried, with the film, for 15 minutes at 120 °C in order to reduce viscosity. This heat treatment causes the flattened mixture to lose viscosity, which facilitates separation from the film. Because the liquid epoxy resin used in this embodiment example has a hardening temperature of 130 °C, it remains uncured (in the B stage) under these heat treatment conditions. Next, the peel-away film was peeled off from the flattened mixture, yielding a conductive polymer mixture in sheet form. Note that the conductive resin mixture 206 may alternately be heat treated at a temperature lower than the curing temperature of the thermosetting resin. Heat treatment facilitates subsequent processing by making it possible to eliminate viscosity while retaining the flexibility of the conductive resin mixture 206. In the event that the mixture was prepared by dissolving thermosetting resin using solvent, heat treatment also serves to eliminate some of the solvent.

(0061) Again referring to FIG. 2, the electrically insulating substrate 201 on which a trace pattern 202 and a ground pattern 203 have now been formed is aligned with and superimposed over the conductive resin mixture 206, as shown in FIG. 2 (c), and then the conductive resin mixture 206 is deformed and packed into the through-hole 205 by applying pressure to the aligned and superimposed pieces, as shown in FIG. 2 (d). After applying pressure, the thermosetting resin in the conductive resin mixture 206 is hardened by heating, which simultaneously molds the shield 204, establishes an electrical connection to the ground pattern 203, and bonds the electrically insulating substrate 201 to the shield 204. Heating is performed at a temperature equal to or greater than the temperature at which the thermosetting resin in the conductive resin mixture 206 hardens (for example, 150 °C to 260 °C), filling the through-hole 205 with the shield 204. Note that the mechanical strength of the circuit substrate can be improved by applying pressure of 100 g/ to 2 kg/ while heating.

(0062) In this way, the circuit substrate 200 described above with reference to FIG. 1 was formed.

(0063) According to the manufacturing method in this embodiment, it is easy to manufacture a circuit substrate.

(0064) Note that, although in this embodiment the trace pattern and the ground pattern were formed by etching of metallic foil, this should not be construed as restricting the material or the formation method.

(0065) (Embodiment 2) FIG. 3 is a cross-section showing the manufacturing process for the circuit substrate 500 of another embodiment of the present invention.

(0066) The circuit substrate 500 in this embodiment, as shown in FIG. 3 (d), differs from the circuit substrate 200 in the above-described embodiment in that it does not have through-

holes. Instead, the ground pattern 503 formed on one main surface of the electrically insulating substrate 501 and the shield 504 formed on the other main surface are electrically connected by means of the portion of the shield serving as a connector component, which is formed around the perimeter of the electrically insulating substrate 501. All other components of the configuration are identical to those of embodiment 1 described above.

(0067) The circuit substrate 500 in this embodiment is formed by first machining an electrically insulating substrate 501 to a flat shape with the designated outer dimensions by cutting or the like, as shown in FIG. 3 (a). Next, as shown in FIG. 3 (b), conductive paste made of conductive powder and thermosetting resin is printed onto the main plane of the electrically insulating substrate 501 in accordance with the trace pattern 502 and the ground pattern 503. After printing, the thermosetting resin is hardened by heating. Examples of conductive powder that can be used include metal powders such as gold, silver, copper, or nickel, and carbon powder. Printing can be performed by screen printing or the like.

(0068) In parallel with the processes in FIG. 3 (a) and (b), a kneaded paste is formed by combining conductive powder with uncured thermosetting resin, and this kneaded paste is molded to a uniform thickness, forming a conductive resin mixture 505 in sheet form. Next, as shown in FIG. 3 (c), pressure is applied to the aligned and superimposed pieces. By using a die while applying pressure, the conductive resin mixture 505 becomes molded in such a way as to be integrated with the main plane and the perimeter of the electrically insulating substrate 501 while also being in contact with the ground pattern 503, as shown in FIG. 3 (d). After applying pressure, the thermosetting resin in the conductive resin mixture 505 is hardened by heating, which simultaneously molds the shield 504, establishes an electrical connection to the ground pattern 503 and the shield 504, and bonds the electrically insulating substrate 501 to the shield 504.

(0069) By means of the above-described method, the circuit substrate 500 is able to reduce the number of processes, and hence can be manufactured at low cost.

(0070) Note that although this embodiment was described with reference to a circuit substrate and a manufacturing method for the same, the same effect can be achieved when applied to a module with embedded circuit components, wherein components are embedded in an insulating substrate.

(0071) Although in this embodiment the trace pattern and the ground pattern were formed by printing with conductive paste made of conductive powder and thermosetting resin, this should not be construed as restricting the material or the formation method.

(0072) (Embodiment 3) FIG. 4 is a cross-section showing the manufacturing method for a circuit substrate 600 in yet another embodiment of the present invention.

(0073) The circuit substrate 600 in this embodiment is identical to that described above in embodiment 1 and embodiment 2, except as regards the formation of the electrically insulating substrate 601. Accordingly, aspects of this embodiment that are not explicitly described should be assumed to be identical

to those in embodiment 1 or embodiment 2, and components and manufacturing methods with the same name should be assumed to have the same function unless otherwise explicitly stated.

(0074) This circuit substrate 600, as shown in FIG. 4 (f), has an electrically insulating substrate 601, a trace pattern 602 formed on the main surface thereof, a shield 603, and a through-hole 604.

(0075) First, as shown in FIG. 4 (a), an insulating resin mixture 607 in sheet form is formed by processing a mixture containing inorganic filler and thermosetting resin. The insulating resin mixture 607 in sheet form can be formed by mixing inorganic filler and uncured thermosetting resin into a kneaded paste and molding this kneaded paste to a uniform thickness. Cutting is then performed to achieve a sheet shape with the designated form.

(0076) Below is a description of an example of how to create the thermosetting resin mixture of the present invention containing inorganic filler and thermosetting resin.

(0077) First, a mixture in the form of a paste was produced by mixing powder with a grain size of roughly $\phi 1 \mu\text{m}$ as the inorganic filler and liquid epoxy resin as the thermosetting resin until attaining a weight ratio of 90%, and then stirring with a stirring mixer for roughly 10 minutes. While stirring, a small amount of low-boiling-point butyl acetate was added to adjust viscosity. This mixture was molded over 75 μm thick polyethylene terephthalate film using a doctor blade in such a way as to achieve a thickness of 400 μm . After molding, the mixture was dried, with the film, for 15 minutes at 120 °C in order to reduce viscosity. This heat treatment causes the flattened mixture to lose viscosity, which facilitates separation from the film. Because the liquid epoxy resin used in this embodiment example has a hardening temperature of 130 °C, it remains uncured (in the B stage) under these heat treatment conditions.

(0078) Next, the peel-away film was peeled off from the flattened mixture, yielding a thermosetting resin mixture in sheet form.

(0079) Again referring to FIG. 4, a lead frame 605 having a trace pattern 602 formed thereupon was created by etching a metal plate, as shown in FIG. 4 (b). Subsequently, as shown in FIG. 4 (c) and (d), the lead frame 605 and the insulating resin mixture 607 were aligned and superimposed, and pressure was applied thereto. Using a die at this time makes it possible to provide the electrically insulating substrate 601 with a through-hole 604 and a groove serving as the ground pattern 602. Heating this then hardens the thermosetting resin in the electrically insulating resin mixture 607, forming an electrically insulating substrate 601. Through this process, a strong mechanical bond is created between the lead frame 605 and the electrically insulating substrate 601.

(0080) In parallel with the processes in FIG. 4 (a) through (d), a conductive resin mixture 606 in sheet form is formed by processing a mixture containing conductive powder and uncured

thermosetting resin into a kneaded paste and molding this kneaded paste to a uniform thickness.

(0081) The resultant electrically insulating substrate 601 and conductive resin mixture 606 are then aligned and superimposed, as shown in FIG. 4 (e). Subsequently, as shown in FIG. 4 (f), the conductive resin mixture 606 is deformed by applying pressure to the aligned and superimposed pieces. At this time, the conductive resin mixture 606 flows into the groove in the conductive insulating substrate 601 via the perimeter and the through-hole 604, forming a ground pattern 602. After applying pressure, the thermosetting resin in the conductive resin mixture 606 is hardened by heating, which simultaneously molds the shield 603 and bonds the electrically insulating substrate 601 to the shield 603. The shield 603 also serves the function of ground pattern. Heating is performed at a temperature greater than or equal to the hardening temperature of the thermosetting resin in the conductive resin mixture 606 (for example, 150 °C to 260 °C), causing the conductive resin mixture 606 to become the shield 603.

(0082) In the circuit substrate 600 indicated for this embodiment, the shield 603 not only provides the effect of blocking electromagnetic waves; it also functions as a ground pattern 602 via the perimeter and the through-hole 604. This has the effect of stabilizing the circuit. Consequently, there is no need to pre-form a ground pattern in advance, as the ground pattern and the shield can be formed as a unit, for which reason the circuit substrate 600 is able to reduce the number of parts and the number of processes, which enables low-cost manufacture.

(0083) Note that although this embodiment was described with reference to a circuit substrate and a manufacturing method for the same, the same effect can be achieved when applied to a module with embedded circuit components, wherein components are embedded in an insulating substrate.

(0084) Although in this embodiment the trace pattern and the ground pattern were formed by means of a lead frame, this should not be construed as restricting the material or the formation method.

(0085) Although in this embodiment the through-hole was formed using a die, this should not be construed as restricting the formation method.

(0086) (Embodiment 4) FIG. 5 is a cross-section of a module with embedded circuit components 400 in an embodiment of the present invention.

(0087) This module with embedded circuit components 400 is furnished with an electrically insulating substrate 401, with a trace pattern 402 and a ground pattern 403 being formed on one main surface of this electrically insulating substrate 401 and a shield 401 being formed on the other main surface. Circuit components 406 connected to the aforesaid patterns 402 and 403 are disposed in the interior of this electrically insulated substrate 401.

(0088) The electrically insulating substrate 401 is a substrate that is electrically insulating, and comprises a composite substrate of inorganic filler and resin whose configuration is identical to that when a composite substrate is used as the

electrically insulating substrate 201 in the above-described embodiment 1, and hence will not be described.

(0089) Mounting circuit components 406 prior to hardening the resin makes it possible to dispose circuit components within the interior of the electrically insulating substrate 401, thereby making it possible to provide a module with embedded circuit components that not only has a structure suitable to miniaturization but also has improved heat dissipation ability. Doing so also provides the effect of preventing mounted electronic components from being exposed to the atmosphere.

(0090) The trace pattern 402, the ground pattern 403, the shield 404, and the through-hole 405 are the same as the trace pattern 202, the ground pattern 203, the shield 204, and the through-hole 205 in the above-described embodiment 1, and will hence not be described.

(0091) The circuit components 406 include at least one of either active components 406a or passive components 406b. Examples of active components 406a that can be used include semiconductor elements such as transistors, IC, LSI, etc. Semiconductor elements may be semiconductor bare chips. Examples of passive components 406b that may be used include chip-form resistors, chip-form capacitors, chip-form inductors, etc. Using chip-form components makes it easy to embed components into the electrically insulating substrate 401. Flip chip bonding, for example, can be used to establish a connection between the trace pattern 402 and the active components 406a. Flip chip bonding of semiconductor bare chips makes it possible to mount semiconductor elements in high density. Furthermore, in the module with embedded circuit components 400, because the circuit components 406 are protected from the atmosphere by the electrically insulating substrate 401, this makes it possible to prevent deterioration of reliability due to moisture. Additionally, because the module with embedded circuit components 400 of the present invention uses a mixture of inorganic filler and thermoplastic resin as the material for the electrically insulating substrate 401, this eliminates the need to perform high-temperature sintering, unlike ceramic substrates, which facilitates the embedding of components.

(0092) In the module with embedded circuit components 400 indicated in this embodiment 4, the shield 404 is molded integrally with the main surface of the electrically insulating substrate 401, and also fills the through-hole 405. This establishes an electrical connection between the shield 404 and the ground pattern 403, resulting in more effective blocking of electromagnetic waves, which stabilizes the circuit. As a result, this eliminates the need to perform plating or use other filler in the through-hole, thereby making it possible to reduce the number of parts and the number of processes needed to create the module with embedded circuit components 400, which enables low-cost manufacture.

(0093) Note that, in this embodiment, the shield 404 is electrically conductive, and also serves the function of ground pattern.

(0094) Although module with embedded circuit components in this embodiment was described with reference to a case in which the trace pattern was present only on the surface layer, a trace pattern may also be formed in the interior of the electrically insulating substrate, with the two being mutually

connected.

(0095) Although the module with embedded circuit components in this embodiment was described with reference to an example in which circuit components are not mounted on the trace pattern, circuit components may be mounted on the trace pattern, and furthermore the module with embedded circuit components may be resin-molded. Mounting circuit components on the trace pattern makes it possible to mount circuit components even more densely.

(0096) Although in this embodiment the shield was formed on only the primary surface on one side, the same effect can be achieved by forming the shield on all sides of the electrically insulating substrate, or around a designated trace pattern or electrical component.

(0097) Although the module with embedded circuit components in this embodiment was described with reference to an example in which there was one layer for the trace pattern, the ground pattern, and the shield, each of these may alternately comprise a plurality of layers.

(0098) FIG. 6 is a process cross-section showing the manufacturing method for the module with embedded circuit components 400 in this embodiment.

(0099) First, as shown in FIG. 6 (a), an insulating resin mixture 409 in sheet form is formed by processing a mixture containing inorganic filler and thermosetting resin. The insulating resin mixture 409 in sheet form can be formed by mixing inorganic filler and uncured thermosetting resin into a kneaded paste and molding this kneaded paste to a uniform thickness. Cutting is then performed to achieve a sheet shape with the designated form.

(0100) In parallel with the process in FIG. 6 (a), the circuit components 406 are mounted on the lead frame 407, on which a trace pattern 402 and a ground pattern 403 have been formed by etching a metal plate. Mounting methods that can be used include solder mounting, which involves printing soldering cream onto the lead frame 407 and heating, as well as using conductive adhesive produced by kneading thermosetting resin together with gold, silver, copper, silver-palladium alloy or the like. Another acceptable method is to pre-form bumps made of solder or bumps produced by gold wire bonding onto the circuit component side, and then mount the circuit components 406 by melting the gold or solder with heat. It is also acceptable to use solder bumps and conductive adhesive in combination.

(0101) Furthermore, sealing resin may be injected into the space between the circuit components 406 and the lead frame 407. (In all of the following embodiments, as well, sealing resin may be injected into the space between the circuit components and the lead frame or between the circuit components and the trace pattern.) The injecting of sealing resin makes it possible to prevent the formation of a gap between semiconductor element and trace pattern when semiconductor elements are embedded into the sheet in a later process. Underfill resin of the kind used in conventional flip chip bonding can be used as the sealing resin.

(0102) Subsequently, as shown in FIG. 6 (c), the lead frame 407 with mounted circuit components 406 and the insulating resin mixture 409 are aligned and superimposed. Applying pressure thereto, as shown in FIG. 6 (d), causes the circuit

components 406 to become embedded in the insulating resin mixture 409. The through-hole 405 may be formed at the same time by using a die when applying pressure. The formation of this through-hole 405 can be performed using either a laser or a drill, either before or after hardening the thermosetting resin. After applying pressure, the thermosetting resin in the thermosetting resin mixture 409 is hardened by applying heat, thereby forming an electrically insulating substrate 401 with a flat form that has circuit components 406 embedded therein. Heating is performed at a temperature greater than or equal to the hardening temperature of the thermosetting resin in the thermosetting resin mixture 409 (for example, 150 °C to 260 °C). Through this process, a strong mechanical bond is created between the lead frame 407, the circuit components 406, and the electrically insulating substrate 401. Note that, when it comes time to harden the thermosetting resin in the insulating resin mixture 409 by heating, the mechanical strength of the circuit component module can be improved by applying pressure at a pressure of 100 g/ to 2 kg/ while heating.

(0103) In parallel with the processes in FIG. 6 (a) through (d), a conductive resin mixture 408 in sheet form is formed by processing a mixture containing conductive powder and thermosetting resin. The conductive resin mixture 408 in sheet form can be formed by mixing conductive powder and uncured thermosetting resin into a kneaded paste, and then molding this kneaded paste to a uniform thickness. Note that the insulating resin mixture 409 and the conductive resin mixture 408 may be heat-treated at a temperature lower than the hardening temperature of the thermosetting resin. Heat treatment facilitates subsequent processing by making it possible to eliminate viscosity while retaining the flexibility of the insulating resin mixture 409 and the conductive resin mixture 408. In the event that the mixture was prepared by dissolving thermosetting resin using solvent, heat treatment also serves to eliminate some of the solvent. In the event that the mixture was prepared by dissolving thermosetting resin using solvent, heat treatment also serves to eliminate some of the solvent.

(0104) The resultant electrically insulating substrate 401 is aligned with and superimposed over the conductive resin mixture 408, as shown in FIG. 6 (e). The conductive resin mixture 408 is then deformed and packed into the through-hole 405 by applying pressure to the aligned and superimposed pieces, as shown in FIG. 6 (f). After applying pressure, the thermosetting resin in the conductive resin mixture 408 is hardened by heating, which simultaneously molds the shield 404, establishes an electrical connection to the ground pattern 403, and bonds the electrically insulating substrate 401 to the shield 404. Heating is performed at a temperature equal to or greater than the temperature at which the thermosetting resin in the conductive resin mixture 408 hardens (for example, 150 °C to 260 °C), causing the conductive resin mixture 408 to become the shield 404. Note that the mechanical strength of the module with embedded circuit components can be improved by applying pressure at a pressure of 100 g/ to 2 kg/ while heating.

(0105) In this way, the module with embedded circuit components 400 shown in FIG. 5 is formed. According to the

manufacturing [method] in this embodiment, it is easy to manufacture the module with embedded circuit components 400 in FIG. 5.

(0106) Note that, although in this embodiment the trace pattern and the ground pattern were formed from a lead frame, this should not be construed as restricting the material or the formation method.

(0107) (Embodiment 5) FIG. 7 is a cross-section showing the manufacturing process for the module with embedded circuit components 700 in another embodiment of the present invention.

(0108) The module with embedded circuit components 700 in this embodiment, as shown in FIG. 7 (g), in addition to being furnished with an electrically insulating substrate 701, is furnished with a trace pattern 702 and ground pattern 703 formed on the interior thereof and circuit components 706 disposed on the interior thereof and connected to these patterns 702 and 703, and is also furnished with a shield 704 and through-hole 705.

(0109) The module with embedded circuit components in this embodiment is the same as the above-described embodiment 4, except as regards the formation of the electrically insulating substrate 701 and the material of the shield 704. Accordingly, aspects of this embodiment that are not explicitly described should be assumed to be identical to those in embodiment 4, and components and manufacturing methods with the same name should be assumed to have the same function unless otherwise explicitly stated.

(0110) First, as shown in FIG. 7 (a), an insulating resin mixture 709 in sheet form is formed by processing a mixture containing inorganic filler and thermosetting resin. The insulating resin mixture 709 in sheet form can be formed by mixing inorganic filler and uncured thermosetting resin into a kneaded paste and molding this kneaded paste to a uniform thickness. Cutting is then performed to achieve a sheet shape with the designated form. Two sheets of this insulating resin mixture 709 are prepared.

(0111) In parallel with FIG. 7 (a), a metal plate is stamped, as shown in FIG. 7 (b), and the circuit components 706 are mounted on the lead frame 707 on which the trace pattern 702 and the ground pattern 703 have been formed.

(0112) Subsequently, as shown in FIG. 7 (c), the insulating resin mixture 709 and the lead frame 707 on which the circuit components 706 have been mounted are aligned and superimposed. Applying pressure thereto causes the circuit components 706 to become embedded in the insulating resin mixture 709. This is then heated to harden the thermosetting resin in the insulating resin mixture 709.

(0113) Next, as shown in FIG. 7 (d), the insulating resin mixture 709 is aligned and superimposed, and pressure is applied so as to embed the trace pattern 702 and the ground pattern 703. After applying pressure, heat is applied to harden the thermosetting resin in the insulating resin mixture 709, thereby forming an electrically insulating substrate 701 in which a trace pattern 702, a ground pattern 703, and circuit components 706 are embedded.

(0114) After creating the electrically insulating substrate 701,

the through-hole 705 is formed, as shown in FIG. 7 (e). Note that this through-hole 705 is preferably formed to have an elongated shape in the direction perpendicular to the surface, rather than being formed to be circular in shape.

(0115) In parallel with the processes in FIG. 7 (a) through (e), a magnetic resin mixture 708 in sheet form is formed by processing a mixture containing magnetic powder and thermosetting resin. The magnetic resin mixture 708 in sheet form can be formed by mixing magnetic powder and uncured thermosetting resin into a kneaded paste and molding this kneaded paste to a uniform thickness. Magnetization of the magnetic material can be prevented by using soft magnetic material for this magnetic powder.

(0116) The resultant electrically insulating substrate 701 and magnetic resin mixture 708 are aligned and superimposed, as shown in FIG. 7 (f). Subsequently, as shown in FIG. 7 (g), pressure is applied to the aligned and superimposed pieces to mold a magnetic resin mixture 708. Part of the magnetic resin mixture 708 enters into the interior of the through-hole 705, forming a closed loop structure enclosing the trace pattern 702 and the ground pattern 703. After applying pressure, the thermosetting resin in the magnetic resin mixture 708 is hardened by applying heat, thereby simultaneously molding the shield 704 and bonding the electrically insulating substrate 701 to the shield 704. Because the shield 704 contains magnetic powder, it has EM wave absorption effect, which helps mitigate the impact of crosstalk between traces. The closed-loop structure also has the effect of furnishing the electrically insulating substrate 701 with the ability to block a broad range of EM waves from the exterior.

(0117) In the module with embedded circuit components indicated in this embodiment 7, the shield 704 not only has the effect of blocking electromagnetic waves over a broad range, but is also able to mitigate the effect of crosstalk between traces, which stabilizes the circuit. This makes it possible to reduce the number of processes required to produce the module with embedded circuit components 700, which enables low-cost manufacture.

(0118) (Embodiment 6) FIG. 8 is a cross-section showing the manufacturing processes for the module with embedded circuit components in yet another embodiment of the present invention.

(0119) The module with embedded circuit components in this embodiment is the same as that described above for embodiment 4, except in regards to the formation of the trace pattern, the formation of the electrically insulating substrate 801, and the structure of the shield 804. Accordingly, aspects of this embodiment that are not explicitly described should be assumed to be identical to those in embodiment 4, and components and manufacturing methods with the same name should be assumed to have the same function unless otherwise explicitly stated.

(0120) The module with embedded circuit components 800 in this embodiment, as shown in FIG. 8 (h), has an electrically insulating substrate 801; a trace pattern 802 and a ground

pattern 803 formed in the interior thereof; a shield 804; circuit components 806 disposed in the interior of the electrically insulating substrate 801 connected to the aforesaid patterns 80 and 803; and a through-hole 805.

(0121) This module with embedded circuit components 800, as shown in FIG. 8 (a), is produced by first forming an insulating resin mixture 809 in sheet form by processing a mixture containing inorganic filler and thermosetting resin. The insulating resin mixture 809 in sheet form can be formed by mixing inorganic filler and uncured thermosetting resin into a kneaded paste and molding this kneaded paste to a uniform thickness. Cutting is then performed to achieve a sheet shape with the designated form. Three sheets of this insulating resin mixture 809 are prepared.

(0122) In parallel with this FIG. 8 (a), as shown in FIG. 8 (b), a trace pattern 802 and a ground pattern 803 are formed on peel-away film 807, and circuit components 806 are mounted thereupon. Examples of film that can be used for the peel-away film 807 include polyethylene terephthalate and polyphenylene sulfide film. The trace pattern 802 and the ground pattern 803 can be formed, for example, by applying copper foil to the peel-away film 807 and then performing a photolithography process and an etching process.

(0123) Subsequently, as shown in FIG. 8 (c), the insulating resin mixture 809 and the peel-away film 807 with circuit components 806 mounted thereupon are aligned and superimposed. This is then processed so as to embed the circuit components 806 in the insulating resin mixture 809. Heating causes the thermosetting resin in the insulating resin mixture 809 to harden. After hardening, the peel-away film 807 is removed, as shown in FIG. 8 (d). This process is performed twice, forming two electrically insulating substrates 801.

(0124) Subsequently, the insulating resin mixture 809 is aligned with and superimposed over one of the electrically insulating substrates 801 in such a way as to embed the trace pattern 802 and the ground pattern 803, as shown in FIG. 8 (f). After applying pressure, the thermosetting resin in the insulating resin mixture 809 is hardened by heating, thereby forming an electrically insulating substrate 801 in which a trace pattern 802, a ground pattern 803, and circuit components 806 are embedded.

(0125) After creating the electrically insulating substrate 801, a through-hole 805 is formed, as shown in FIG. 8 (f).

(0126) In parallel with the processes in FIG. 8 (a) through (f), a conductive resin mixture 808 in sheet form is formed by processing a mixture containing conductive powder and thermosetting resin. The conductive resin mixture 808 in sheet form can be formed by mixing conductive powder and uncured thermosetting resin into a kneaded paste and molding this kneaded paste to a uniform thickness. Three sheets of this conductive resin mixture are formed. The resultant electrically insulating substrate 801 is aligned and superimposed with the conductive resin mixture 808, as shown in FIG. 8 (g). Subsequently, a conductive resin mixture 808 is molded by aligning and superimposing and then applying pressure, as

shown in FIG. 8 (h). Part of the conductive resin mixture 808 enters into the interior of the through-hole 805, where it comes into contact with the ground pattern 803. After applying pressure, the thermosetting resin in the conductive resin mixture 808 is hardened by applying heat, whereby it is possible to simultaneously mold the shield 804, electrically connect the ground pattern 803 and the shield 804, and bond the electrically insulating substrate 801 and the shield 804.

(0127) In the module with embedded circuit components 800 shown in this embodiment 6, the shield 804 has the effect of blocking electromagnetic waves over a broad range, and furthermore the module with embedded circuit components 800 is able to be manufactured with fewer processes, and hence at lower cost.

(0128)

(EFFECT OF THE INVENTION) As described above, according to the circuit substrate of the present invention, the shield provides the effect of blocking electromagnetic waves, as well as serving the function of establishing an electrical connection to the ground pattern, which stabilizes the circuit. Consequently, this makes it possible to reduce the number of parts and the number of processes, which makes it possible to manufacture the circuit substrate at low cost.

(BRIEF DESCRIPTION OF THE INVENTION)

(FIG. 1) Cross-section of the circuit substrate in embodiment 1 of the present invention.

(FIG. 2) Cross-section showing the manufacturing process for the circuit substrate in FIG. 1.

(FIG. 3) Cross-section showing the manufacturing process for circuit substrate in embodiment 2 of the present invention.

(FIG. 4) Cross-section showing the manufacturing process for circuit substrate in embodiment 3 of the present invention.

(FIG. 5) Cross-section showing the module with embedded circuit substrates in embodiment 4 of the present invention.

(FIG. 6) Cross-section showing the manufacturing process for the module with embedded circuit components in FIG. 5.

(FIG. 7) Cross-section showing the manufacturing process for module with embedded circuit substrates in embodiment 5 of the present invention.

(FIG. 8) Cross-section showing the manufacturing process for module with embedded circuit substrates in embodiment 6 of the present invention.

(DESCRIPTION OF THE SYMBOLS)

200, 500, 600: Circuit substrate

201, 301, 401, 501, 601, 701, 801: Electrically insulating substrate

202, 302, 402, 502, 602, 702, 802: Trace pattern

203, 303, 403, 503, 603, 703, 803: Ground pattern

204, 304, 404, 504, 604, 704, 804: Shield

205, 305, 405, 604, 705, 805: Through-hole

408, 505, 606, 808: Conductive resin mixture

207: Copper foil

300, 400, 700, 800: Circuit component module

306, 406, 706, 806: Circuit component

306a, 406a, 706a, 806a: Active component

306b, 406b, 706b, 806b: Passive component

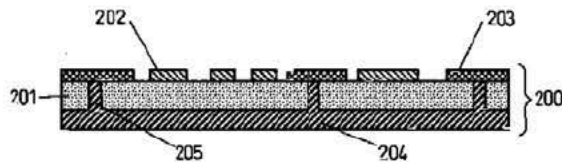
407, 605, 707: Lead frame

409, 709, 809: Insulating resin mixture

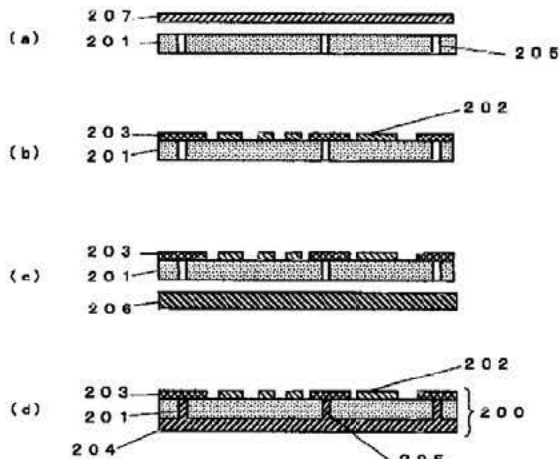
708: Magnetic resin mixture

807: Peel-away film

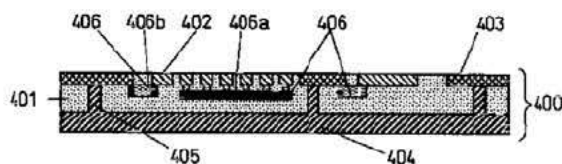
(FIG. 1)



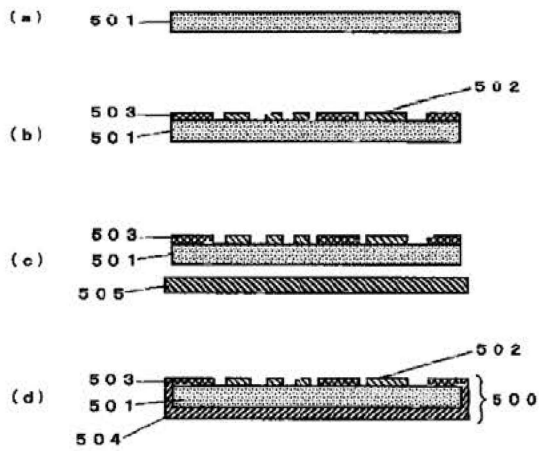
(FIG. 2)



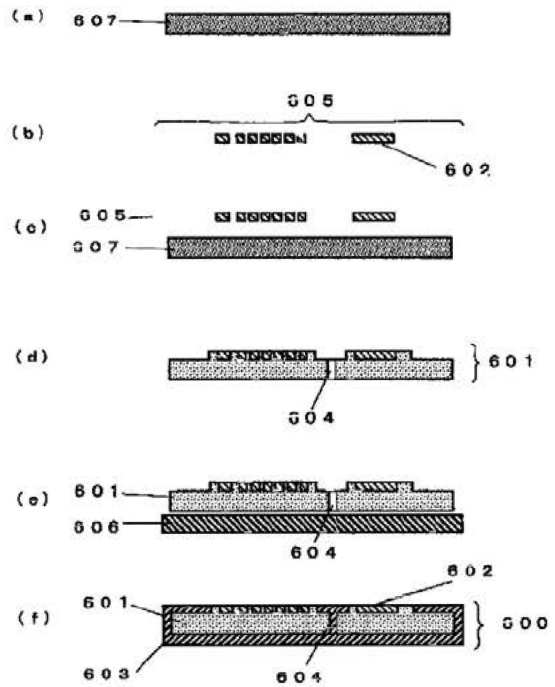
(FIG. 5)



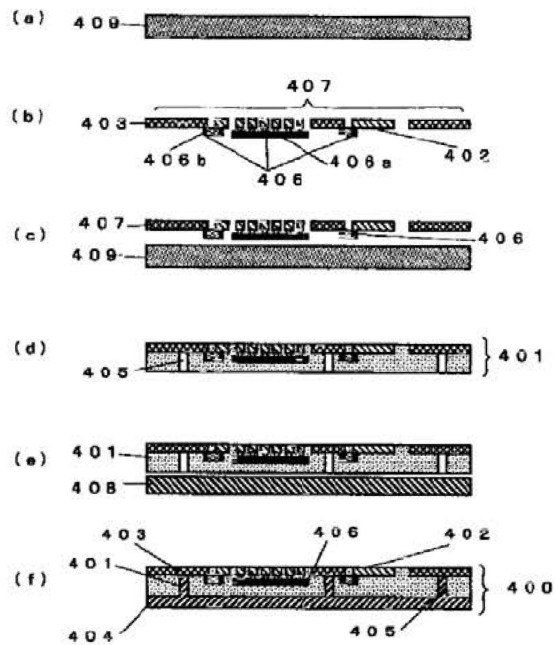
(FIG. 3)



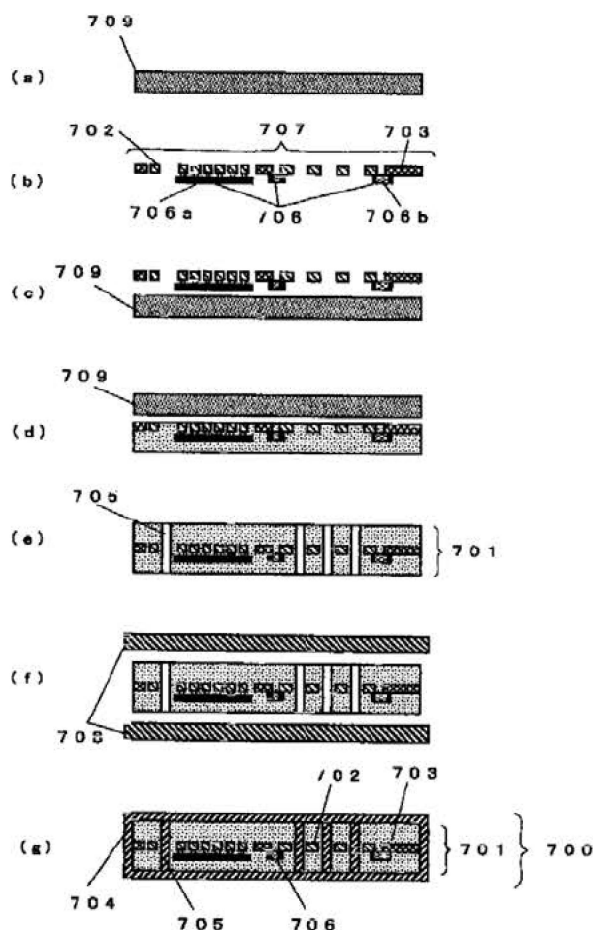
(FIG. 4)



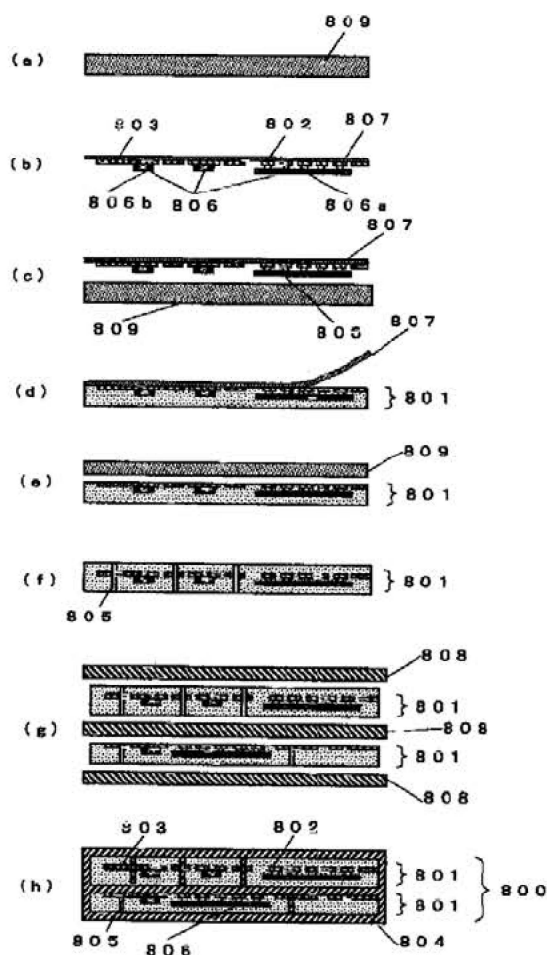
(FIG. 6)



(FIG. 7)



(FIG. 8)



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