明　細　書

半導体装置とその製造方法

技術分野

本発明は半導体装置に関し、特にフリップチップ実装技術を用いた半導体装置及びその製造方法に関するものである。

背景技術

近年、半導体素子の集積度が高くなり、半導体装置の小型化及び接続端子の狭ピッチ化が進んでいる。このためフリップチップ実装技術を用いた半導体装置の開発が盛んに行われている。以下図面を参照しながら、従来のフリップチップ実装技術を用いた半導体装置の一例について説明する。

図９に、従来のフリップチップ実装技術を用いた半導体装置の断面図を示す。半導体素子１０１の素子形成面上にはアルミ電極端子１０２が形成され、アルミ電極端子１０２以外の部分はＳｉ酸化膜あるいは窒化膜等からなる絶縁膜１０３で覆われている。アルミ電極端子１０２面上には、Ａｕ、Ｃｕ等の導電性金属材料からなる突起電極１０４が形成されている。一方、樹脂、セラミクス、ガラス等の絶縁物からなる回路基板１０５の主面上には、所望の回路パターン１０６及び電極端子１０７が形成されている。

電極端子１０７は回路パターン１０６に接続され、フリップチップ実装の際半導体素子１０１と電気的接続を行う。突起電極１０４と電極端子１０７とは、導電性接着剤１０８により電気的に接続されている。導電性接着剤１０８はＡｇ、Ｃｕ、Ｎｉ等の導電性金属材料の粉体を樹脂

中に含んだ接着剤である。半導体素子１０１と回路基板１０５の間の隙間部は絶縁樹脂１０９が充填されている。絶縁樹脂１０９が硬化されると、その硬化収縮応力により半導体素子１０１と回路基板１０５を接着した後、これらを強力に引きつけて固定する。そのため、半導体装置における半導体素子１０１と回路基板１０５の接続の機械的強度を高められ、安定した固定が保たれることになる。

以上のように構成された従来の半導体装置の製造方法を、図１０の製造プロセスを示す工程図を用いて説明する。まず、通常の半導体プロセスによって所望の素子や配線及び絶縁膜１０３を形成した半導体素子１０１を多数個形成した半導体ウエハを作製する。

次に、アルミ電極端子１０２にプローブを接触させ電気的検査を行い半導体素子１０１の良否を判定したうえで、突起電極１０４を形成する。さらに、半導体ウエハを個々の半導体素子１０１に切断する。

一方、予めＡｕやＣｕ等の導電性金属材料を用いて、絶縁物からなる回路基板１０５上に所望の回路パターン１０６や電極端子１０７を形成しておき、この回路基板１０５上に導電性接着剤１０８を介して所定の電極端子１０７と突起電極１０４の電気的接続が行えるように半導体素子１０１をフェースダウンにて配置する。

その後、加熱処理を行い導電性接着剤１０８を硬化させ、電気検査を行い動作状態を確認する。そして正常な動作を確認した後、半導体素子１０１と回路基板１０６の間に液状のエポキシ系等の絶縁性を有する樹脂１０９を毛細管現象を利用して充填する。充填完了後、加熱処理等を行い絶縁樹脂１０９を硬化させてフリップチップ実装を行う。

以上のような製造プロセスを経て、フリップチップ実装技術を用いた半導体装置を製造していた。

しかしながら、前記従来の半導体装置及びその製造方法では、図１１

に示すように、主に、回路基板１０５の局所的な反りやうねり等により回路基板１０５の平坦精度にばらつきがあり、また電極端子１０７部の膜厚精度にもばらつきがあるため、一つの半導体素子領域内に位置する回路基板側の電極端子１０７の先端面が、一定水平面上になく、高さ方向においてばらつきがあった。

このため、半導体素子１０１をフェースダウンにて搭載する際には、回路基板１０７の凹部においては半導体素子１０１と回路基板１０５の間の隙間部の寸法が他の部分と比較して大きいため、この凹部に位置する電極端子１０７の先端面に導電性接着剤１０８が到達することができず、電気的接続の不良が発生する場合があるという問題点があった。

発明の開示

本発明は前記従来の問題点を解決するため、半導体素子と回路基板とをより確実に安定して電気的に接続することにより、極めて品質の安定した、生産性の良い半導体装置及びその製造方法を提供することを目的とする。

前記目的を達成するため、本発明の半導体装置は、半導体素子の素子形成面上の電極端子部に形成した導電性金属材料の突起電極と、導電性接着剤と、回路基板上の電極端子とを介して、前記半導体素子と前記回路基板との電気的接続を行なうフリップチップ実装技術が用いられている半導体装置であって、前記各突起電極の先端面と前記導電性接着剤を介して相対向する各電極端子面との間の距離が、それぞれ均一となるよう前記各突起電極が高さ方向に塑性変形していることを特徴とする。

前記のような半導体装置によれば、各突起電極の先端面と前記導電性接着剤を介して相対向する各電極端子面との間の距離が、それぞれ均一となるよう突起電極の高さが適正に加工されているため、半導体素子と

回路基板との電気的接続を確実なものとすることができる。

前記半導体装置においては、前記突起電極の材料が、Ａｕ及びＣｕから選ばれる少なくとも一つの金属材料であることが好ましい。

また、前記各突起電極の先端面と前記導電性接着剤を介して相対向する各電極端子面との間の距離が、１μｍ～１０μｍの範囲であることが好ましい。

また、半導体素子の素子形成面上の電極端子と、導電性接着剤と、回路基板上の電極端子部に形成した導電性金属材料の突起電極とを介して、前記半導体素子と前記回路基板との電気的接続を行なうフリップチップ実装技術が用いられていることが好ましい。

前記の回路基板側に突起電極が形成された好ましい半導体装置においては、半導体素子の素子形成面上の電極端子上に、導電性金属材料の積層膜からなるバリヤ層が形成されていることが好ましい。

前記バリヤ層が形成された好ましい半導体装置によれば、半導体素子の素子形成面上の電極端子の腐食を防止することができる。

また、前記半導体装置においては、突起電極の突出高さが、実質的に同じであることが好ましい。

前記突起電極の突出高さが、実質的に同じであることが好ましい半導体装置においては、突起電極を導電性接着剤による接着の前に、予め硬質材料の平面部に押し当てて各突起電極の先端面の高さを均一なものとしておくことが好ましい。

また、前記突起電極を硬質材料の平面部に押し当てて各突起電極の先端面の高さを均一なものとした好ましい半導体装置においては、前記突起電極を硬質材料の平面部に押し当てることにより、前記突起電極の先端面における圧力を1.5×10^{8}～5.0×10^{8}Ｎ／m^{2}の範囲とすることが好ましい。

また、前記硬質材料の平面性が距離２０ｍｍ間において４μｍ以内であることが好ましい。

次に、本発明の第１番目の半導体装置の製造方法は、半導体素子の素子形成面に突起電極を形成した後、突起電極の頂頭部に導電性接着剤を転写させ、半導体素子を回路基板上にフェースダウンにて搭載する際に、半導体素子の背面より加圧することにより、半導体素子の各突起電極の先端面とこれと相対向する回路基板側の電極端子面との間の距離が、それぞれ均一となるように半導体素子の突起電極を塑性変形させることを特徴とする。

前記第１番目の半導体装置の製造方法によれば、半導体素子の背面より加圧することにより、各突起電極の先端面と前記導電性接着剤を介して相対向する各電極端子面との間の距離が、それぞれ均一となるよう突起電極の高さを適正に加工できるため、極めて信頼性の高い半導体装置を容易かつ安価に製造できる。

前記第１番目の半導体装置の製造方法においては、前記半導体素子の背面より加圧することにより、突起電極の先端面における圧力を１．５×10^8～５．０×10^8Ｎ／m^2の範囲とすることが好ましい。

また、半導体素子の突起電極を塑性変形させた後に、半導体素子の各突起電極の頂頭部に導電性接着剤を転写させて、再度半導体素子を回路基板上にフェースダウンにて搭載することが好ましい。

前記の突起電極を塑性変形させた後に、再度半導体素子を回路基板ににフェースダウンにて搭載する好ましい半導体装置の製造方法においては、フェースダウンにて半導体素子を回路基板の搭載する際には、半導体素子はほとんど加圧されないので、半導体素子と回路基板との位置ずれを防止することができる。

次に、本発明の第２番目の半導体装置の製造方法は、回路基板の電極

端子部に突起電極を形成した後、この突起電極を硬質材料の平面部に押し当てて各突起電極の先端面の高さを均一なものとし、その後前記各突起電極の頂頭部に導電性接着剤を転写させてから、回路基板上に前記半導体素子をフェースダウンにて搭載することを特徴とする。

前記第２番目の半導体装置の製造方法によれば、半導体素子を加圧する工程が無いので、半導体素子に与えるダメージを小さくすることができる。

前記第２番目の半導体装置の製造方法においては、前記突起電極を硬質材料の平面部に押し当てることにより、前記突起電極の先端面における圧力を1.5×10^{8}～5.0×10^{8}N／m^{2}の範囲とすることが好ましい。

また、前記硬質材料の平面性が距離２０ｍｍ間において４μｍ以内であることが好ましい。

図面の簡単な説明

図１は、本発明の実施例１に係る半導体装置の断面図。

図２は、本発明の実施例１に係る半導体装置の製造プロセスを示す工程図。

図３Ａは、図２の製造プロセスにおいて、導電性接着剤転写工程における半導体装置の断面図、図３Ｂは、マウント工程から半導体素子加圧工程における半導体装置の断面図。

図４は、本発明の実施例２に係る半導体装置の製造プロセスを示す工程図。

図５Ａは、図４の製造プロセスにおいて、マウント工程から半導体素子加圧工程における半導体装置の断面図、図５Ｂは、導電性接着剤転写工程における半導体装置の断面図。

図６は、本発明の実施例３に係る半導体装置の断面図

図７は、本発明の実施例３に係る半導体装置の製造プロセスを示す工程図。

図８Ａは、図７の回路基板加圧工程において、回路基板加圧前の状態を示した半導体装置の断面図、図８Ｂは、回路基板加圧後の状態を示した半導体装置の断面図。

図９は、従来のフリップチップ実装技術を用いた半導体装置の一例の断面図。

図１０は、従来のフリップチップ実装技術を用いた半導体装置の製造プロセスの一例を示す工程図。

図１１は、従来の半導体装置の一例の断面図。

発明を実施するための最良の形態

以下、本発明の半導体装置及びその半導体の製造方法の実施例について、図面を用いて説明する。

（実施例１）

図１は実施例１に係る半導体装置の断面図である。図１に示すように、半導体素子１の素子形成面上にはアルミ電極端子２が形成され、アルミ電極端子２以外の部分はＳｉ酸化膜や窒化膜等からなる絶縁膜３で覆われている。

アルミ電極端子２上には、Ａｕ、Ｃｕ等の導電性金属材料からなる突起電極４が形成されている。一方、樹脂、セラミクス、ガラス等の絶縁物からなる回路基板５上には所望の回路パターン６及び電極端子７が形成されている。電極端子７は回路パターン６に接続され、フリップチップ実装の際、半導体素子１との電気的接続を行う。導電性接着剤８はＡｇ、Ｃｕ、Ｎｉ等の導電性金属材料の粉体を樹脂中に含んだ接着剤であ

る。半導体素子１と回路基板５の間の隙間部には絶縁樹脂９が充填されている。

絶縁樹脂９が硬化されると、その硬化収縮力により半導体素子１と回路基板５を接着した後、半導体素子１と回路基板５を強力に引きつけて固定する。そのため、半導体装置における半導体素子１と回路基板５の接続の機械的強度が高められ、安定した固定が保たれる。

図１に示したように、突起電極４の高さは、回路基板５上の電極端子７の高さに応じて加工されている。すなわち、主に回路基板５の主面上の平坦精度のばらつき及び電極端子７の膜厚精度のばらつきに起因して電極端子７の先端面の高さ方向の位置にはばらつきがあるが、このばらつきに応じて突起電極４の高さは、塑性変形により高さを低くしている。この場合、塑性変形前の突起電極４の高さのばらつきは電極端子７の先端面の高さ方向の位置のばらつきと比べると小さく、その高さはほぼ一定であるため、電極端子７の先端面の高さ方向の位置に応じて、塑性変形による突起電極４の高さの変化量は異なることなる。具体的には、電極端子７の先端面と半導体素子１との距離が短い程、突起電極４の高さの変化量は大きくなっている。

このため、半導体素子１側の突起電極４先端面と回路基板５側の電極端子７面との間の距離が均一となる。この距離は１μｍ～１０μｍの範囲であることが好ましい。より好ましくは、５μｍ程度である。この結果、突起電極４頂頭部に転写された導電性接着剤８からなる接合層は、確実に回路基板５側の電極端子７面に到達して付着することができ、電気的接続不良の発生を防ぐことができる。

次に、実施例１に係る半導体装置の製造方法を、図２、３を参照しながら説明する。図２は、実施例１に係る半導体装置の製造プロセスを示す工程図である。図２に示したように、まず、従来プロセスと同様に、

半導体素子１の素子形成面に素子を形成する。

次に、ボールボンディング法を用いてアルミ電極端子２面上にＡｕの突起電極４を形成した後、半導体ウエハを個々の半導体素子１に切断する。その後、突起電極４の頂頭部のみに必要量の導電性接着剤８を転写した後、予め所望の回路パターン６や電極端子７を形成した回路基板５上の所定の位置に配置した上で、半導体素子１の背面より加圧して突起電極４の塑性変形を促し、突起電極４の高さを適正にする加工を施す。

最後に、加熱処理を行い導電性接着剤８を硬化させ、電気検査により正常な動作を確認した後、半導体素子１と回路基板６の間に液状のエポキシ系等の絶縁性樹脂９を充填し硬化させて半導体装置とする。

図３は、図２に示した製造プロセスにおいて、導電性接着剤転写から半導体素子加圧工程までを説明した図である。図３において、図中に示した番号は図１と同じである。図３Ａは、図２の製造プロセスにおいて、導電性接着剤転写工程における半導体装置の断面図、図３Ｂは、マウント工程から半導体素子加圧工程における半導体装置の断面図を示している。

図３Ａに示したように、突起電極４の頂頭部付近にのみ必要量の導電性接着剤８が転写される。次に図３Ｂに示したように、半導体素子１は回路基板５上の所定の位置にフェースダウンにて配置された後、半導体素子１の背面より圧力Ｐが加圧されて、突起電極４の塑性変形を促し突起電極４の高さが適正となるまで加工が行われる共に、フェースダウン方式によるマウントを完了する。

半導体素子１の背面より加圧する圧力は、前記突起電極４の先端面において１．５×10^{8}～５．０×10^{8}Ｎ／m^{2}の範囲であることが好ましい。このような圧力の範囲であれば、突起電極４の先端面と電極端子７面との間の距離を１μｍ～１０μｍの範囲で均一にできる。

なお、突起電極４を形成する際、転写バンプ法を用いて、予め別の場所で作製したＡｕやＣｕ等の導電性金属材料魂を、アルミ電極端子２面に押し当て、圧力、熱、及び超音波振動等を加えて導電性金属材料魂をアルミ電極端子２面に付着させ、突起電極４としても良い。

また、無電解あるいは電解によるメッキ法を用いて、アルミ電極端子２面上に導電性金属材料を析出して突起電極４としても良い。

以上のように、実施例１に係る半導体装置の製造方法によれば、従来のプロセスと比較して、突起電極を加圧する工程と半導体素子をマウントする工程を同時に行えるため、工程の簡略化が図られるという効果も併せ持つ。

（実施例２）

次に、本発明の製造方法の半導体装置の実施例２について図４、５を参照しながら説明する。図４は実施例２に係る半導体装置の製造プロセスを示す工程図である。前記実施例１に係る半導体装置の製造方法では、先に導電性接着剤を転写した半導体素子を、回路基板上にフェースダウンにて配置した後、加圧して突起電極の塑性変形とマウントを同時に行っていた。

実施例２に係る半導体装置の製造方法では、予め回路基板上でフェースダウンにて配置した半導体素子を加圧して突起電極の塑性変形を行った後、いったん、半導体素子を回路基板から取り外し、導電性接着剤の転写を行った上で、再度、フェースダウン方式によるマウントを実施する。

図５は、図４に示した製造プロセスにおいて、フェースダウン方式によるマウント（１）から導電性接着剤転写までを説明した図である。図５において、図中に示した番号は図１と同じである。図５Ａは、図４の製造プロセスにおいて、マウント工程から半導体素子加圧工程における

半導体装置の断面図、図５Ｂは、導電性接着剤転写工程における半導体装置の断面図を示している。

図５Ａに示したように、回路基板５上の所定の位置にフェースダウンにて配置された半導体素子１は背面より圧力Ｐが加圧され、適正な突起電極４の塑性変形が施される。

次に、半導体素子１は、いったん回路基板５より取り外された後、図５Ｂに示したように、突起電極４の頂頭部のみに必要量の導電性接着剤８が転写される。その後、再度、回路基板５上の所定位置にフェースダウン方式にてマウントされる。このようにして、図１に示す構成と実質的に同一の構成を有する半導体装置を製造することができる。

前記実施例１に係る半導体装置の製造方法においては半導体素子のマウント時に加圧されるため、半導体素子と回路基板との位置関係が所定の位置よりずれる可能性があるが、実施例２に係る半導体装置の製造方法によれば、マウントする際には加圧がほとんど加えられないので、半導体素子と回路基板との位置関係が所定の位置よりずれる可能性は少ない。このため、微細ピッチ接続構造のようなマウント精度を有する半導体装置の製造に適している。

（実施例３）

次に、実施例３に係る半導体装置及びその製造方法について、図６から図８を参照しながら説明する。図６は実施例３に係る半導体装置を示す断面図である。図6において、１２はアルミ電極端子面上に形成されたＣｒ及びＡｕの積層膜からなるバリア層で、１４は回路基板側の電極端子面上に形成した突起電極である。その他は図１と同じである。

図１に示した実施例１に係る半導体装置の構成と異なるのは、アルミ電極端子２面に直接導電性接着剤が接触すると、アルミが腐食する可能性があるため、バリヤ層１２を形成した点と、Ａｕ、Ｃｕ等の導電性金

属材料からなる突起電極１４が回路基板５側の電極端子７面上に形成されている点である。

本実施例に係る半導体装置においても実施例１に係る半導体装置と同じく、図６に示したように、突起電極１４の高さは、回路基板５上の電極端子７の高さ方向の位置に応じて加工されている。すなわち、主に回路基板５の主面上の平坦精度のばらつき及び電極端子７の膜厚精度のばらつきに起因して電極端子７の高さ方向の位置にはばらつきがあるが、このばらつきに応じて突起電極１４は塑性変形により高さを低くしている。この場合、塑性変形前の突起電極１４の高さのばらつきは電極端子７の高さ方向の位置のばらつきと比べると小さく、その高さはほぼ一定であるため、電極端子７の先端面の高さ方向の位置に応じて、塑性変形による突起電極１４の高さの変化量は異なることなる。具体的には、電極端子７の先端面と半導体素子１との距離が短い程、突起電極１４の高さの変化量は大きくなっている。

このため、半導体素子１側のバリア層１２の表面と突起電極１４先端面との間の距離は均一となる。この距離は、実施例１と同様に１μｍ～１０μｍの範囲であることが好ましい。より好ましくは、５μｍ程度である。この結果、突起電極１４頂頭部に転写された導電性接着剤８からなる接合層は、確実に半導体素子１側のバリア層１２面に到達して付着することができ、電気的接続不良が発生しない。

次に、実施例３に係る半導体装置の製造方法について、図７、８を参照しながら説明する。図７は、実施例３に係る半導体装置の製造プロセスを示す工程図である。図７に示したように、半導体素子１の素子形成面に素子を形成した後、アルミ電極端子２面上にメッキ法によりＣｒ及びＡｕを積層したバリヤ層１２形成する。その後、検査を行った上で半導体ウエハを個々の半導体素子１に切断する。

一方、回路基板５は、主面上に所望の回路パターン６や電極端子７を形成した後、電極端子面７上にボールボンディング法を用いてＡｕの突起電極１４を形成する。

次に、この突起電極１４を所望の平坦精度を有し、かつ硬質な材料から成る平面板に押し当てることで突起電極１４の適正な塑性変形を促し、突起電極１４先端面の高さをほぼ均一化する。

その後、突起電極１４の頂頭部のみに必要量の導電性接着剤８ペーストを転写させてから、回路基板５上の所定の位置に半導体素子１をフェースダウンにてマウントした後、加熱処理を行い導電性接着剤８を硬化させ、電気検査により正常な動作を確認して、最後に半導体素子１と回路基板６の間に液状のエポキシ系等の絶縁性を有する樹脂９を充填し硬化させて半導体装置とする。

図８は、図７に示した製造プロセスにおいて、回路基板加圧から導電性接着剤転写工程までを説明した図である。図７において、図中に示した番号は図６と同じである。図８Ａは、図７の回路基板加圧工程において、回路基板加圧前の状態を示した半導体装置の断面図、図８Ｂは、回路基板加圧後の状態を示した半導体装置の断面図を示している。

図８Ａに示したように、回路基板５の主面上に形成した突起電極１４を所望の平坦精度を有し、かつ硬質な材料からなる平面板に押し当てることで突起電極１４の適正な塑性変形を促し、突起電極１４先端面の高さを均一化する。前記硬質材料の平面性は、距離２０ｍｍ間において４μｍ以内であることが好ましい。硬質な材料からなる平面板に押し当てる圧力は、前記突起電極４の先端面において１．５×10^{8}～５．０×10^{8}Ｎ／m^{2}の範囲であることが好ましい。その後、図８Ｂに示すように突起電極１４の頂頭部のみに導電性接着剤８ペーストを転写させてから、半導体素子１のマウントを行う。

なお、突起電極１４を形成する際、転写バンプ法を用いて、予め別の場所で作製したＡｕやＣｕ等の導電性金属材料魂を、電極端子７面に押し当て、圧力、熱、及び超音波振動等を加えて導電性金属材料魂を電極端子７面に付着させ、突起電極１４としても良い。

また、無電解あるいは電解によるメッキ法を用いて、電極端子７面上に導電性金属材料を析出して突起電極１４としても良い。

また、ペーストを用いた厚膜製膜技術を用いても良い。バリヤ層１２については、材料はＣｒ－Ａｕ膜以外でもかまわない。

また、アルミ電極端子２がアルミ以外のＡｕやＰｔ等の侵されにくい材料で形成されている場合は、特にバリア層を必要としない。

以上のように、実施例３に係る半導体装置の製造方法よれば、半導体素子を加圧する工程がなくなるので、半導体素子に与えるダメージが少なくてすむ利点がある。特に半導体素子がＧａ－Ａｓ等の化合物半導体などのもろい材料で作製されている場合には、効果的である。

以上のように、本発明の半導体装置によれば、各突起電極の先端面と前記導電性接着剤を介して相対向する各電極端子面との間の距離が、それぞれ均一となるよう突起電極の高さが適正に加工されているため、半導体素子と回路基板との電気的接続を確実なものとすることができる。

また、本発明の半導体装置の製造方法によれば、半導体素子の背面より加圧することにより、各突起電極の先端面と前記導電性接着剤を介して相対向する各電極端子面との間の距離が、それぞれ均一となるよう突起電極の高さが適正に加工できるため、半導体素子と回路基板との電気的接続の確実な極めて信頼性の高い半導体装置を容易かつ安価に製造できる。

産業上の利用可能性

以上のように、本発明の半導体装置は、半導体素子と回路基板との電気的接続が確実で極めて信頼性が高いので、半導体素子と回路基板とが電気的に接続される半導体装置として利用できる。

また、本発明の半導体装置の製造方法によれば、各突起電極が塑性変形させることにより、半導体素子と回路基板との電気的接続を確実にすることができるので、フリップチップ実装技術を用いた半導体装置の製造方法として利用できる。

請　求　の　範　囲

1．半導体素子の素子形成面上の電極端子部に形成した導電性金属材料の突起電極と、導電性接着剤と、回路基板上の電極端子とを介して、前記半導体素子と前記回路基板との電気的接続を行なうフリップチップ実装技術が用いられている半導体装置であって、前記各突起電極の先端面と前記導電性接着剤を介して相対向する各電極端子面との間の距離が、それぞれ均一となるよう前記各突起電極が高さ方向に塑性変形していることを特徴とする半導体装置。

2．前記突起電極の材料が、Ａｕ及びＣｕから選ばれる少なくとも一つの金属材料である請求項１に記載の半導体装置。

3．前記各突起電極の先端面と前記導電性接着剤を介して相対向する各電極端子面との間の距離が、１μｍ～１０μｍの範囲である請求項１に記載の半導体装置。

4．半導体素子の素子形成面上の電極端子と、導電性接着剤と、回路基板上の電極端子部に形成した導電性金属材料の突起電極とを介して、前記半導体素子と前記回路基板との電気的接続を行なうフリップチップ実装技術が用いられている請求項１に記載の半導体装置。

5．前記半導体素子の素子形成面上の電極端子上に、導電性金属材料の積層膜からなるバリヤ層が形成されている請求項４に記載の半導体装置。

6．前記突起電極の突出高さが、実質的に同じである請求項１に記載の半導体装置。

7．前記突起電極を導電性接着剤による接着の前に、予め硬質材料の平面部に押し当てて各突起電極の先端面の高さを均一なものとしておく請求項６に記載の半導体装置。

* C L M S *

8．前記突起電極を硬質材料の平面部に押し当てることにより、前記突起電極の先端面における圧力を1．5×10^{8}～5．0×10^{8}N／m^{2}の範囲とする請求項7に記載の半導装置。

9．前記硬質材料の平面性が距離20mm間において4μm以内である請求項7に記載の半導装置。

10．半導体素子の素子形成面に突起電極を形成した後、突起電極の頂頭部に導電性接着剤を転写させ、半導体素子を回路基板上にフェースダウンにて搭載する際に、半導体素子の背面より加圧することにより、半導体素子の各突起電極の先端面とこれと相対向する回路基板側の電極端子面との間の距離が、それぞれ均一となるように半導体素子の突起電極を塑性変形させることを特徴とした半導体装置の製造方法。

11．前記半導体素子の背面より加圧することにより、前記突起電極の先端面における圧力を1．5×10^{8}～5．0×10^{8}N／m^{2}の範囲とする請求項10に記載の半導装置の製造方法。

12．半導体素子の突起電極を塑性変形させた後に、半導体素子の各突起電極の頂頭部に導電性接着剤を転写させて、再度半導体素子を回路基板上にフェースダウンにて搭載する請求項10に記載の半導体装置の製造方法。

* C L M S *

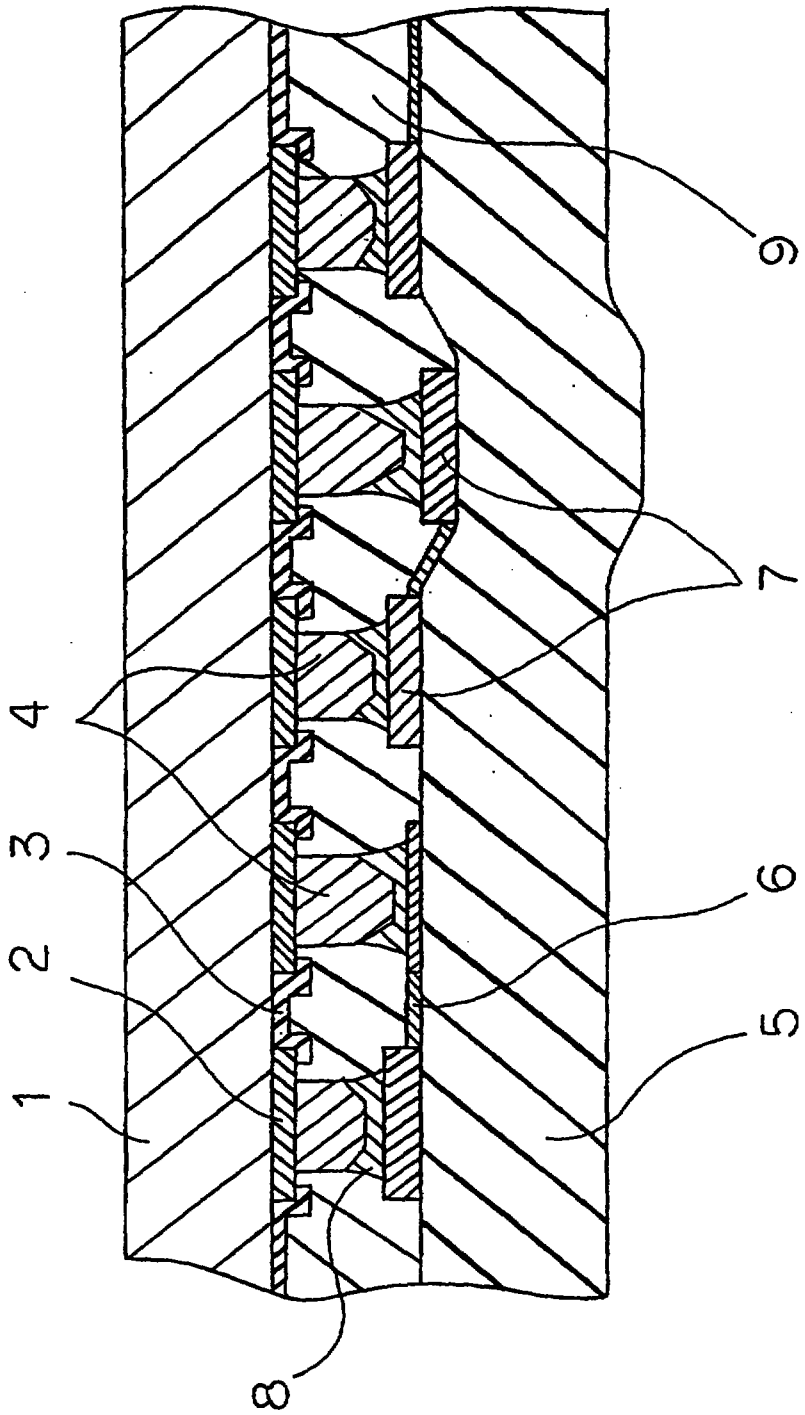


FIG. 1

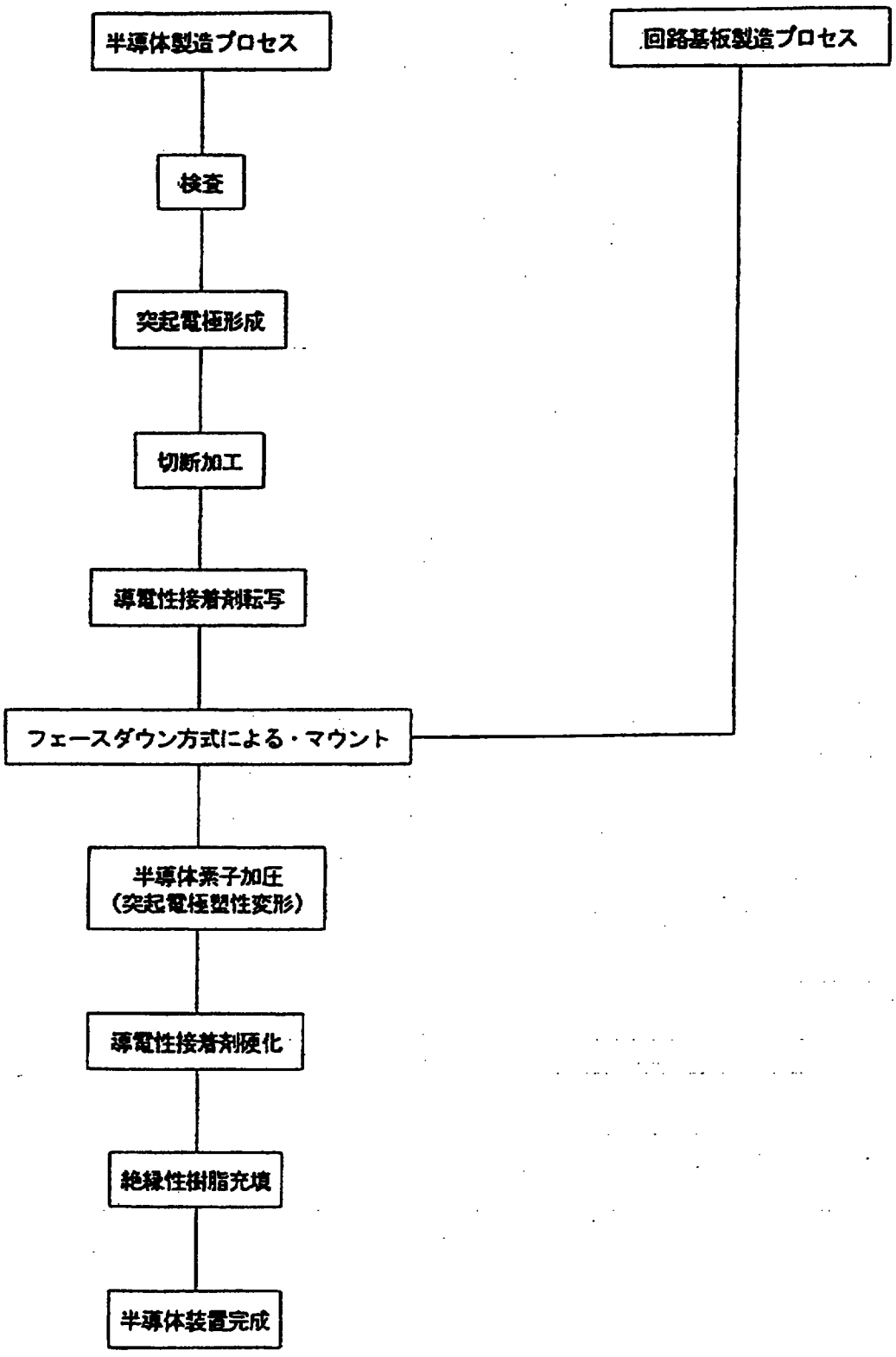

半導体製造プロセス
回路基板製造プロセス
検査
突起電極形成
切断加工
導電性接着剤転写
フェースダウン方式による・マウント
半導体素子加圧
(突起電極塑性変形)
導電性接着剤硬化
絶縁性樹脂充填
半導体装置完成

FIG. 2

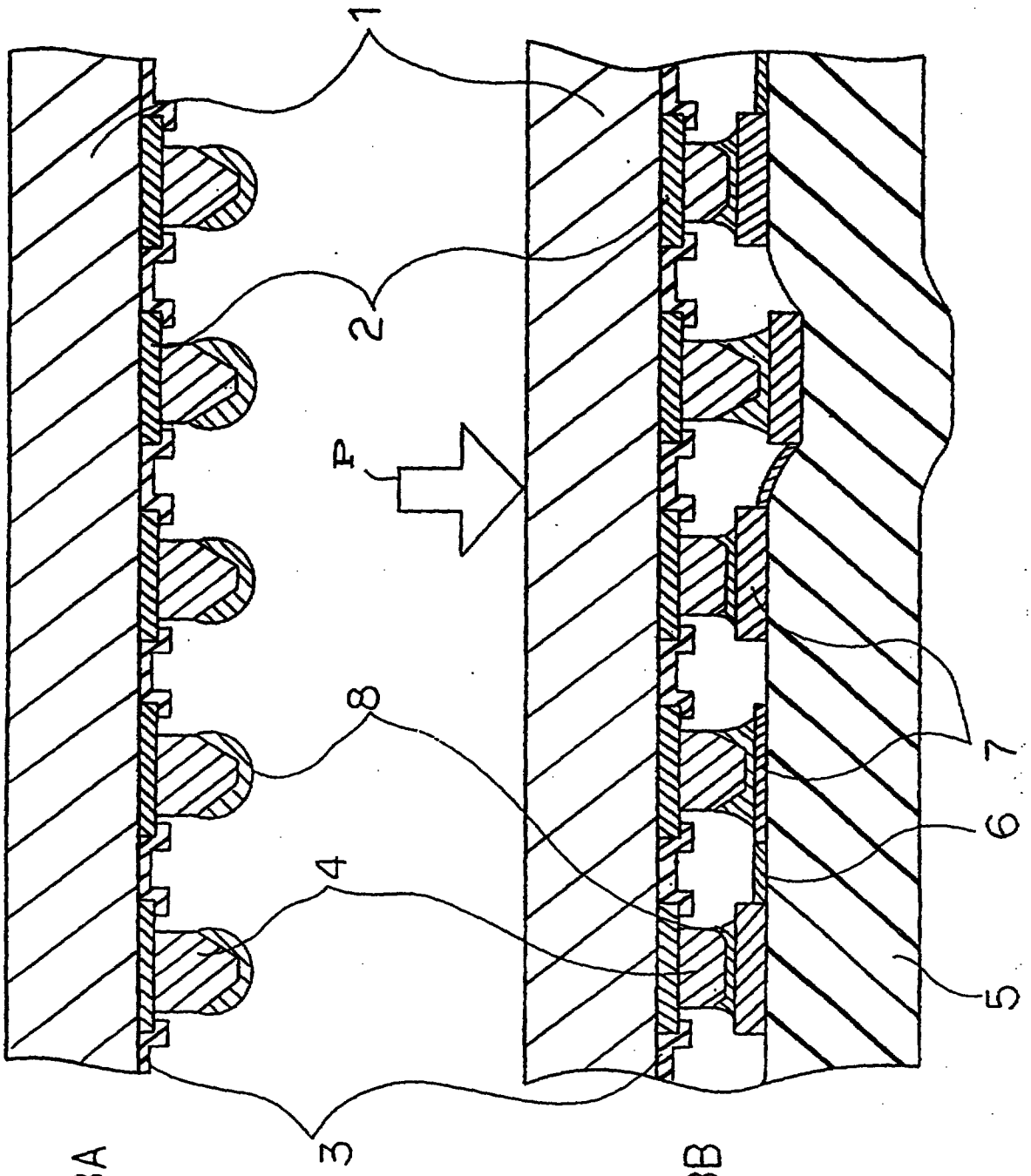


FIG. 3A

FIG. 3B

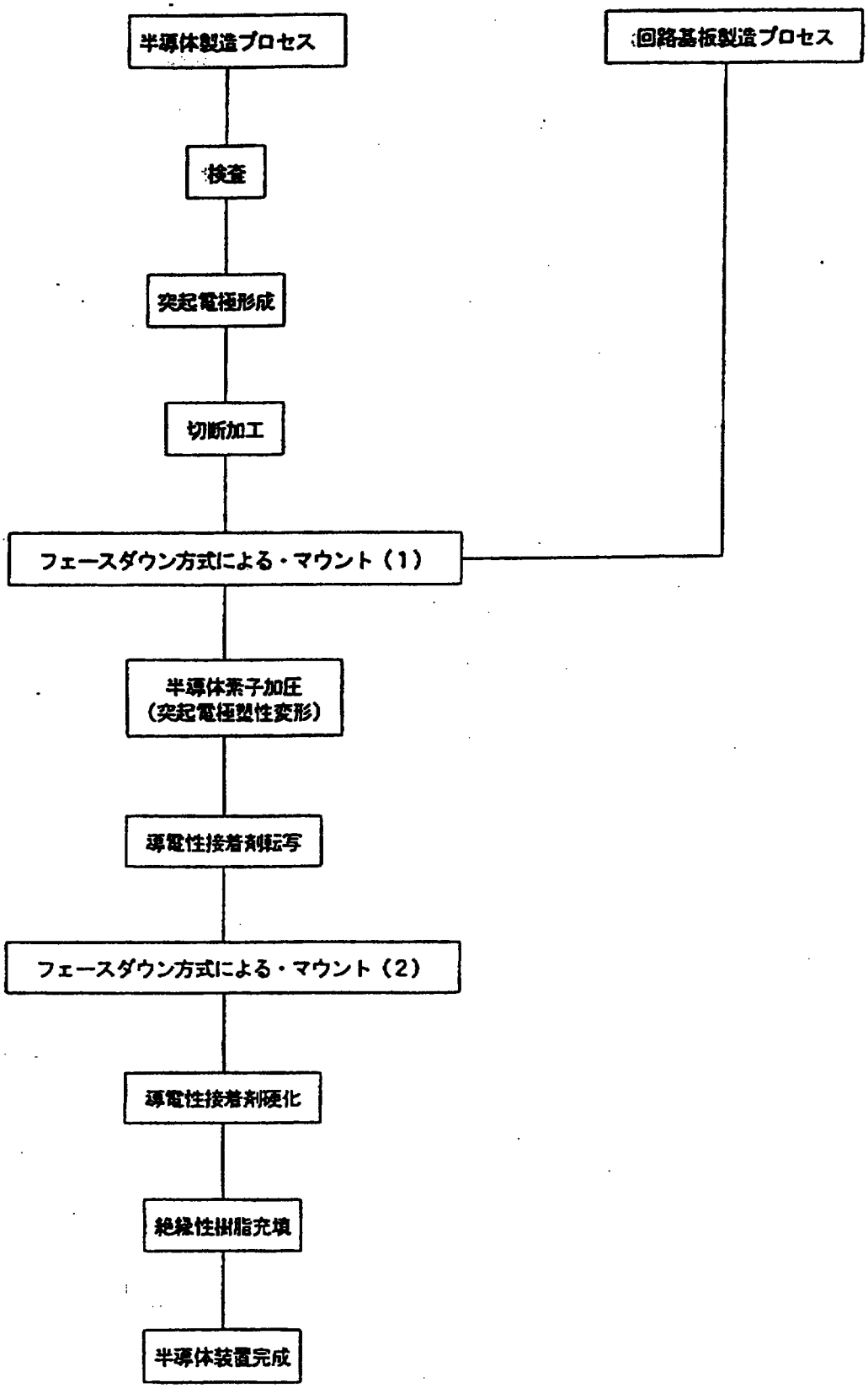

半導体製造プロセス
回路基板製造プロセス
検査
突起電極形成
切断加工
フェースダウン方式による・マウント（1）
半導体素子加圧
（突起電極塑性変形）
導電性接着剤転写
フェースダウン方式による・マウント（2）
導電性接着剤硬化
絶縁性樹脂充填
半導体装置完成

FIG. 4

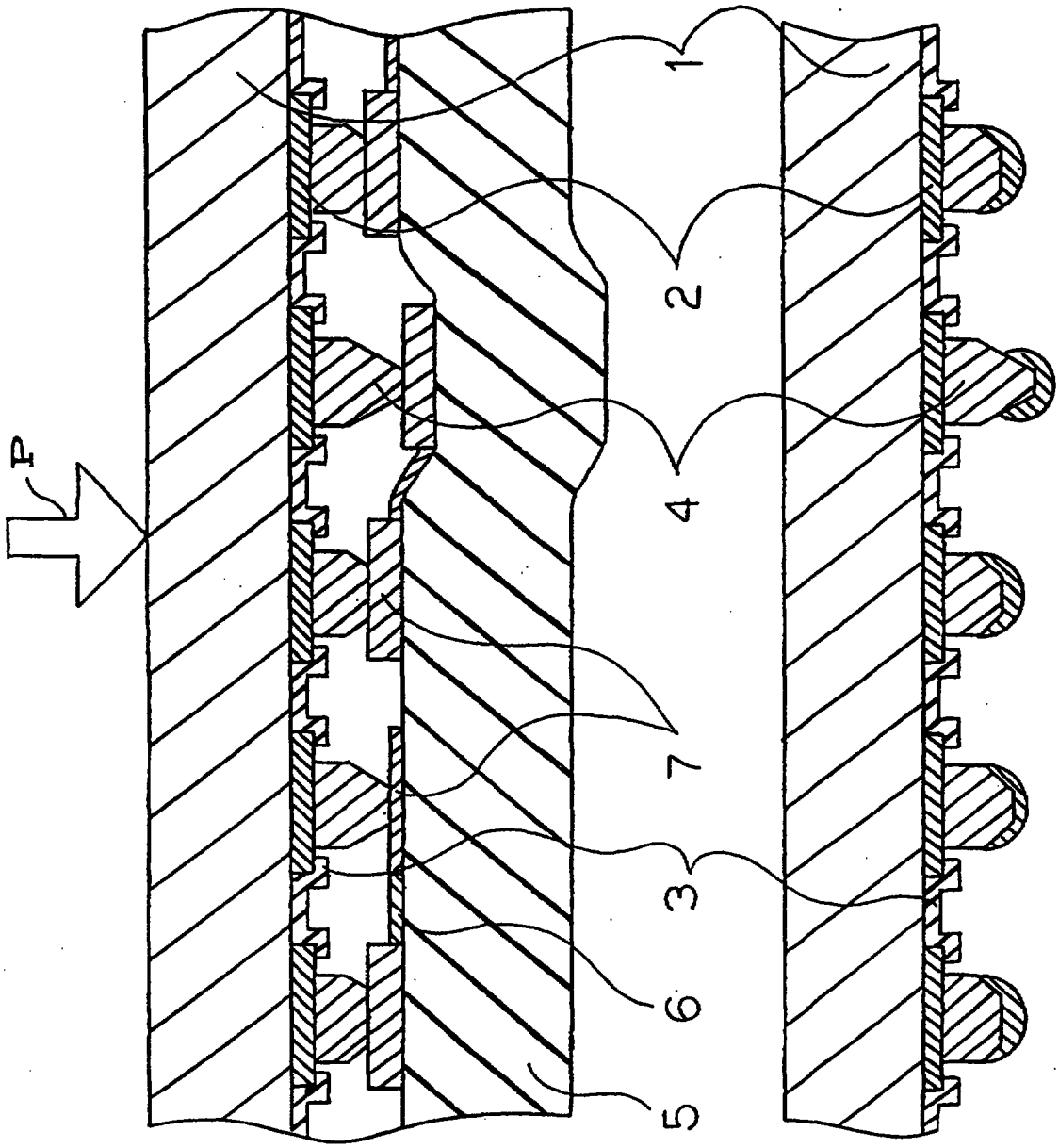


FIG. 5A FIG. 5B

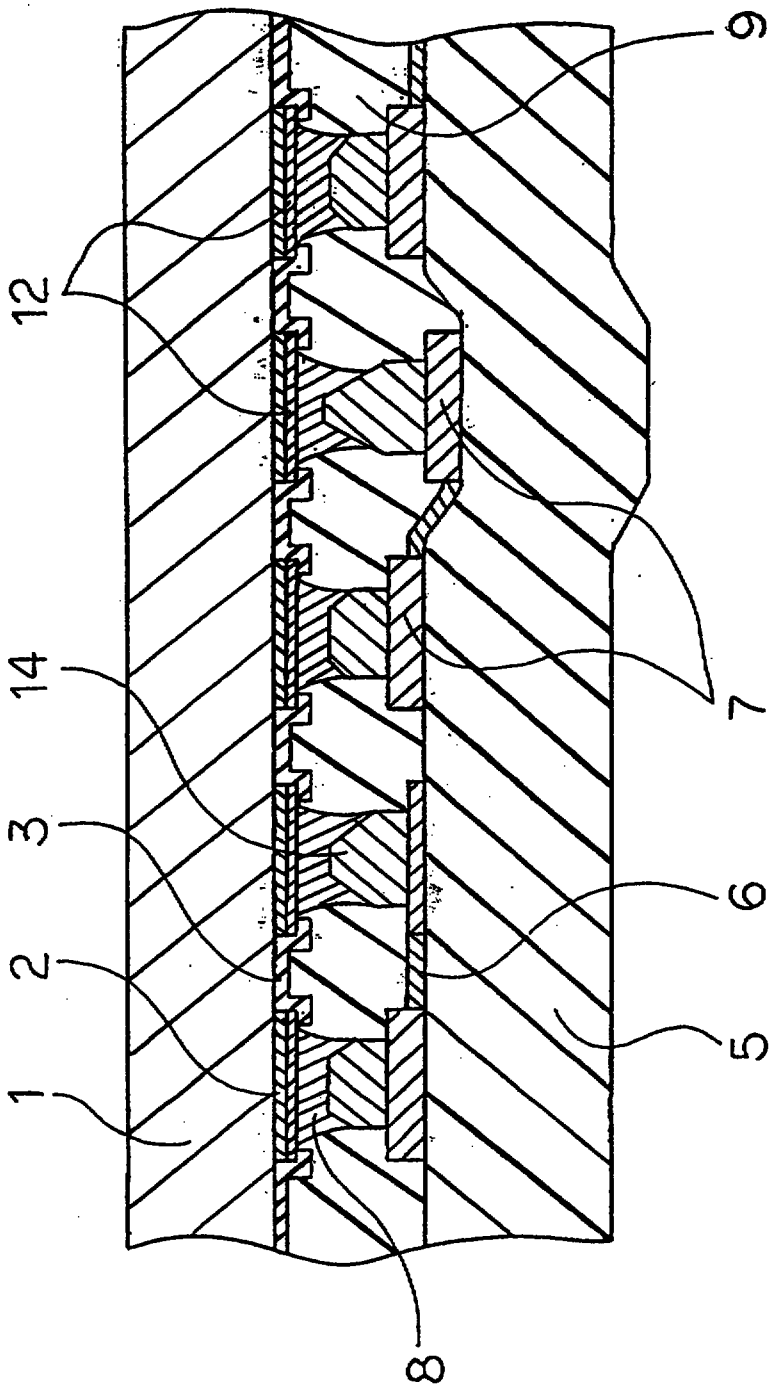


FIG. 6

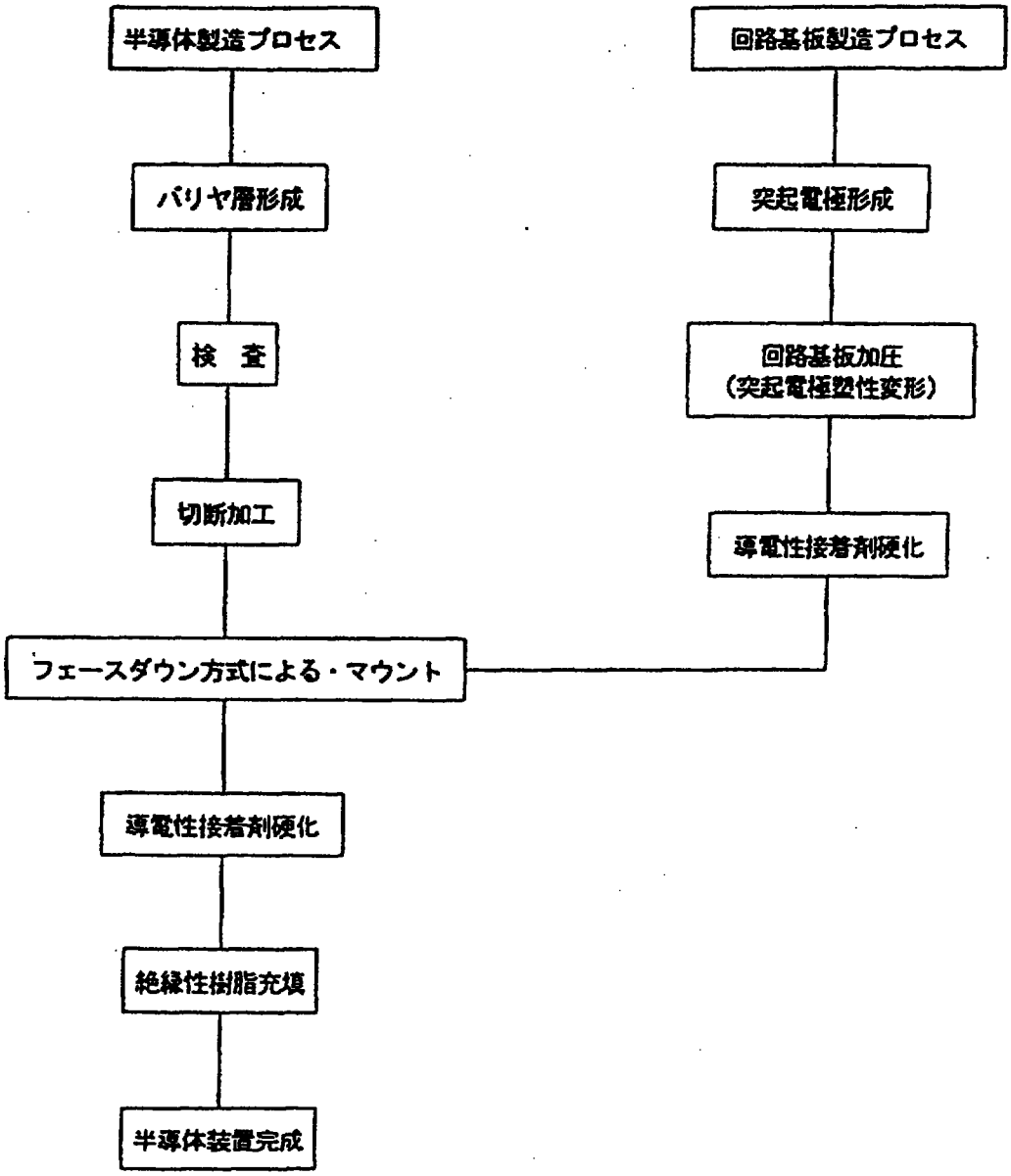

半導体製造プロセス
回路基板製造プロセス
バリヤ層形成
突起電極形成
検　査
回路基板加圧
(突起電極塑性変形)
切断加工
導電性接着剤硬化
フェースダウン方式による・マウント
導電性接着剤硬化
絶縁性樹脂充填
半導体装置完成

FIG. 7

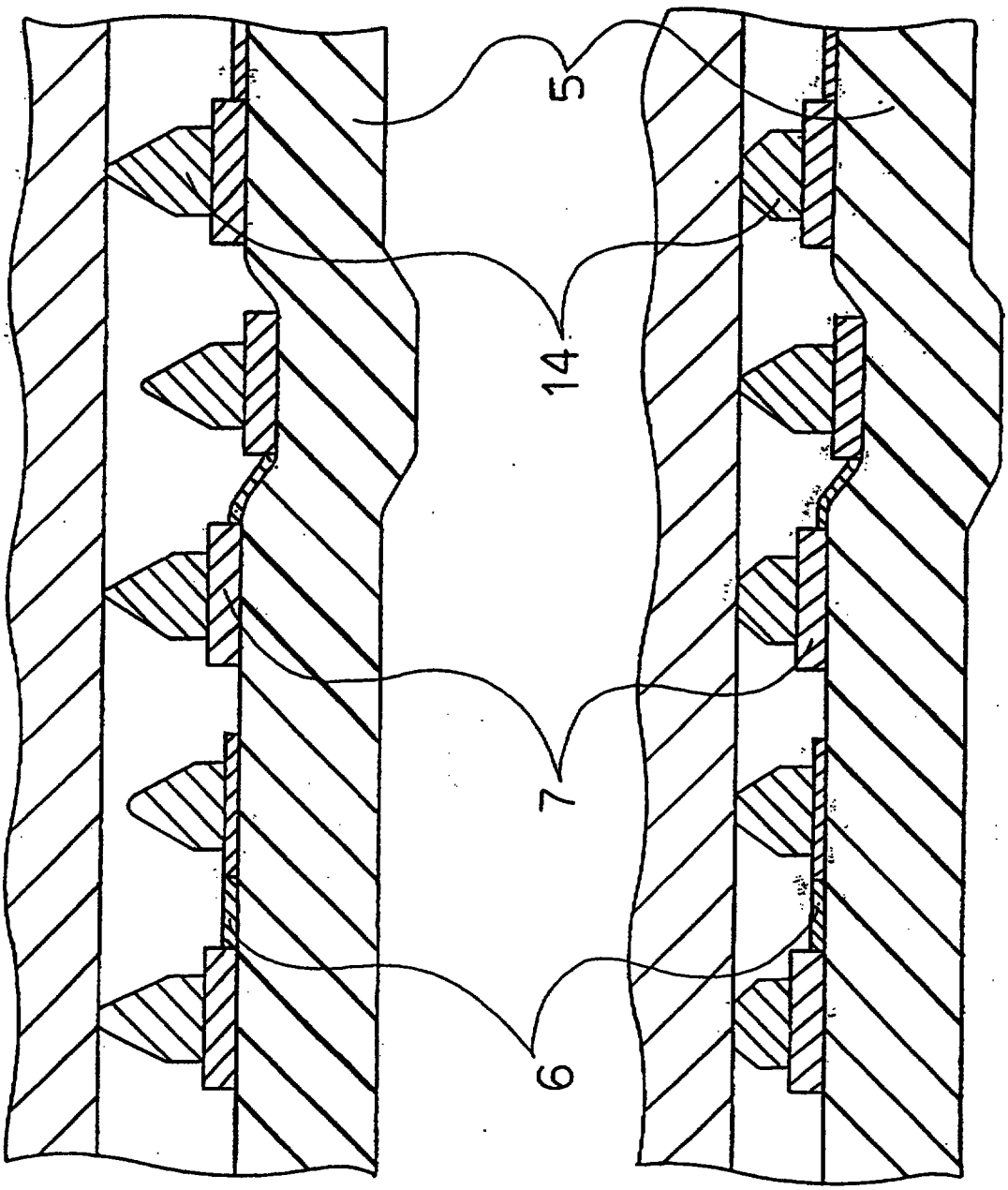


FIG. 8A

FIG. 8B

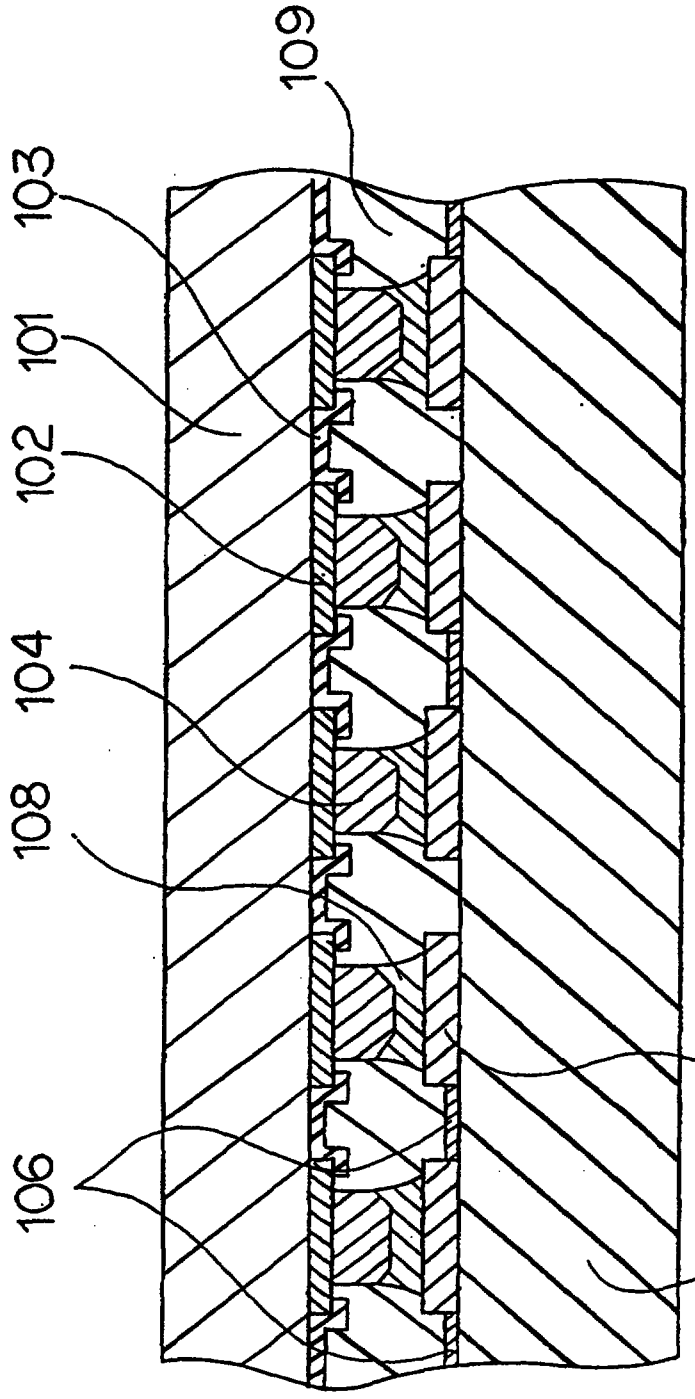


FIG. 9

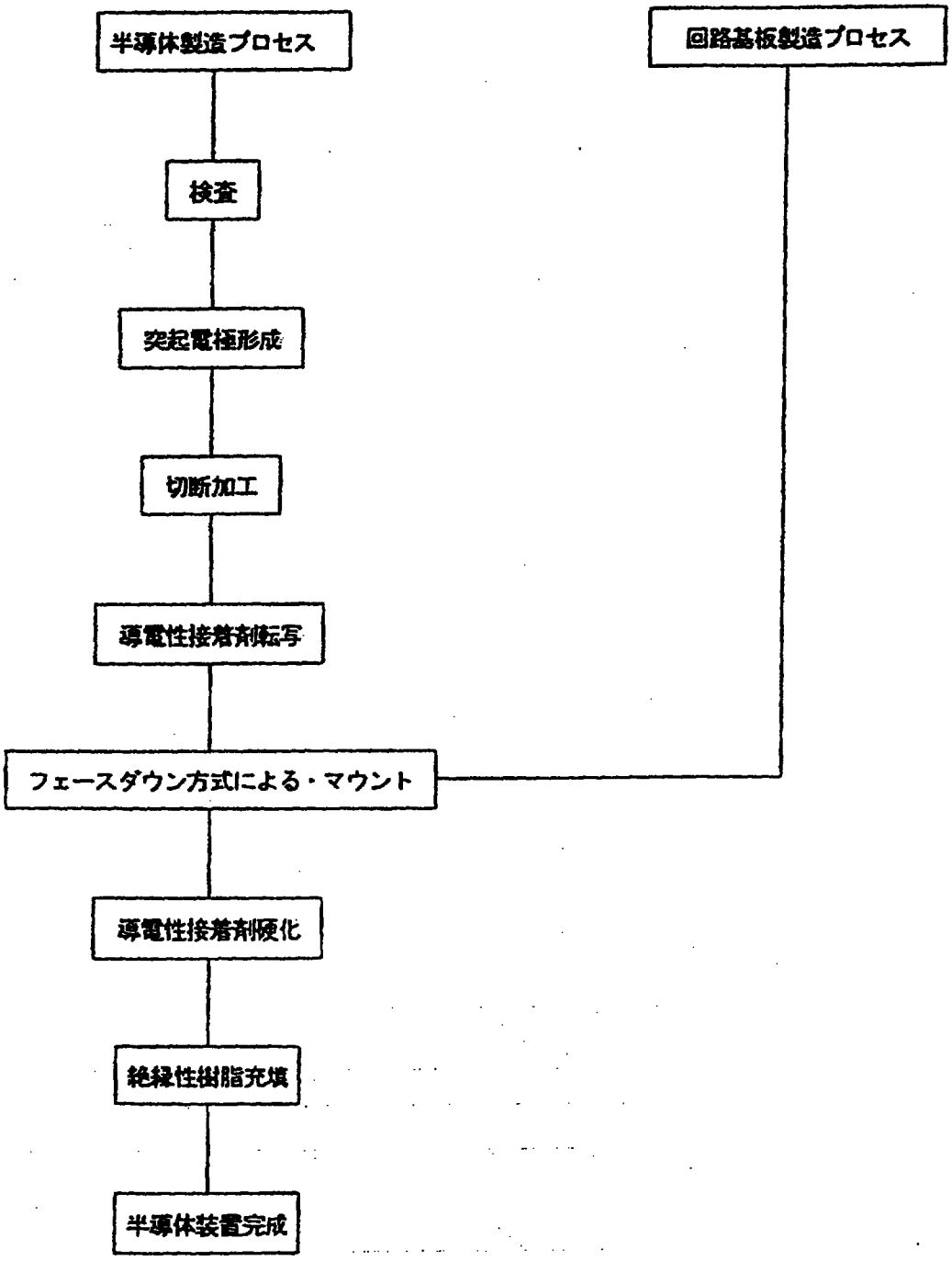

半導体製造プロセス
回路基板製造プロセス
検査
突起電極形成
切断加工
導電性接着剤転写
フェースダウン方式による・マウント
導電性接着剤硬化
絶縁性樹脂充填
半導体装置完成

FIG. 10

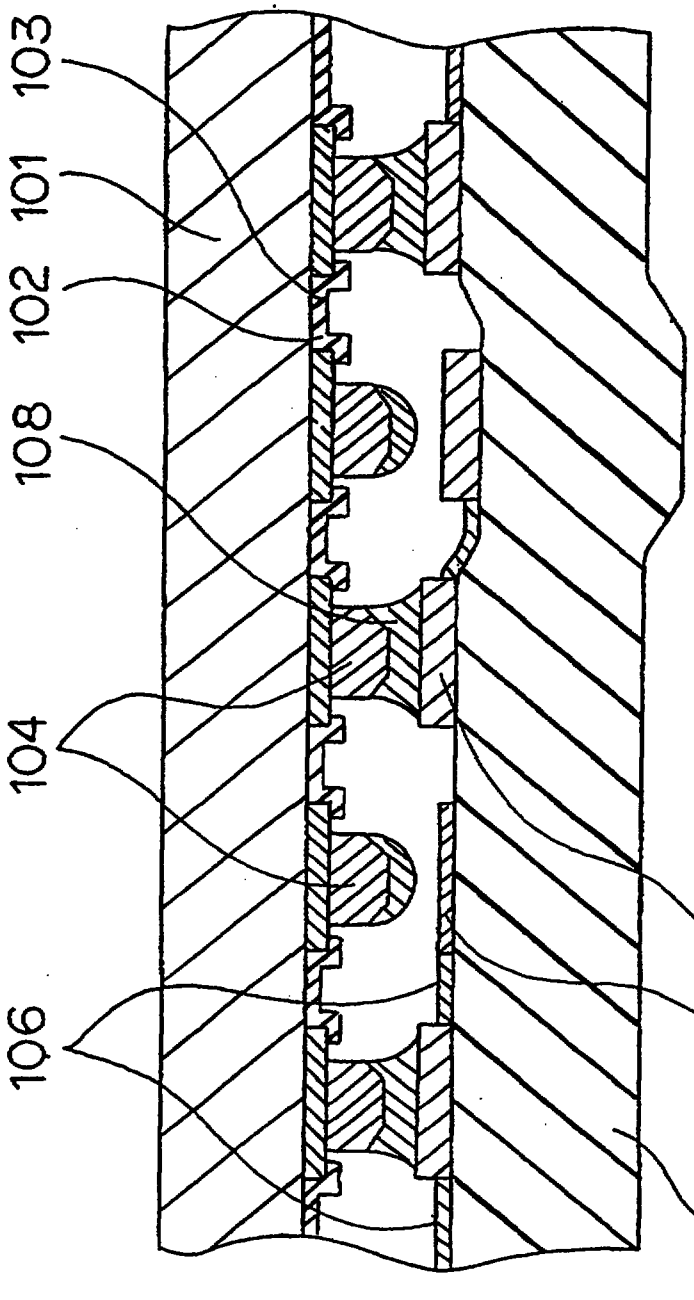


FIG. 11

DESCRIPTION

SEMICONDUCTOR APPARATUS AND METHOD FOR PRODUCING THE SAME

Technical Field

The present invention relates to a semiconductor apparatus. In particular, the present invention relates to a semiconductor apparatus in which a flip-chip packaging technique is used and a method for producing the same.

Background Art

Recently the semiconductor element has become increasingly integrated, the size of the semiconductor apparatus has become miniaturized and the pitch between the connecting terminals has become narrower. Under these circumstances, the semiconductor apparatus in which the flip-chip packaging technique is used has been developed more and more. Hereinafter, one example of semiconductor apparatus in which the flip-chip packaging technique is used will be explained, referring to the figures.

FIG. 9 is a sectional view showing a semiconductor in which the flip-chip packaging technique is used. An aluminum electrode terminal 102 is formed on the semiconductor element 101. The area of the semiconductor element other than where the aluminum electrode terminal 102 is formed is covered with an insulating film 103 composed of Si oxide film, Si nitrogen film and the like. On the aluminum electrode terminal 102, a projected electrode 104 composed of conductive metallic material such as Au or Cu and the like is formed. On the other hand, a desired circuit pattern 106 and an electrode terminal 107 are formed on the principal surface of circuit substrate 105 composed of insulating material such as resin, ceramic or glass

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and the like. The electrode terminal 107 is connected to the circuit pattern 106. In flip-chip packaging, the electrode terminal 107 connects electrically with the semiconductor element 101. A projected electrode 104 is electrically connected with the electrode terminal 107 by the conductive adhesive 108. The conductive adhesive 108 contains a powder of conductive metallic material such as Ag, Cu or Ni and the like in the resin. The insulating resin 109 is filled in the space between the semiconductor element 101 and the circuit substrate 105. When the insulating resin 109 is hardened, the semiconductor element 101 and the circuit substrate 105 are bonded by the hardening shrinkage force of the insulating resin 109, and are attracted powerfully and fixed. Consequently, the mechanical strength of connecting the semiconductor element 101 and the circuit substrate 105 of the semiconductor apparatus is enhanced and a stable fixing can be maintained.

A method for producing the conventional semiconductor apparatus as above-mentioned will be explained referring to FIG. 10, which is a flow chart showing the process of producing the semiconductor apparatus. First, a semiconductor element 101, on which a desired element, a wiring and an insulating film 103 are formed by the normal process of producing the semiconductor, is produced. Then the semiconductor wafer, on which a numerous pieces of semiconductor element 101 are formed, is produced. Then, the quality of the semiconductor element 101 is checked by electrical inspection, that is, by contacting the probe, and the projected electrode 104 is formed. After that, the semiconductor wafer is cut into individual semiconductor elements101. On the other hand, in advance, a desired circuit pattern 106 and an electrode terminal 107 are formed using conductive material such as conductive metal, e.g. Au or Cu and the like on the circuit substrate 105 which is composed of the insulating material.

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Then the semiconductor element 101 is positioned on the circuit substrate 105 with its face down via conductive adhesive 108 so that the predetermined electrode terminal 107 can be connected electrically with the projected electrode 104. After that, the conductive adhesive 108 is hardened by heat treatment and electrical inspection is conducted to confirm the acting state. After the normal acting state is confirmed, the liquid insulating resin such as epoxy-based resin is filled in the space between the semiconductor element 101 and the circuit substrate 106 by capillary action. After the insulating resin is filled in the space, the insulating resin 109 is hardened by heat treatment and the like, and accordingly the flip-chip packaging is completed.

The semiconductor apparatus in which the flip-chip packaging technique is used was produced according to the above-mentioned production processes.

However, according to the above-mentioned conventional semiconductor apparatus and the method for producing the conventional semiconductor apparatus as shown in FIG. 11, irregularity of the flatness accuracy of the surface of the circuit substrate 105 is caused by the warp, swell and the like in some parts of the circuit substrate 105. Further, there is also the irregularity of the film thickness accuracy of the electrode terminal 107. Consequently, the protruding surface of the electrode terminal 107 at the side of the circuit substrate in the region of one semiconductor element is not positioned at the horizontal surface respectively, and therefore an irregularity of the position of the protruding surface of the electrode terminal 107 at the side of the circuit substrate in the direction of height of the protruding surface is caused.

Consequently, in mounting the semiconductor element 101 with face down, the size of the space between the semiconductor element 101 and the

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circuit substrate 105 in the concave portion of the circuit substrate 107 is larger than that of other parts of the circuit substrate 107. As a result, the conductive adhesive 108 can not reach to the protruding surface of the electrode terminal 107 positioned in the concave portion of the circuit substrate. Consequently, the electrical connection failure is caused.

Disclosure of Invention

It is an object of the present invention to provide a semiconductor apparatus which is stable in quality and has good productivity, and a method for producing the same by connecting electrically the semiconductor element and the circuit substrate more reliably.

In order to achieve the above-mentioned objects, in the semiconductor apparatus of this invention, the flip-chip packaging technique is used for connecting electrically a semiconductor element and a circuit substrate via a projected electrode composed of conductive metallic material formed on an electrode terminal, which is formed on the surface of the semiconductor element where the element is formed, a conductive adhesive and an electrode terminal on the circuit substrate, wherein the individual projected electrode is deformed plastically in the direction of the height so that the distance between a protruding surface of an individual projected electrode and an opposing surface of the individual electrode terminal via the conductive adhesive is unified.

According to the semiconductor apparatus in this invention, the height of the projected electrode is processed appropriately so that the distance between the protruding surface of the individual projected electrode and the opposing surface of the individual electrode terminal via the conductive adhesive is uniform. Consequently, the semiconductor element can be connected electrically with the circuit substrate reliably.

It is preferable that in the semiconductor apparatus, the material of

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the projected electrode is at least one metallic material selected from the group consisting of Au and Cu.

Furthermore, it is preferable that the distance between the protruding surface of the individual projected electrode and the opposing surface of the individual electrode terminal via the conductive adhesive is in a range of 1 μm to 10 μm.

Furthermore, it is preferable that the flip-chip packaging technique is used for connecting the semiconductor element and the circuit substrate via the electrode terminal formed on the semiconductor element where the element is formed, the conductive adhesive and the projected electrode composed of the conductive metallic material formed on the electrode terminal on the circuit substrate.

In the preferred semiconductor apparatus in which the projected electrode is formed at the side of the circuit substrate, it is preferable that a barrier layer composed of conductive metallic laminated film is formed on the electrode terminal on the semiconductor element where the element is formed.

According to the preferred semiconductor apparatus on which the barrier layer is formed, the corrosion of the electrode terminal formed on the semiconductor element where the element is formed can be prevented.

In the semiconductor apparatus, it is preferable that the height of the projection of the projected electrode is substantially uniform.

In the semiconductor apparatus whose height of the projection of the projected electrode is substantially uniform, it is preferable that the height of the protruding surface of the individual projected electrode is unified by pushing the projected electrode on a flat surface of a hard material before the projected electrode is bonded with conductive adhesive.

In the semiconductor apparatus in which the height of the protruding

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surface of the individual projected electrode is unified by pushing the projected electrode on the flat surface of the hard material, it is preferable that the pressure on the protruding surface of the projected electrode which is caused by pushing on the flat surface of the hard material is in a range of 1.5×10^8 to 5.0×10^8 N/m^2.

Furthermore, it is preferable that the variation in flatness of the hard material is 4 μm or less over a distance of 20mm.

According to a first aspect of the method for producing the semiconductor apparatus, a projected electrode is formed on the semiconductor element where the element is formed, a conductive adhesive is transferred on the vertex of the projected electrode and the semiconductor element is pressured from the back when the semiconductor element is mounted on the circuit substrate with its face down. According to that, the projected electrode formed on the semiconductor element is deformed plastically to unify the distance between the protruding surface of the individual projected electrode formed on the semiconductor element and the opposing surface of the individual electrode terminal at the side of the circuit substrate.

According to the first aspect of the method for producing the semiconductor apparatus, the height of the projected electrode can be processed appropriately so that the distance between the protruding surface of the individual projected electrode and the opposing surface of the individual electrode terminal via the conductive adhesive can be unified. As a result, the semiconductor apparatus with high reliability can be produced easily and at a low cost.

In the first aspect of the method for producing the semiconductor apparatus, it is preferable that the pressure on the protruding surface of the projected electrode caused by pushing the semiconductor element from the

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back is in a range of 1.5×10^8 to 5.0×10^8 N/m^2.

Furthermore, it is preferable that after the projected electrode formed on the semiconductor element is deformed plastically, the conductive adhesive is transferred to the vertex of the individual projected electrode formed on the semiconductor element and the semiconductor element is mounted on the circuit substrate with face down again.

In the method for producing the preferred semiconductor apparatus in which the projected electrode is deformed plastically, and then the semiconductor element is mounted on the circuit substrate again, the semiconductor element is not pressured substantially when the semiconductor element is mounted on the circuit substrate its with face down. Therefore the shift of the position of the semiconductor element and the circuit substrate can be prevented.

According to a second aspect of the method for producing the semiconductor apparatus, after a projected electrode is formed on the electrode terminal formed on the circuit substrate, the height of the protruding surface of the individual projected electrode is unified by pushing the projected electrode to the flat surface of the hard material, the conductive adhesive is transferred to the vertex of the individual projected electrode and the semiconductor element is mounted on the circuit substrate with its face down.

According to the second aspect of the method for producing the semiconductor apparatus, a step of pressuring the semiconductor element is not present. Therefore the damage inflicted on the semiconductor element can be decreased.

In the second aspect of the method for producing the semiconductor apparatus, it is preferable that the pressure which is caused by pushing the projected electrode to the flat surface of the hard material to apply to the

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protruding surface of the projected electrode is in a range of 1.5×10^8 to 5.0×10^8 N/m^2.

Furthermore, it is preferable that the variation in flatness of the hard material is 4 μm or less over a distance of 20mm.

Brief Description of Drawings

FIG. 1 is a sectional view showing a semiconductor apparatus in Example 1 of this invention.

FIG. 2 is a flow chart showing the process of producing the semiconductor apparatus in Example 1.

FIG. 3A is a sectional view showing a semiconductor apparatus in the step of transferring conductive adhesive in the process of producing a semiconductor apparatus shown in FIG. 2.

FIG. 3B is a sectional view showing a semiconductor apparatus in the step of mounting and that of pressuring the semiconductor element.

FIG. 4 is a flow chart showing a process of producing the semiconductor apparatus in Example 2.

FIG. 5A is a sectional view showing a semiconductor apparatus in the step of mounting and the step of pressuring the semiconductor element in the process of producing a semiconductor apparatus shown in FIG. 4.

FIG. 5B is a sectional view showing a semiconductor apparatus in the step of transferring the conductive adhesive.

FIG. 6 is a sectional view showing a semiconductor apparatus in Example 3.

FIG. 7 is a flow chart showing the process of producing the semiconductor apparatus in Example 3.

FIG. 8A is a sectional view showing a semiconductor apparatus prior to pressuring the circuit substrate in the step of pressuring the circuit substrate shown in FIG. 7.

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FIG. 8B is a sectional view showing a semiconductor after the circuit substrate is pressured.

FIG. 9 is a sectional view showing one example of semiconductor apparatus in which conventional flip-chip packaging technique is used.

FIG. 10 is a flow chart showing a process of producing a semiconductor apparatus in which the conventional flip-chip packaging technique is used.

FIG. 11 is a sectional view showing one example of conventional semiconductor apparatus.

Best Mode for Carrying Out the Invention

Hereinafter, an example of a semiconductor apparatus of this invention and a method for producing the same will be explained referring to figures.

(Example 1)

FIG. 1 is a sectional view showing a semiconductor apparatus in Example 1 of this invention. As shown in FIG. 1, an aluminum electrode terminal 2 is formed on the surface of semiconductor element 1 where the element is formed. The area of the semiconductor element 1 other than where the aluminum electrode terminal 2 is formed is covered with an insulating film 3 composed of Si oxide film, Si nitrogen film and the like.

On the aluminum electrode terminal 2, a projected electrode 4 composed of conductive metallic material such as Au or Cu and the like is formed. On the other hand, a desired circuit pattern 6 and an electrode terminal 7 are formed on a circuit substrate 5 composed of insulating material such as resin, ceramic or glass and the like. The electrode terminal 7 is connected to the circuit pattern 6. In flip-chip packaging, the electrode terminal 7 connects electrically with the semiconductor element 1. A conductive adhesive 8 contains the powder of conductive metallic material

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such as Ag, Cu or Ni and the like in the resin. The insulating resin 9 is filled in the space between the semiconductor element 1 and the circuit substrate 5.

When the insulating resin 9 is hardened, the semiconductor element 1 and the circuit substrate 5 are bonded by the hardening shrinkage force of the insulating resin 9, and are attracted powerfully and fixed. Consequently, the mechanical strength of connecting the semiconductor element 1 and the circuit substrate 5 of the semiconductor apparatus is enhanced and the stable fixing can be maintained.

As shown in FIG. 1, the height of the projected electrode 4 is processed according to the height of the respective electrode terminals 7 formed on the circuit substrate 5. That is, there is the irregularity of the flat accuracy of the principal surface of the circuit substrate 5 and the film thickness accuracy of the electrode terminal 7. Consequently, the irregularity of the position of the electrode terminal 7 in the direction of height of the protruding surface is caused. The height of the projected electrode 4 is lowered by plastic deformation in accordance with the irregularity respectively. In this case, the irregularity of the height of the projected electrode 4 which is pre-deformed plastically is smaller than that of the position of the electrode terminal 7 in the direction of height of the protruding surface, and the height is constant substantially. Consequently, the amount of the change of the height of the projected electrode 4 caused by plastic deformation is different based on the position of the electrode terminal 7 in the direction of height of the protruding surface. Concretely, when the distance between the protruding surface of the electrode terminal 7 and the semiconductor element 1 is shorter, the amount of change of height of the projected electrode 4 becomes larger.

As a result, the distance between protruding surface of the projected

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electrode 4 formed at the side of the semiconductor element 1 and the surface of the electrode terminal 7 formed at the side of the circuit substrate 5 becomes uniform. It is preferable that the distance is in a range of 1 μm to 10 μm. It is more preferable that the distance is about 5 μm. Consequently, the junction layer composed of conductive adhesive 8 which is transferred on the vertex of the projected electrode 4 reliably reaches the surface of the electrode terminal 7 at the side of the circuit substrate 5 and as a result, the electrical connecting failure can be prevented.

Next, a method for producing the semiconductor apparatus in Example 1 will be explained referring to FIGs.2 and 3. FIG. 2 is a flow chart showing the process of producing the semiconductor apparatus in Example 1. As shown in FIG. 2, in the same way as that of conventional process, a semiconductor element 1 is formed on the surface where the element is formed. Then, a projected electrode 4 composed of Au is formed on the surface of the aluminum electrode terminal 2 by a ball bonding technique and the semiconductor wafer is cut into individual semiconductor elements 1. After that, the required amount of conductive adhesive 8 is transferred only to the vertex of the projected electrode 4, and the projected electrode 4 is positioned on the predetermined part of the circuit substrate 5 on which a desired circuit pattern 6 and an electrode terminal 7 are formed in advance. The projected electrode 4 is pressured from the back of the semiconductor element 1 to cause plastic deformation of the projected electrode 4 and the process to make the height of the projected electrode 4 appropriate is conducted. Finally, after the conductive adhesive 8 is hardened by heat treatment, the normal action is confirmed by the electrical inspection, the liquid epoxy based insulating resin 9 is filled in the space between the semiconductor element 1 and the circuit substrate 6 and is hardened. As a result, a semiconductor apparatus is produced.

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FIG. 3 is a figure showing a step of transferring conductive adhesive and that of pressuring the semiconductor element in the process of producing a semiconductor apparatus as shown in FIG. 2. The reference number used in FIG. 3 is the same as that used in FIG. 1. FIG. 3A is a sectional view showing a semiconductor apparatus in the step of transferring conductive adhesive in the process of producing a semiconductor apparatus. FIG. 3B is a sectional view showing a semiconductor apparatus in the step of mounting and that of pressuring the semiconductor element. As shown in FIG. 3A, the required amount of conductive adhesive 8 is transferred only to the vertex of the projected electrode 4. As shown in FIG. 3B, the semiconductor element 1 is positioned at the predetermined part of the circuit substrate 5 with its face down, and the pressure P is applied from the back of the semiconductor element 1 to cause plastic deformation of the projected electrode 4. The process is continued to make the height of the projected electrode 4 appropriate. Accordingly, the step of mounting with face down method is completed. It is preferable that the pressure applied from the back of the semiconductor element 1 is in a range of 1.5×10^8 to 5.0×10^8 N/m^2. When a pressure in the above-mentioned range is applied, the distance between the protruding surface of the projected electrode 4 and the surface of the electrode terminal surface 7 can be unified in a range of 1 μm to 10 μm.

Furthermore, a projected electrode 4 may be formed by the transferring bump technique in which the surface of the aluminum electrode terminal 2 is pushed by the block of the conductive metallic material such as Au or Cu and the like which is produced in advance, and then, pressure, heat or ultrasonic vibration is applied to attach the block of the conductive metallic material to the surface of the aluminum electrode terminal 2.

Furthermore, a projected electrode 4 may be formed by depositing the

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conductive metallic material on the aluminum electrode terminal 2 by electroless plating or electrolytic plating.

As above-mentioned, according to the method for producing the semiconductor apparatus in Example 1, the step of pressuring the projected electrode and that of mounting the semiconductor element can be conducted at the same time. As a result, in comparison with the conventional process of producing the semiconductor apparatus, the step also can be simplified.

(Example 2)

A method for producing the semiconductor apparatus in Example 2 will be explained referring to FIGs. 4 and 5. FIG. 4 is a flow chart showing a process of producing the semiconductor apparatus in Example 2. In a method for producing the semiconductor apparatus in Example 1, the semiconductor element to which the conductive adhesive is transferred in advance is positioned on the circuit substrate with its face down. After that, the step of deforming the projected electrode plastically and that of mounting were conducted at the same time by applying the pressure.

However, according to a method for producing the semiconductor apparatus in Example 2, a semiconductor element which is positioned in advance on the circuit substrate with surface down is pressured to cause plastic deformation of the projected electrode. Then, the semiconductor element is once detached from the circuit substrate, the conductive adhesive is transferred and the semiconductor element is mounted with its face down again.

FIG. 5 is a figure explaining from a step of mounting with its face down (1) to a step of transferring the conductive adhesive in the producing process as shown in FIG. 4. The reference number used in FIG. 5 is same as that used in FIG. 1. FIG. 5A is a sectional view showing a semiconductor apparatus from a step of mounting to a step of pressuring the semiconductor

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element in the process of producing a semiconductor apparatus as shown in FIG.4. FIG. 5B is a sectional view showing a semiconductor apparatus in the step of transferring the conductive adhesive.

As shown in FIG. 5A, the semiconductor element 1 is positioned at the predetermined part of the circuit substrate 5 with its face down and the pressure P is applied to the back of the semiconductor element 1. Consequently, the appropriate plastic deformation of the projected electrode 4 is conducted.

Next, the semiconductor element 1 is once detached from the circuit substrate 5, as shown in FIG. 5B, and the required amount of the conductive adhesive is transferred only to the vertex of the projected electrode 4. After that, the semiconductor element 1 is mounted again on the predetermined part of the circuit substrate 5 with its face down. As above-mentioned, the semiconductor apparatus having the constitution which is substantially uniform like that shown in FIG. 1 can be produced.

According to the method for producing the semiconductor apparatus in Example 1, when the semiconductor element is mounted, the pressure is applied. As a result, the position of the semiconductor element and the circuit substrate may be shifted from that of the predetermined position of the semiconductor element and the circuit substrate. On the other hand, according to the method for producing the semiconductor apparatus in Example 2, when the semiconductor element is mounted, the pressure is hardly applied to the semiconductor element at all. Therefore the possibility that the position of the semiconductor element and the circuit substrate is shifted from that of the predetermined position of the semiconductor element and the circuit substrate is small. Consequently, the method for producing the semiconductor apparatus in Example 2 is suitable for producing the semiconductor apparatus requiring mounting

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accuracy such as minute pitch connecting construction.

(Example 3)

A method for producing the semiconductor apparatus in Example 3 will be explained referring to FIGs. 6,7 and 8. FIG. 6 is a sectional view showing a semiconductor apparatus in Example 3. In FIG. 6, 12 indicates a barrier layer composed of Cr or Au formed on the surface of the aluminum electrode and 14 indicates a projected electrode formed on the electrode terminal at the side of the circuit substrate. The other elements are the same as those of FIG. 1.

Unlike the semiconductor apparatus of Example 1 shown in FIG. 1, in the semiconductor apparatus of Example 3, a barrier layer 12 is formed because the aluminum may be corroded when a conductive adhesive is contacted directly with the surface of the aluminum electrode terminal 2. Further, in the semiconductor apparatus of Example 3, a projected electrode 14 composed of conductive metallic material such as Au or Cu and the like is formed on the surface of the electrode terminal 7 at the side of the circuit substrate 5.

As shown in FIG. 6, the height of the projected electrode 14 is processed according to the position in the direction of the height of the electrode terminal 7 formed on the circuit substrate 5 respectively in the same way as the semiconductor apparatus of Example 1 was produced. That is, there is the irregularity of the flat accuracy of the principal surface of the circuit substrate 5 and the film thickness accuracy of the electrode terminal 7. Consequently, the irregularity of the position of the electrode terminal 7 in the direction of the height of the protruding surface is caused. The height of the projected electrode 14 is lowered by plastic deformation in accordance with the irregularity respectively. In this case, the irregularity of the height of the projected electrode 14 which is pre-deformed plastically is

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smaller than that of the position of the electrode terminal 7 in the direction of height of the protruding surface, and the height is constant substantially. Consequently, the amount of the change of the height of the projected electrode 14 caused by plastic deformation is different based on the position in the direction of the height of the electrode terminal 7 in the direction of the protruding surface. Concretely, when the distance between the protruding surface of the electrode terminal 7 and the semiconductor element 1 is shorter, the amount of change of height of the projected electrode 14 becomes larger.

As a result, the distance between the surface of the barrier layer 12 at the side of the semiconductor element 1 and the protruding surface of the projected electrode 14 becomes uniform. It is preferable that the distance is in a range of 1 μm to 10 μm in the same way as Example 1. It is more preferable that the distance is about 5 μm. Consequently, the junction layer composed of conductive adhesive 8 which is transferred on the vertex of the projected electrode 14 reaches reliably the surface of the barrier layer 12 at the side of the semiconductor element 1 and as a result, the electrical connecting failure can be prevented.

Next, a method for producing the semiconductor apparatus in Example 3 will be explained referring to FIGs.7 and 8. FIG. 7 is a flow chart showing the process of producing the semiconductor apparatus in Example 3. As shown in FIG. 7, an element is formed on the surface of semiconductor element 1 and after that a barrier layer 12 is formed by layering Cr and Au on the surface of the aluminum electrode terminal 2 with a plating technique. Then, the inspection is conducted and the semiconductor wafer is cut into individual semiconductor elements 1.

On the other hand, a desired circuit pattern 6 and an electrode terminal 7 are formed on the principal surface of the circuit substrate 5 and

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after that a projected electrode 14 composed of Au is formed on the surface of the electrode terminal 7 with a ball bonding technique.

Then, the projected electrode 14 is pushed onto the flat plate having a desired flatness accuracy and composed of hard material. Consequently, the appropriate plastic deformation of the projected electrode 14 is conducted and the height of the protruding surface of the projected electrode 14 becomes uniform respectively. After that, the required amount of the conductive adhesive paste 8 is transferred only to the vertex of the projected electrode 14, the semiconductor element 1 is mounted on the predetermined part of the circuit substrate 5 with its face down, heat treatment is applied to the conductive adhesive 8 to be hardened, electrical inspection is carried out to confirm the normal action, and finally the space between the semiconductor element 1 and the circuit substrate 6 is filled with insulating resin 9 such as liquid epoxy based resin. According to the above-mentioned steps, the semiconductor apparatus is produced.

FIG. 8 is a figure explaining from a step of pressuring the circuit substrate to a step of transferring the conductive adhesive in the process of producing a semiconductor apparatus as shown in FIG. 7. The reference number used in FIG. 7 is same as that used in FIG. 6. FIG. 8A is a sectional view showing a semiconductor apparatus prior to pressuring the circuit substrate. FIG. 8B is a sectional view showing a semiconductor after the circuit substrate is pressured. As shown in FIG. 8A, the projected electrode 14 which is formed on the principal surface of the circuit substrate 5 is pushed to the flat plate having a desired flat accuracy and composed of hard material. Consequently, the appropriate plastic deformation of the projected electrode 14 is conducted and the height of the protruding surface of the projected electrode 14 is unified. It is preferable that the variation in flatness of the above-mentioned hard material is 4 μm or less over a distance

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of 20mm. It is preferable that the pressure which is applied to the flat plate composed of hard material is in a range of 1.5×10^8 to 5.0×10^8 N/m^2 at the protruding surface of the projected electrode 4. Then, as shown in FIG. 8B, the conductive adhesive 8 paste is transferred only to the vertex of the projected electrode 14 and the semiconductor element 1 is mounted.

Furthermore, a projected electrode 14 may be formed by the transferring bump technique in which the surface of the electrode terminal 7 is pushed by the block of the conductive metallic material such as Au or Cu and the like which is produced in advance, and then, pressure, heat or ultrasonic vibration is applied to attach the block of the conductive metallic material to the surface of the electrode terminal 7.

Furthermore, a projected electrode 14 may be formed by depositing the conductive metallic material on the electrode terminal 7 by electroless plating or electrolytic plating.

Furthermore, a technique of forming a thick film using paste may be used. Regarding the barrier layer 12, a material other than Cr-Au film may be used.

Furthermore, in a case when an aluminum electrode terminal 2 is composed of material except for aluminum which is not corroded easily such as Au or Pt and the like, the barrier layer is not required to be formed.

As above-mentioned, according to the method for producing the semiconductor apparatus in Example 3, the step of pressuring the semiconductor element can be omitted, therefore the damage which is inflicted on the semiconductor element is reduced. In particular, when the semiconductor element is produced by using the brittle material such as compound semiconductor, Ga-As, the method for producing semiconductor apparatus in Example 3 is very effective.

As above-mentioned, according to the semiconductor apparatus of

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this invention, the height of the projected electrode is processed appropriately to unify the distance between the protruding surface of the projected electrode and the opposing surface of the individual electrode via the above-mentioned conductive adhesive respectively. Consequently, the electrical connection between the semiconductor element and the circuit substrate can be made reliably.

Further, according to the method for producing the semiconductor apparatus of this invention, the height of the projected electrode can be processed appropriately to unify the distance between the protruding surface of the projected electrode and the opposing surface of the individual electrode terminal via conductive adhesive respectively by applying the pressure to the back of the semiconductor element. Consequently, a semiconductor apparatus in which the semiconductor element and the circuit substrate are electrically connected reliably can be produced easily and at a low cost.

Industrial Applicability

As above-mentioned, the semiconductor element and the circuit substrate are electrically connected reliably in the semiconductor apparatus of this invention, the semiconductor apparatus of this invention can be used as a semiconductor apparatus in which the semiconductor element and the circuit substrate are electrically connected.

Further, according to a method for producing the semiconductor apparatus of this invention, each projected electrode can be deformed plastically and the semiconductor element and circuit substrate can be electrically connected reliably. Consequently, the method for producing the semiconductor apparatus of this invention can be utilized as a method for producing a semiconductor apparatus in which a flip-chip packaging technique is used.

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CLAIMS

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1. A semiconductor apparatus in which a flip-chip packaging technique is used for connecting electrically a semiconductor element and a circuit substrate via a projected electrode composed of conductive metallic material formed on an electrode terminal which is formed on the surface of said semiconductor element where the element is formed, a conductive adhesive and an electrode terminal on said circuit substrate, wherein said individual projected electrode is deformed plastically in the direction of height so that the distance between a protruding surface of said individual projected electrode and an opposing surface of said individual electrode terminal via said conductive adhesive is unified.

2. The semiconductor apparatus according to Claim 1 wherein the material of said projected electrode is at least one metallic material selected from the group consisting of Au and Cu.

3. The semiconductor apparatus according to Claim 1 wherein a distance between the protruding surface of said individual projected electrode and the opposing surface of the individual electrode terminal via said conductive adhesive is in a range of 1 μm to 10 μm.

4. The semiconductor apparatus according to Claim 1 wherein the flip-chip packaging technique is used for connecting electrically said semiconductor element and said circuit substrate via said electrode terminal formed on the surface of said semiconductor element where the element is formed, said conductive adhesive and said projected electrode composed of the conductive metallic material formed on said electrode terminal on said circuit substrate.

5. The semiconductor apparatus according to Claim 4 wherein a barrier layer composed of conductive metallic laminated film is formed on



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said electrode terminal on the surface of said semiconductor element where the element is formed.

6. The semiconductor apparatus according to Claim 1 wherein the height of projection of said projected electrode is substantially uniform.

7. The semiconductor apparatus according to Claim 6 wherein the height of the protruding surface of said individual projected electrode is unified by pushing said projected electrode on a flat surface of a hard material before said projected electrode is bonded with conductive adhesive.

8. The hando-souchi according to Claim 7 wherein the pressure on said protruding surface of said projected electrode which is caused by pushing on the flat surface of said hard material is in a range of 1.5×10^8 to 5.0×10^8 N/m^2.

9. The hando-souchi according to Claim 7 wherein the variation in flatness of said hard material is 4 μm or less over a distance of 20mm.

10. A method for producing a semiconductor apparatus, comprising the steps of forming a projected electrode on a surface of a semiconductor element where the element is formed, transferring a conductive adhesive to the vertex of said projected electrode and mounting said semiconductor element on a circuit substrate with its face down, wherein said semiconductor element is pushed from the back in said step of mounting so that the projected electrode formed on said semiconductor element is deformed plastically to unify the distance between the protruding surface of said individual projected electrode formed on said semiconductor element and the opposing surface of the individual electrode terminal at the side of said circuit substrate.

11. The method for producing a hando-souchi according to Claim 10, wherein the pressure on the protruding surface of said projected



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electrode, which is caused by pushing said semiconductor element from the back, is in a range of 1.5×10^8 to 5.0×10^8 N/m^2.

12. The method for producing a semiconductor apparatus according to Claim 10, wherein the projected electrode on the semiconductor element is deformed plastically, the conductive adhesive is transferred to the vertex of the individual projected electrode on said semiconductor element and said semiconductor element is mounted on said circuit substrate with its face down again.

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ABSTRACT

This invention provides a semiconductor apparatus in which the height of the projected electrode (4) formed on the semiconductor element (1) is deformed plastically so as to unify the distance of the protruding surface of the projected electrode (4) and the surface of the electrode terminal (7) at the side of the circuit substrate (5), and the semiconductor element and the circuit substrate are connected electrically with reliability. This invention also provides a method for producing the semiconductor apparatus. After the semiconductor element (1) is positioned on the predetermined part of the circuit substrate (5), the projected electrode (4) is deformed plastically by pushing the semiconductor element (1) from the back and the height of the projected electrode (4) is processed appropriately. According to the method for producing the semiconductor apparatus, even if there is irregularity of the height of the surface of the electrode terminal (7) formed on the circuit substrate (5) which connects with the semiconductor element (1), the semiconductor element (1) and the circuit substrate (5) can be connected electrically with reliability.

AMENDMENT

(the Japanese Law § 11 based on PCT § 34(2)(b))

To : Examiner of the Patent Office

1. Identification of the International Application

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4. Date of order of amendment

09. 09. 97

5. Item to be amended

Disclosure of invention of specification and Claims

6. Subject matter of Amendment

(1) As per the attached sheets, amend "in the semiconductor apparatus of this invention, the flip-chip packaging technique is used for connecting electrically a semiconductor element and a circuit substrate via a projected electrode composed of conductive metallic material formed on an electrode terminal, which is formed on the surface of the semiconductor element where the element is formed, a conductive adhesive and an electrode terminal on the circuit substrate, wherein the individual projected electrode is deformed plastically in the direction of height so that the distance between

a protruding surface of an individual projected electrode and an opposing surface of the individual electrode terminal via the conductive adhesive is unified." in lines 10-20, page 4 of the specification to "in the semiconductor apparatus of this invention, the flip-chip packaging technique is used for connecting electrically a semiconductor element and a circuit substrate via a projected electrode composed of conductive metallic material formed on an electrode terminal, which is formed on the surface of the semiconductor element where the element is formed, a conductive adhesive and an electrode terminal on the circuit substrate. According to the semiconductor apparatus in this invention, the individual projected electrode is deformed plastically respectively in the direction of the height in accordance with the height of an opposing surface of electrode terminal formed on the circuit substrate in the part of the circuit substrate where the height of the surface of the electrode terminal is different so that the distance between a protruding surface of the individual projected electrode and an opposing surface of the individual electrode terminal formed on the circuit substrate via the conductive adhesive is unified."

(2) As per the attached sheets, amend " Furthermore, it is preferable that the flip-chip packaging technique is used for connecting a semiconductor element and a circuit substrate via an electrode terminal formed on the semiconductor element where the element is formed, a conductive adhesive and the projected electrode composed of the conductive metallic material formed on the electrode terminal on the circuit substrate.

In the preferred semiconductor apparatus in which the projected electrode is formed at the side of the circuit substrate, it is preferable that a barrier layer composed of conductive metallic laminated film is formed on the electrode terminal on the semiconductor element where the element is formed." in lines 6-16, page 5 of the specification to "Next, in a second aspect

of semiconductor apparatus in this invention, the flip-chip packaging technique is used for connecting electrically a semiconductor element and a circuit substrate via an electrode terminal formed on the surface of a semiconductor element where the element is formed, a conductive adhesive and a projected electrode composed of conductive metallic material formed on an electrode terminal on the circuit substrate. According to the semiconductor apparatus in this invention, in the part of the circuit substrate where the height of the surface of the electrode terminal formed on the circuit substrate is different, the individual projected electrode is processed in the direction of height in accordance with the height of the opposing surface of the electrode terminal formed on the circuit substrate, respectively, so that the distance between the protruding surface of the individual projected electrode and the opposing surface of the individual electrode terminal formed on the semiconductor element where the element is formed via the conductive adhesive becomes uniform. In the second aspect of semiconductor apparatus in this invention, it is preferable that a barrier layer composed of laminated film of conductive metallic material is formed on the electrode terminal formed on the semiconductor element where the element is formed."

(3) As per the attached sheets, amend "Furthermore, it is preferable that the variation in flatness of the hard material is 4 μ m or less over a distance of 20mm. According to a first aspect of the method for producing the semiconductor apparatus, a projected electrode is formed on the semiconductor element where the element is formed, a conductive adhesive is transferred on the vertex of the projected electrode and the semiconductor element is pressured from the back when the semiconductor element is mounted on the circuit substrate with its face down. According to that, the projected electrode formed on the semiconductor element is deformed

plastically to unify the distance between the protruding surface of the individual projected electrode formed on the semiconductor element and the opposing surface of the electrode terminal at the side of the circuit substrate." in lines 5-17, page 6 of the specification to " Furthermore, it is preferable that the variation in flatness of the hard material is 4 μ m or less over a distance of 20mm. Further, it is preferable that the material of the projected electrode is at least one metallic material selected from a group consisting of Au and Cu. Further, it is preferable that the distance between the protruding surface of the individual projected electrode and the opposing surface of the individual electrode terminal via the conductive adhesive is in a range of 1 μ m to 10 μ m. According to a first aspect of the method for producing the semiconductor apparatus, a projected electrode is formed on the semiconductor element where the element is formed, a conductive adhesive is transferred onto the vertex of the projected electrode and the semiconductor element is pressured from the back when the semiconductor element is mounted on a circuit substrate with its face down. According to that, in the part of the circuit substrate where the height of the surface of electrode terminal is different, the individual projected electrode formed on the semiconductor element is deformed plastically in the direction of height in accordance with the height of the opposing surface of electrode terminal formed on the circuit substrate, respectively, so that the distance between the protruding surface of the individual projected electrode formed on the semiconductor element and the opposing surface of the individual electrode terminal at the side of the circuit substrate is unified."

(4) As per the attached sheets, amend "According to a second aspect of the method for producing the semiconductor apparatus, after a projected electrode is formed on the electrode terminal formed on the circuit substrate, the height of the protruding surface of the individual projected electrode is

Date:

unified by pushing the projected electrode to the flat surface of the hard material, the conductive adhesive is transferred to the vertex of the individual projected electrode and the semiconductor element is mounted on the circuit substrate with face down.

According to the second aspect of the method for producing the semiconductor apparatus, a step of pressuring the semiconductor element is not present. Therefore the damage inflicted on the semiconductor element can be decreased.

In the second aspect of the method for producing the semiconductor apparatus, it is preferable that the pressure which is caused by pushing the projected electrode to the flat surface of the hard material to apply to the protruding surface of the projected electrode is in a range of 1.5×10^8 to 5.0×10^8 N/m^2." in line 17, page 7 to in line 1, page 8 of the specification to "According to a second aspect of the method for producing the semiconductor apparatus, after a projected electrode is formed on the electrode terminal formed on a circuit substrate, the individual projected electrode is processed in the direction of height, so that the distance between the protruding surface of the individual projected electrode formed on the circuit substrate and an opposing surface of electrode terminal formed on a semiconductor element is unified, in the part of the circuit substrate where the height of the surface of the electrode terminal is different, a conductive adhesive is transferred to the vertex of the individual projected electrode and then the semiconductor element is mounted on the circuit substrate with its face down. According to the second aspect of the method for producing the semiconductor apparatus, a step of pressuring the semiconductor element is not present. Therefore the damage which inflicted on the semiconductor element can be decreased. Further, it is preferable that the height of the protruding surface of the individual projected electrode is unified by pushing

the projected electrode to a flat surface of a hard material before the projected electrode is bonded with adhesive. Further, it is preferable that the pressure which is caused by pushing the projected electrode to the flat surface of the hard material is in a range of 1.5×10^8 to 5.0×10^8 N/m^2."

(5) As per the attached sheets, amend "A semiconductor apparatus in which the flip-chip packaging technique is used for connecting electrically the semiconductor element and the circuit substrate via the projected electrode composed of conductive metallic material formed on the electrode terminal which is formed on the surface of the semiconductor element where the element is formed, the conductive adhesive and the electrode terminal on the circuit substrate, wherein said individual projected electrode is deformed plastically in the direction of height so that the distance between the protruding surface of said individual projected electrode and the opposing surface of the individual electrode terminal via said conductive adhesive is unified." of Claim 1 to "A semiconductor apparatus in which the flip-chip packaging technique is used for connecting electrically a semiconductor element and a circuit substrate via a projected electrode composed of conductive metallic material formed on an electrode terminal which is formed on the surface of said semiconductor element where the element is formed, a conductive adhesive and an electrode terminal on said circuit substrate, wherein said individual projected electrode is deformed plastically in the direction of height in accordance with the height of an opposing surface of said electrode terminal formed on said circuit substrate in the part of said circuit substrate where the height of the surface of said electrode terminal is different so that the distance between a protruding surface of said individual projected electrode and an opposing surface of said individual electrode terminal formed on said circuit substrate via said conductive adhesive is unified."

(6) As per the attached sheets, amend "The semiconductor apparatus according to Claim 1 wherein the flip-chip packaging technique is used for connecting electrically the semiconductor element and the circuit substrate via the electrode terminal formed on the surface of the semiconductor element where the element is formed, the conductive adhesive and the projected electrode composed of the conductive metallic material formed on the electrode terminal on the circuit substrate." of Claim 4 to "A semiconductor apparatus where a flip-chip packaging technique is used for connecting electrically a semiconductor element and a circuit substrate via an electrode terminal formed on the surface of said semiconductor element where the element is formed, a conductive adhesive and a projected electrode composed of conductive metallic material formed on an electrode terminal on said circuit substrate, wherein said individual projected electrode is processed in the direction of height in accordance with a height of an opposing surface of said electrode terminal formed on said circuit substrate in the part of said circuit substrate where the height of the surface of electrode terminal is different, so that the distance between a protruding surface of said individual projected electrode and an opposing surface of said individual electrode terminal formed on said semiconductor element where the element is formed via said conductive adhesive is unified."

(7) As per the attached sheets, amend "The semiconductor apparatus according to Claim 1" of Claim 6 to "The semiconductor apparatus according to Claim 4"

(8) As per the attached sheets, amend "The hando-souchi according to Claim 7" of Claim 8 to "The handotai-souchi (semiconductor apparatus) according to Claim 7."

(9) As per the attached sheets, amend "The hando-souchi according to Claim 7" of Claim 9 to "The handotai-souchi (semiconductor apparatus)

according to Claim 7."

(10) As per the attached sheets, amend "A method for producing the semiconductor apparatus, comprising the steps of forming a projected electrode on a surface of a semiconductor element where the element is formed, transferring a conductive adhesive to the vertex of said projected electrode and mounting said semiconductor element on said circuit substrate with face down, wherein said semiconductor element is pushed from the back so that the projected electrode formed on said semiconductor element is deformed plastically to unify the distance between the protruding surface of the individual electrode formed on said semiconductor element and the opposing surface of the individual electrode terminal at the side of the circuit substrate." of Claim 10 to "A method for producing the semiconductor apparatus, comprising the steps of forming a projected electrode on a surface of a semiconductor element where the element is formed, of transferring a conductive adhesive to the vertex of said projected electrode and mounting said semiconductor element on a circuit substrate with face down, wherein in the part of said circuit substrate where the height of the surface of electrode terminal on the circuit substrate is different, in said step of mounting, said semiconductor element is pushed from the back so that the projected electrode formed on said semiconductor element is deformed plastically in the direction of height in accordance with the height of the opposing surface of said electrode terminal formed on said circuit substrate to unify the distance between the protruding surface of said individual projected electrode formed on said semiconductor element and the opposing surface of the individual electrode terminal at the side of said circuit substrate."

(11) As per the attached sheets, amend "The hando-souchi according to Claim 10" of Claim 11 to "The handotai-souchi (semiconductor apparatus) according to Claim 10."

(12) As per the attached sheets, Claim 13 is added as follows.

"A method for producing a semiconductor apparatus comprising the steps of forming a projected electrode on an electrode terminal formed on a circuit substrate, processing said individual projected electrode in the direction of height to unify the distance between a protruding surface of said individual projected electrode formed on said circuit substrate and an opposing surface of an electrode terminal formed on a semiconductor element in the part of said circuit substrate where the height of the surface of electrode terminal is different, transferring a conductive adhesive to the vertex of said individual projected electrode and mounting said semiconductor element on said circuit substrate with face down."

(13) As per the attached sheets, Claim 14 is added as follows.

"The method for producing the semiconductor apparatus according to Claim 13, wherein the height of the protruding surface of said individual projected electrode is unified by pushing said projected electrode to a flat surface of a hard material before said projected electrode is bonded with adhesive.

(14) As per the attached sheets, Claim 15 is added as follows.

"The method for producing the semiconductor apparatus according to Claim 14, wherein the pressure which is caused by pushing said projected electrode to the flat surface of said hard material is in a range of 1.5×10^8 to 5.0×10^8 N/m^2."

(15) As per the attached sheets, Claim 16 is added as follows.

"The method for producing the semiconductor apparatus according to Claim 14, wherein the variation in flatness of said hard material is 4 μm or less over a distance of 20mm."

(16) As per the attached sheets, Claim 17 is added as follows.

"The semiconductor apparatus according to Claim 4, wherein the

material of said projected electrode is at least one metallic material selected from a group consisting of Au and Cu."

(17) As per the attached sheets, Claim 18 is added as follows.

"The semiconductor apparatus according to Claim 4, wherein the distance between the protruding surface of said individual projected electrode and the opposing surface of said individual electrode terminal via said conductive adhesive is in a range of 1 μ m to 10 μ m."

7. List of documents attached

Amended specification: Page 4 to Page 19/1 (one copy)

Amended claim :Page 20 to Page 22/1 (one copy)

circuit substrate 105 in the concave portion of the circuit substrate 107 is larger than that of other parts of the circuit substrate 107. As a result, the conductive adhesive 108 can not reach to the protruding surface of the electrode terminal 107 positioned in the concave portion of the circuit substrate. Consequently, the electrical connection failure is caused.

Disclosure of Invention

It is an object of the present invention to provide a semiconductor apparatus which is stable in quality and has good productivity, and a method for producing the same by connecting electrically the semiconductor element and the circuit substrate more reliably. In order to achieve the above-mentioned objects, in the semiconductor apparatus of this invention, the flip-chip packaging technique is used for connecting electrically a semiconductor element and a circuit substrate via a projected electrode composed of conductive metallic material formed on an electrode terminal, which is formed on the surface of the semiconductor element where the element is formed, a conductive adhesive and an electrode terminal on the circuit substrate. According to the semiconductor apparatus in this invention, the individual projected electrode is deformed plastically respectively in the direction of the height in accordance with the height of an opposing surface of the electrode terminal formed on the circuit substrate in the part of the circuit substrate where the height of the surface of the electrode terminal is different so that the distance between a protruding surface of the individual projected electrode and an opposing surface of the individual electrode terminal formed on the circuit substrate via the conductive adhesive is unified.

According to the semiconductor apparatus in this invention, the height of the projected electrode is processed appropriately so that the distance between the protruding surface of the individual projected electrode

and the opposing surface of the individual electrode terminal via the conductive adhesive becomes uniform. Consequently, the semiconductor element can be connected electrically with the circuit substrate reliably.

It is preferable that in the semiconductor apparatus, the material of the projected electrode is at least one metallic material selected from the group consisting of Au and Cu.

Furthermore, it is preferable that the distance between the protruding surface of the individual projected electrode and the opposing surface of the individual electrode terminal via the conductive adhesive is in a range of 1 μ m to 10 μ m.

Next, in a second aspect of semiconductor apparatus in this invention, the flip-chip packaging technique is used for connecting electrically a semiconductor element and a circuit substrate via an electrode terminal formed on the surface of the semiconductor element where the element is formed, a conductive adhesive and a projected electrode composed of conductive metallic material formed on an electrode terminal on the circuit substrate. According to the semiconductor apparatus in this invention, the individual projected electrode is processed in the direction of height in accordance with the height of an opposing surface of the electrode terminal formed on the circuit surface respectively in the part of the circuit substrate where the height of the surface of the electrode terminal formed on the circuit substrate is different, so that the distance between a protruding surface of the individual projected electrode and an opposing surface of the individual electrode terminal formed on the surface of the semiconductor element where the element is formed via the conductive adhesive is unified. In the second aspect of semiconductor apparatus in this invention, it is preferable that a barrier layer composed of conductive metallic laminated film is formed on the electrode terminal on the surface of the semiconductor

element where the element is formed.

According to the preferred semiconductor apparatus on which the barrier layer is formed, the corrosion of the electrode terminal formed on the semiconductor element where the element is formed can be prevented.

In the semiconductor apparatus, it is preferable that the height of the projection of the projected electrode is substantially uniform.

In the semiconductor apparatus whose height of the projection of the projected electrode is substantially uniform, it is preferable that the height of the protruding surface of the individual projected electrode is unified by pushing the projected electrode on a flat surface of a hard material before the projected electrode is bonded with conductive adhesive.

In the semiconductor apparatus in which the height of the protruding surface of the individual projected electrode is unified by pushing the projected electrode on the flat surface of the hard material, it is preferable that the pressure on the protruding surface of the projected electrode which is caused by pushing on the flat surface of the hard material is in a range of 1.5×10^8 to $5.0 \times 10^8 N/m^2$.

Furthermore, it is preferable that the variation in flatness of the hard material is 4μ m or less over a distance of 20mm. Further, it is preferable that the material of the projected electrode is at least one metallic material selected from a group consisting of Au and Cu. Further, it is preferable that the distance between the protruding surface of the individual projected electrode and the opposing surface of the individual electrode terminal via the conductive adhesive is in a range of 1μ m to 10μ m.

According to a first aspect of the method for producing the semiconductor apparatus, a projected electrode is formed on the semiconductor element where the element is formed, a conductive adhesive is transferred onto the vertex of the projected electrode and the semiconductor element is pressured

from the back when the semiconductor element is mounted on a circuit substrate with its face down. According to that, in the part of the circuit substrate where the height of the surface of electrode terminal is different, the individual projected electrode formed on the semiconductor element is deformed plastically in the direction of height in accordance with the height of the opposing surface of electrode terminal formed on the circuit substrate, respectively, so that the distance between the protruding surface of the individual projected electrode formed on the semiconductor element and the opposing surface of the individual electrode terminal at the side of the circuit substrate is unified.

According to the first aspect of the method for producing the semiconductor apparatus, the height of the projected electrode can be processed appropriately so that the distance between the protruding surface of the individual projected electrode and the opposing surface of the individual electrode terminal via the conductive adhesive can be unified. As a result, the semiconductor apparatus with high reliability can be produced easily and at a low cost.

In the first aspect of the method for producing the semiconductor apparatus, it is preferable that the pressure on the protruding surface of the projected electrode which is caused by pushing the semiconductor element from the back is in a range of 1.5×10^8 to 5.0×10^8 N/m^2.

Furthermore, it is preferable that after the projected electrode formed on the semiconductor element is deformed plastically, the conductive adhesive is transferred to the vertex of the individual projected electrode formed on the semiconductor element and the semiconductor element is mounted on the circuit substrate with face down again.

In the method for producing the preferred semiconductor apparatus in which the projected electrode is deformed plastically, and then the

semiconductor element is mounted on the circuit substrate again, the semiconductor element is not pressured substantially when the semiconductor element is mounted on the circuit substrate with its face down. Therefore the shift of the position of the semiconductor element and the circuit substrate can be prevented.

According to a second aspect of the method for producing the semiconductor apparatus, after a projected electrode is formed on an electrode terminal formed on a circuit substrate, the individual projected electrode is processed in the direction of height, so that the distance between the protruding surface of the individual projected electrode formed on the circuit substrate and an opposing surface of electrode terminal formed on a semiconductor element is unified, in the part of the circuit substrate where the height of the surface of the electrode terminal is different, a conductive adhesive is transferred to the vertex of the individual projected electrode and then the semiconductor element is mounted on the circuit substrate with its face down. According to the second aspect of the method for producing the semiconductor apparatus, a step of pressuring the semiconductor element is not present. Therefore the damage inflicted on the semiconductor element can be decreased. Further, it is preferable that the height of the protruding surface of the individual projected electrode is unified by pushing the projected electrode to a flat surface of a hard material before the projected electrode is bonded with adhesive. Further, it is preferable that the pressure which is caused by pushing the projected electrode to the flat surface of the hard material is in a range of 1.5×10^8 to 5.0×10^8 N/m^2.

Furthermore, it is preferable that the flatness of the hard material is 4 μ m or less over a distance of 20mm.

Brief Description of Drawings

FIG. 1 is a sectional view showing a semiconductor apparatus in

Example 1 of this invention.

FIG. 2 is a flow chart showing the process of producing the semiconductor apparatus in Example 1.

FIG. 3A is a sectional view showing a semiconductor apparatus in the step of transferring conductive adhesive in the process of producing a semiconductor apparatus shown in FIG. 2.

FIG. 3B is a sectional view showing a semiconductor apparatus in the step of mounting and that of pressuring the semiconductor element.

FIG. 4 is a flow chart showing a process of producing the semiconductor apparatus in Example 2.

FIG. 5A is a sectional view showing a semiconductor apparatus in the step of mounting and the step of pressuring the semiconductor element in the process of producing a semiconductor apparatus shown in FIG. 4.

FIG. 5B is a sectional view showing a semiconductor apparatus in the step of transferring the conductive adhesive.

FIG. 6 is a sectional view showing a semiconductor apparatus in Example 3.

FIG. 7 is a flow chart showing the process of producing the semiconductor apparatus in Example 3.

FIG. 8A is a sectional view showing a semiconductor apparatus prior to pressuring the circuit substrate in the step of pressuring the circuit substrate shown in FIG. 7.

FIG. 8B is a sectional view showing a semiconductor after the circuit substrate is pressured.

FIG. 9 is a sectional view showing one example of semiconductor apparatus in which conventional flip-chip packaging technique is used.

FIG. 10 is a flow chart showing a process of producing a semiconductor apparatus in which the conventional flip-chip packaging

technique is used.

FIG. 11 is a sectional view showing one example of conventional semiconductor apparatus.

Best Mode for Carrying Out the Invention

Hereinafter, an example of a semiconductor apparatus of this invention and a method for producing the same will be explained referring to figures.

(Example 1)

FIG. 1 is a sectional view showing a semiconductor apparatus in Example 1 of this invention. As shown in FIG. 1, an aluminum electrode terminal 2 is formed on the surface of semiconductor element 1 where the element is formed. The area of the semiconductor element 1 other than where the aluminum electrode terminal 2 is formed is covered with an insulating film 3 composed of Si oxide film, Si nitrogen film and the like.

On the aluminum electrode terminal 2, a projected electrode 4 composed of conductive metallic material such as Au or Cu and the like is formed. On the other hand, a desired circuit pattern 6 and an electrode terminal 7 are formed on a circuit substrate 5 composed of insulating material such as resin, ceramic or glass and the like. The electrode terminal 7 is connected to the circuit pattern 6. In flip-chip packaging, the electrode terminal 7 connects electrically with the semiconductor element 1. A conductive adhesive 8 contains the powder of conductive metallic material such as Ag, Cu or Ni and the like in the resin. The insulating resin 9 is filled in the space between the semiconductor element 1 and the circuit substrate 5.

When the insulating resin 9 is hardened, the semiconductor element 1 and the circuit substrate 5 are bonded by the hardening shrinkage force of the insulating resin 9, and are attracted powerfully and fixed.

Consequently, the mechanical strength of connecting the semiconductor element 1 and the circuit substrate 5 of the semiconductor apparatus is enhanced and the stable fixing can be maintained.

As shown in FIG. 1, the height of the projected electrode 4 is processed according to the height of the respective electrode terminals 7 formed on the circuit substrate 5. That is, there is the irregularity of the flat accuracy of the principal surface of the circuit substrate 5 and the film thickness accuracy of the electrode terminal 7. Consequently, the irregularity of the position of the electrode terminal 7 in the direction of height of the protruding surface is caused. The height of the projected electrode 4 is lowered by plastic deformation in accordance with the irregularity respectively. In this case, the irregularity of the height of the projected electrode 4 which is pre-deformed plastically is smaller than that of the position of the electrode terminal 7 in the direction of height of the protruding surface, and the height is constant substantially. Consequently, the amount of the change of the height of the projected electrode 4 caused by the plastic deformation is different based on the position of the electrode terminal 7 in the direction of height of the protruding surface. Concretely, when the distance between the protruding surface of the electrode terminal 7 and the semiconductor element 1 is shorter, the amount of change of height of the projected electrode 4 becomes larger.

As a result, the distance between protruding surface of the projected electrode 4 formed at the side of the semiconductor element 1 and the surface of the electrode terminal 7 formed at the side of the circuit substrate 5 becomes uniform. It is preferable that the distance is in a range of 1 μ m to 10 μ m. It is more preferable that the distance is about 5 μ m. Consequently, the junction layer composed of conductive adhesive 8 which is transferred on the vertex of the projected electrode 4 reliably reaches the

surface of the electrode terminal 7 at the side of the circuit substrate 5 and as a result, the electrical connecting failure can be prevented.

Next, a method for producing the semiconductor apparatus in Example 1 will be explained referring to FIGs.2 and 3. FIG. 2 is a flow chart showing the process of producing the semiconductor apparatus in Example 1. As shown in FIG. 2, in the same way as that of conventional process, a semiconductor element 1 is formed on the surface where the element is formed. Then, a projected electrode 4 composed of Au is formed on the surface of the aluminum electrode terminal 2 by a ball bonding technique and the semiconductor wafer is cut into individual semiconductor elements 1. After that, the required amount of conductive adhesive 8 is transferred only to the vertex of the projected electrode 4, and the projected electrode 4 is positioned on the predetermined part of the circuit substrate 5 on which a desired circuit pattern 6 and an electrode terminal 7 are formed in advance, is pressured from the back of the semiconductor element 1 to cause the plastic deformation of the projected electrode 4 and the process to make the height of the projected electrode 4 appropriate is conducted. Finally, after the conductive adhesive 8 is hardened by heat treatment, the normal action is confirmed by the electrical inspection, the liquid epoxy based insulating resin 9 is filled in the space between the semiconductor element 1 and the circuit substrate 6 and is hardened. As a result, a semiconductor apparatus is produced.

FIG. 3 is a figure showing a step of transferring conductive adhesive and that of pressuring the semiconductor element in the process of producing a semiconductor apparatus as shown in FIG. 2. The reference number used in FIG. 3 is the same as that used in FIG. 1. FIG. 3A is a sectional view showing a semiconductor apparatus in the step of transferring conductive adhesive in the process of producing a semiconductor apparatus. FIG. 3B is

a sectional view showing a semiconductor apparatus in the step of mounting and that of pressuring the semiconductor element. As shown in FIG. 3A, the required amount of conductive adhesive 8 is transferred only to the vertex of the projected electrode 4. As shown in FIG. 3B, the semiconductor element 1 is positioned at the predetermined part of the circuit substrate 5 with its face down, and the pressure P is applied from the back of the semiconductor element 1 to cause the plastic deformation of the projected electrode 4. The process is continued to make the height of the projected electrode 4 appropriate. Accordingly, the step of mounting with face down method is completed. It is preferable that the pressure applied from the back of the semiconductor element 1 is in a range of 1.5×10^8 to 5.0×10^8 N/m^2. When a pressure in the above-mentioned range is applied, the distance between the protruding surface of the projected electrode 4 and the surface of the electrode terminal surface 7 can be unified in a range of 1 μ m to 10 μ m.

Furthermore, a projected electrode 4 may be formed by the transferring bump technique in which the surface of the aluminum electrode terminal 2 is pushed by the block of the conductive metallic material such as Au or Cu and the like which is produced in advance, and then, pressure, heat or ultrasonic vibration is applied to attach the block of the conductive metallic material to the surface of the aluminum electrode terminal 2.

Furthermore, a projected electrode 4 may be formed by depositing the conductive metallic material on the aluminum electrode terminal 2 by electroless plating or electrolytic plating.

As above-mentioned, according to the method for producing the semiconductor apparatus in Example 1, the step of pressuring the projected electrode and that of mounting the semiconductor element can be conducted at the same time. As a result, in comparison with the conventional process

of producing the semiconductor apparatus, the step also can be simplified.

(Example 2)

A method for producing the semiconductor apparatus in Example 2 will be explained referring to FIGs. 4 and 5. FIG. 4 is a flow chart showing a process of producing the semiconductor apparatus in Example 2. In a method for producing the semiconductor apparatus in Example 1, the semiconductor element to which the conductive adhesive is transferred in advance is positioned on the circuit substrate with its face down. After that, the step of deforming the projected electrode plastically and that of mounting were conducted at the same time by applying the pressure.

However, according to a method for producing the semiconductor apparatus in Example 2, a semiconductor element which is positioned in advance on the circuit substrate with surface down is pressured to cause the plastic deformation of the projected electrode. Then, the semiconductor element is once detached from the circuit substrate, the conductive adhesive is transferred and the semiconductor element is mounted with its face down again.

FIG. 5 is a figure explaining from a step of mounting with face down (1) to a step of transferring the conductive adhesive in the producing process as shown in FIG. 4. The reference number used in FIG. 5 is same as that used in FIG. 1. FIG. 5A is a sectional view showing a semiconductor apparatus in the step of mounting and that of pressuring the semiconductor element in the process of producing a semiconductor apparatus as shown in FIG.4. FIG. 5B is a sectional view showing a semiconductor apparatus in the step of transferring the conductive adhesive.

As shown in FIG. 5A, the semiconductor element 1 is positioned at the predetermined part of the circuit substrate 5 with its face down and the pressure P is applied to the back of the semiconductor element 1.

Consequently, the appropriate plastic deformation of the projected electrode 4 is conducted.

Next, the semiconductor element 1 is once detached from the circuit substrate 5, as shown in FIG. 5B, and the required amount of the conductive adhesive is transferred only to the vertex of the projected electrode 4. After that, the semiconductor element 1 is mounted again on the predetermined part of the circuit substrate 5 with its face down. As above-mentioned, the semiconductor apparatus having the constitution which is substantially uniform like that shown in FIG. 1 can be produced.

According to the method for producing the semiconductor apparatus in Example 1, when the semiconductor element is mounted, the pressure is applied. As a result, the position of the semiconductor element and the circuit substrate may be shifted from that of the predetermined position of the semiconductor element and the circuit substrate. On the other hand, according to the method for producing the semiconductor apparatus in Example 2, when the semiconductor element is mounted, the pressure is not applied to the semiconductor element at all. Therefore the possibility that the position of the semiconductor element and the circuit substrate is shifted from that of the predetermined position of the semiconductor element and the circuit substrate is small. Consequently, the method for producing the semiconductor apparatus in Example 2 is suitable for producing the semiconductor apparatus requiring a mounting accuracy such as minute pitch connecting construction.

(Example 3)

A method for producing the semiconductor apparatus in Example 3 will be explained referring to FIGs. 6,7 and 8. FIG. 6 is a sectional view showing a semiconductor apparatus in Example 3. In FIG. 6, 12 indicates a barrier layer composed of Cr or Au formed on the surface of the aluminum

electrode and 14 indicates a projected electrode formed on the electrode terminal at the side of the circuit substrate. The other elements are the same as those of FIG. 1.

Unlike the semiconductor apparatus of Example 1 shown in FIG. 1, in the semiconductor apparatus of Example 3, a barrier layer 12 is formed because the aluminum may be corroded when a conductive adhesive is contacted directly with the surface of the aluminum electrode terminal 2. Further, in the semiconductor apparatus of Example 3, a projected electrode 14 composed of conductive metallic material such as Au or Cu and the like is formed on the surface of the electrode terminal 7 at the side of the circuit substrate 5.

As shown in FIG. 6, the height of the projected electrode 14 is processed according to the position of the height of the electrode terminal 7 formed on the circuit substrate 5 respectively in the same way as the semiconductor apparatus of Example 1 was produced. That is, there is the irregularity of the flat accuracy of the principal surface of the circuit substrate 5 and the film thickness accuracy of the electrode terminal 7. Consequently, the irregularity of the position of the electrode terminal 7 in the direction of the height of the protruding surface is caused. The height of the projected electrode 14 is lowered by plastic deformation in accordance with the irregularity respectively. In this case, the irregularity of the height of the projected electrode 14 which is pre-deformed plastically is smaller than that of the position of the electrode terminal 7 in the direction of height of the protruding surface, and the height is constant substantially. Consequently, the amount of the change of the height of the projected electrode 14 caused by the plastic deformation is different based on the position of the height of the electrode terminal 7 in the direction of the protruding surface. Concretely, when the distance between the protruding

surface of the electrode terminal 7 and the semiconductor element 1 is shorter, the amount of change of height of the projected electrode 14 becomes larger.

As a result, the distance between the surface of the barrier layer 12 at the side of the semiconductor element 1 and the protruding surface of the projected electrode 14 becomes uniform. It is preferable that the distance is in a range of 1 μ m to 10 μ m in the same way as Example 1. It is more preferable that the distance is about 5 μ m. Consequently, the junction layer composed of conductive adhesive 8 which is transferred on the vertex of the projected electrode 14 reaches reliably the surface of the barrier layer 12 at the side of the semiconductor element 11 and as a result, the electrical connecting failure can be prevented.

Next, a method for producing the semiconductor apparatus in Example 3 will be explained referring to FIGs.7 and 8. FIG. 7 is a flow chart showing the process of producing the semiconductor apparatus in Example 3. As shown in FIG. 7, an element is formed on the surface of semiconductor element 1 and after that a barrier layer 12 is formed by layering Cr and Au on the surface of the aluminum electrode terminal 2 with a plating technique. Then, the inspection is conducted and the semiconductor wafer is cut into individual semiconductor elements 1.

On the other hand, a desired circuit pattern 6 and an electrode terminal 7 are formed on the principal surface of the circuit substrate 5 and after that a projected electrode 14 composed of Au is formed on the surface of the electrode terminal 7 with a ball bonding technique.

Then, the projected electrode 14 is pushed onto the flat plate having a desired flatness accuracy and composed of hard material. Consequently, the appropriate plastic deformation of the projected electrodes 14 is conducted and the height of the protruding surface of the projected electrode

14 becomes uniform respectively. After that, the required amount of the conductive adhesive paste 8 is transferred only to the vertex of the projected electrode 14, the semiconductor element 1 is mounted on the predetermined part of the circuit substrate 5 with its face down, heat treatment is applied to the conductive adhesive 8 to be hardened, electrical inspection is carried out to confirm the normal action, and finally the space between the semiconductor element 1 and the circuit substrate 6 is filled with insulating resin 9 such as liquid epoxy based resin. According to the above-mentioned steps, the semiconductor apparatus is produced.

FIG. 8 is a figure explaining a step of pressuring the circuit substrate and that of transferring the conductive adhesive in the process of producing a semiconductor apparatus as shown in FIG. 7. The reference number used in FIG. 7 is same as that used in FIG. 6. FIG. 8A is a sectional view showing a semiconductor apparatus prior to pressuring the circuit substrate. FIG. 8B is a sectional view showing a semiconductor after the circuit substrate is pressured. As shown in FIG. 8A, the projected electrode 14 which is formed on the principal surface of the circuit substrate 5 is pushed to the flat plate having a desired flat accuracy and composed of hard material. Consequently, the appropriate plastic deformation of the projected electrode 14 is conducted and the height of the protruding surface of the projected electrode 14 is unified. It is preferable that the variation in flatness of the above-mentioned hard material is 4 μ m or less over a distance of 20mm. It is preferable that the pressure which is applied to the flat plate composed of hard material is in a range of 1.5×10^8 to 5.0×10^8 N/m^2 at the protruding surface of the projected electrode 4. Then, as shown in FIG. 8B, the conductive adhesive 8 paste is transferred only to the vertex of the projected electrode 14 and the semiconductor element 1 is mounted.

Furthermore, a projected electrode 14 may be formed by the

transferring bump technique in which the surface of the electrode terminal 7 is pushed by the block of the conductive metallic material such as Au or Cu and the like which is produced in advance, and then, pressure, heat or ultrasonic vibration is applied to attach the block of the conductive metallic material to the surface of the electrode terminal 7.

Furthermore, a projected electrode 14 may be formed by depositing the conductive metallic material on the electrode terminal 7 by electroless plating or electrolytic plating.

Furthermore, a technique of forming a thick film using paste may be used. Regarding the barrier layer 12, a material other than Cr-Au film may be used.

Furthermore, in a case when an aluminum electrode terminal 2 is composed of material except for aluminum which is not corroded easily such as Au or Pt and the like, the barrier layer is not required to be formed.

As above-mentioned, according to the method for producing the semiconductor apparatus in Example 3, the step of pressuring the semiconductor element can be omitted, therefore the damage which is inflicted on the semiconductor element is reduced. In particular, when the semiconductor element is produced by using the brittle material such as compound semiconductor, Ga-As, the method for producing semiconductor apparatus in Example 3 is very effective.

As above-mentioned, according to the semiconductor apparatus of this invention, the height of the projected electrode is processed appropriately to unify the distance between the protruding surface of the projected electrode and the opposing surface of the individual electrode via the above-mentioned conductive adhesive respectively. Consequently, the electrical connection between the semiconductor element and the circuit substrate can be made reliably.

Further, according to the method for producing the semiconductor apparatus of this invention, the height of the projected electrode can be processed appropriately to unify the distance between the protruding surface of the projected electrode and the opposing surface of the individual electrode terminal via conductive adhesive respectively by applying the pressure to the back of the semiconductor element. Consequently, a semiconductor apparatus in which the semiconductor element and the circuit substrate are electrically connected reliably can be produced easily and at a low cost.

Industrial Applicability

As above-mentioned, the semiconductor element and the circuit substrate are electrically connected reliably in the semiconductor apparatus of this invention, the semiconductor apparatus of this invention can be used as a semiconductor apparatus in which the semiconductor element and the circuit substrate are electrically connected.

Further, according to a method for producing the semiconductor apparatus of this invention, each projected electrode can be deformed plastically and the semiconductor element and circuit substrate can be electrically connected reliably. Consequently, the method for producing the semiconductor apparatus of this invention can be utilized as a method for producing a semiconductor apparatus in which a flip-chip packaging technique is used.

CLAIMS

1. (Amended) A semiconductor apparatus in which a flip-chip packaging technique is used for connecting electrically a semiconductor element and a circuit substrate via a projected electrode composed of conductive metallic material formed on an electrode terminal which is formed on the surface of said semiconductor element where the element is formed, a conductive adhesive and an electrode terminal on said circuit substrate, wherein said individual projected electrode is deformed plastically in the direction of height in accordance with the height of an opposing surface of said electrode terminal formed on said circuit substrate in the part of said circuit substrate where the height of the surface of said electrode terminal is different so that the distance between a protruding surface of said individual projected electrode and an opposing surface of said individual electrode terminal formed on said circuit substrate via said conductive adhesive is unified.

2. The semiconductor apparatus according to Claim 1 wherein the material of said projected electrode is at least one metallic material selected from the group consisting of Au and Cu.

3. The semiconductor apparatus according to Claim 1 wherein a distance between the protruding surface of said individual projected electrode and the opposing surface of the individual electrode terminal via said conductive adhesive is in a range of 1 μ m to 10 μ m.

4. (Amended) A semiconductor apparatus where a flip-chip packaging technique is used for connecting electrically a semiconductor element and a circuit substrate via an electrode terminal formed on the surface of said semiconductor element where the element is formed, a conductive adhesive and a projected electrode composed of conductive metallic material formed on an electrode terminal on said circuit substrate, wherein said individual



projected electrode is processed in the direction of height in accordance with a height of an opposing surface of the electrode terminal formed on said circuit substrate, in the part of said circuit substrate where the height of the surface of electrode terminal is different so that the distance between a protruding surface of said individual projected electrode and an opposing surface of said individual electrode terminal formed on the surface of said semiconductor element where the element is formed via said conductive adhesive is unified.

5. The semiconductor apparatus according to Claim 4 wherein a barrier layer composed of conductive metallic laminated film is formed on said electrode terminal on the surface of said semiconductor element where the element is formed.

6.(Amended) The semiconductor apparatus according to Claim 4 wherein the height of projection of said projected electrode is substantially uniform.

7. The semiconductor apparatus according to Claim 6 wherein the height of the protruding surface of said individual projected electrode is unified by pushing said projected electrode on a flat surface of a hard material before said projected electrode is bonded with conductive adhesive.

8.(Amended) The semiconductor apparatus according to Claim 7 wherein the pressure on said protruding surface of said projected electrode which is caused by pushing on the flat surface of said hard material is in a range of 1.5×10^8 to 5.0×10^8 N/m^2.

9.(Amended) The semiconductor apparatus according to Claim 7 wherein the variation in flatness of said hard material is 4 μ m or less over a distance of 20mm.

10.(Amended) A method for producing the semiconductor apparatus, comprising the steps of forming a projected electrode on a surface of a semiconductor element where the element is formed, transferring a

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conductive adhesive to the vertex of said projected electrode and mounting said semiconductor element on a circuit substrate with face down, wherein in the part of said circuit substrate where the height of the surface of electrode terminal is different, in said step of mounting, said semiconductor element is pushed from the back so that the projected electrode formed on said semiconductor element is deformed plastically in the direction of height in accordance with the height of the opposing surface of said electrode terminal formed on said circuit substrate to unify the distance between the protruding surface of said individual projected electrode formed on said semiconductor element and the opposing surface of the individual electrode terminal at the side of said circuit substrate.

11.(Amended) The method for producing the semiconductor apparatus according to Claim 10, wherein the pressure on the protruding surface of said projected electrode, which is caused by pushing said semiconductor element from the back is in a range of 1.5×10^8 to 5.0×10^8 N/m^2.

12. The method for producing the semiconductor apparatus according to Claim 10, wherein the projected electrode on the semiconductor element is deformed plastically, the conductive adhesive is transferred to the vertex of the individual projected electrode on the semiconductor element and said semiconductor element is mounted on said circuit substrate with its face down again.

13.(New) A method for producing a semiconductor apparatus comprising the steps of forming a projected electrode on an electrode terminal formed on a circuit substrate, processing said individual projected electrode in the direction of height to unify the distance between a protruding surface of said individual projected electrode formed on said circuit substrate and an opposing surface of an electrode terminal formed on a semiconductor element in the part of said circuit substrate where the height of the surface of

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electrode terminal is different, transferring a conductive adhesive to the vertex of said individual projected electrode and mounting said semiconductor element on said circuit substrate with face down.

14.(New) The method for producing the semiconductor apparatus according to Claim 13, wherein the height of the protruding surface of said individual projected electrode is unified by pushing said projected electrode to a flat surface of a hard material before said projected electrode is bonded with adhesive.

15.(New) The method for producing the semiconductor apparatus according to Claim 14, wherein the pressure which is caused by pushing said projected electrode to the flat surface of said hard material is in a range of 1.5×10^8 to $5.0 \times 10^8 N/m^2$.

16.(New) The method for producing the semiconductor apparatus according to Claim 14, wherein the variation in flatness of said hard material is $4 \mu m$ or less over a distance of 20mm.

17.(New) The semiconductor apparatus according to Claim 4, wherein the material of said projected electrode is at least one metallic material selected from a group consisting of Au and Cu.

18.(New) The method semiconductor apparatus according to Claim 4, wherein the distance between the protruding surface of said individual projected electrode and the opposing surface of said individual electrode terminal via said conductive adhesive is in a range of $1 \mu m$ to $10 \mu m$.

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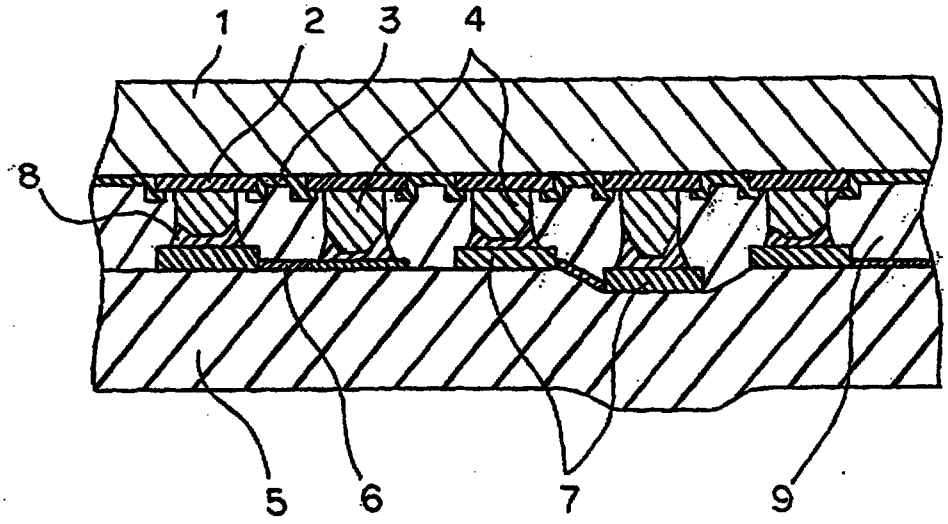
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(54)発明の名称 半導体装置とその製造方法



(57) Abstract

A semiconductor device in which a semiconductor chip (1) and a circuit board (5) are electrically connected to each other by plastically deforming projected electrodes (4) formed on the chip (1) so that the distances between the end faces of the electrodes (4) and the surfaces of electrode terminals (7) on the circuit board (5) side are uniform. There is also disclosed a process for producing such a semiconductor device, in which the electrical connection between the chip (1) and circuit board (5) is ensured even when the heights of the electrode terminals (7) formed on the circuit board (5) to which the chip (1) is to be connected vary, by pressing the chip (1) from the back after the element is placed in a prescribed position on the circuit board (5) so as to plastically deform the electrodes (4) and make the heights of the electrodes (4) appropriate.

（５７）要約

半導体素子（１）に形成された突起電極（４）の高さが、この突起電極（４）の先端面と回路基板（５）側の電極端子（７）面との距離が均一となるよう、塑成変形されていることにより、半導体素子と回路基板との電気的接続が確実な半導体装置を提供する。加えて、半導体素子（１）を回路基板（５）の所定の位置に配置した後、半導体素子（１）の背面より加圧して突起電極（４）の塑成変形を促し、突起電極（４）の高さを適正にすることにより、半導体素子（１）を接続する相手側である回路基板（５）上に形成した電極端子（７）面の高さ寸法に、ばらつきがあっても、半導体素子（１）と回路基板（５）との電気的接続を確実に行うことが出来る半導体装置の製造方法を提供する。

情報としての用途のみ
ＰＣＴに基づいて公開される国際出願をパンフレット第一頁にＰＣＴ加盟国を同定するために使用されるコード

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