

## Description

### BACKGROUND OF THE INVENTION

#### 5 Field of the Invention

The present invention relates to a ceramics substrate for mounting electronic components and the like thereon, and more particularly to a surface structure of a ceramics substrate having superior heat resistance and method of manufacturing the same.

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#### Description of the Background Art

A surface of a ceramics substrate is metallized to mount or seal electronic components. With reference to Fig. 1 showing a conventional surface structure of a ceramics substrate, a refractory metal 2 such as W or Mo is formed by baking on a ceramic substrate 1 of alumina, for example, an Ni plating layer 3 is formed thereon, and an Au plating layer 4 is formed further thereon. The Ni plating layer 3 facilitates soldering of the electronic components or the like, and serves to protect the metallized layer 2 formed thereunder. The Au plating layer 4 prevents oxidation of the Ni plating layer 3 formed thereunder to provide superior connection between the Ni plating layer 3 and the electronic components, thereby maintaining superior reliability of the electronic components and the like.

When elements are to be bonded on the Au plating by soldering, the ceramics substrate or the surface of the ceramics substrate is heated. However, the uppermost Au layer is tarnished by the heating, which prevents superior bonding. The cause of the tarnish of the Au plating layer may be diffusion of Ni of the Ni plating layer into the Au plating layer caused by heating, in which Ni is coupled with oxygen introduced from the air, providing Ni oxide.

In order to avoid the above described problem, the thickness of the Au plating layer is generally made as thick as about 2 $\mu$ m. However, in order to reduce cost, the Au plating layer should preferably be reduced in thickness.

Japanese Patent Laying Open No. 59-114846 discloses a method of suppressing diffusion of Ni in the Ni plating layer to the Au plating layer. More specifically, after the Ni plating layer is formed, the Ni plating layer is heat treated with a temperature range of 900°C to 1400°C in a reducing atmosphere, so as to improve heat resistance of the Ni plating layer.

However, the above method cannot sufficiently prevent tarnish of the Au plating layer. Especially when the thickness of the Au plating layer is not larger than 1 $\mu$ m, the Au plating layer is tarnished when electronic components and the like are bonded. JP-A-59 114 846 discloses a surface structure with the features of the preamble of claim 1.

### SUMMARY OF THE INVENTION

The present invention was made in view of the foregoing and its object is to provide a surface structure of a ceramics substrate capable of suppressing diffusion of Ni in the Ni layer to the Au plating layer and of reducing thickness of the Au plating layer, and to provide a method of manufacturing the same.

The surface structure of the ceramics substrate in accordance with the present invention is characterized in claim 1.

The method of manufacturing the surface structure of the ceramics substrate in accordance with the present invention, is characterized in claim 6.

In the present invention, NiAu alloy layer is positioned below the Au plating layer. Since Ni in the NiAu alloy layer is not easily released, diffusion of Ni into the Au plating layer can be suppressed sufficiently. Therefore, the Au plating layer can be reduced in thickness.

The foregoing and other objects, features, aspects and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

### BRIEF DESCRIPTION OF THE DRAWINGS

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Fig. 1 is a sectional view showing a conventional surface structure of a ceramics substrate; and Figs. 2A to 2E are sectional views for explaining a method of manufacturing a surface structure of a ceramics substrate in accordance with the present invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

An example of a specific processing method to provide the surface structure of the ceramics substrate in accordance with the present invention will be described in conjunction with Figs. 2A to 2E in the following.

First, a metallized layer 12 is formed on a ceramics substrate 11, as illustrated in Fig. 2A. A refractory metal such as W, Mo or Ta may be employed as a metal for forming the metallized layer 12. A plating layer may be formed on the refractory metal layer. Vapor deposition, ion plating, sputtering or the like may be employed to form the metallized layer.

As illustrated in Fig. 2B, an Ni layer 13 is formed on the metallized layer 12. Various methods may be used for forming the Ni layer 13. Preferably, an electrolytic plating method is employed. Electroless plating may be employed. However, the Ni layer may be formed not by the plating method but vapor deposition, ion plating or sputtering.

Then an Au layer 14 is formed on the Ni layer 13, as illustrated in Fig. 2C. At this time, the Au plating layer 14 may be formed by usual plating method or by vapor deposition, ion plating or sputtering. The Ni layer may be formed not directly on the metallized layer. The Ni layer may be formed after another metal layer is formed.

The above mentioned Ni layer 13 and the Au layer 14 should have as uniform thickness as possible on the entire surface, respectively. If these layers are not uniform in thickness, color shade may be generated. The ratio of thickness of the Au layer 14 to that of Ni layer 13 is preferably not larger than 1/2. If the thickness of the Au layer 14 is larger than this ratio, it will be difficult to have a suitable alloy layer by the alloying processing described later. The most preferable ratio of the thickness of the Au layer 14 to the Ni layer 13 is not higher than 1/10.

Then the ceramics substrate 11 having the metallized layer 12, the Ni layer 13 and the Au layer 14 thereon is heated for 4 to 5 minutes in a non-oxidizing atmosphere at a temperature higher than 500°C to cause alloying reaction between the Ni layer 13 and the Au layer 14. By this heat treatment, an NiAu alloy layer 15 is formed as the uppermost layer, as illustrated in Fig. 2D.

Then an Au plating layer 16 is formed by usual plating method on the NiAu alloy layer 15, as illustrated in Fig. 2E. Preferably, electrolytic plating method or electroless plating method is employed to form the Au plating layer 16. The heat resistance is improved as the thickness of the Au plating layer 16 is increased. However, since the NiAu alloy layer 15 below suppresses releasing of Ni, diffusion of Ni to the Au plating layer 16 can be prevented as much as possible. Therefore, even if the thickness of the Au plating layer 16 is not larger than 1.0μm, tarnish of the Au plating layer 16 is not generated during heating for bonding the electronic components and the like. The heat treatment for bonding is usually carried out under the condition of 450°C x 3 min. since the NiAu alloy layer 15 suppresses release of Ni, the sufficient thickness of the Au plating layer 16 is generally about 0.2μm. In any case, the thickness of the Au plating layer 16 is determined corresponding to the necessary characteristics.

Example

16 AlN substrates having W metallized layer were prepared. An Ni plating layer was formed under various conditions on each substrate, and an Au plating layer was formed thereon. Table 1 shows thicknesses of the plating layers corresponding to the respective samples.

Table 1

| Sample No. | Ni plating thickness ( $\mu\text{m}$ ) | Au plating thickness ( $\mu\text{m}$ ) | Heating temperature ( $^{\circ}\text{C}$ ) | Upper-most Au plating layer ( $\mu\text{m}$ ) | Tarnish evaluation |
|------------|----------------------------------------|----------------------------------------|--------------------------------------------|-----------------------------------------------|--------------------|
| 1          | 3                                      | 0.1                                    | 900                                        | 0.05                                          | $\Delta$           |
| 2          | 3                                      | 0.1                                    | 900                                        | 0.1                                           | o                  |
| 3          | 3                                      | 0.1                                    | 900                                        | 0.3                                           | o                  |
| 4          | 3                                      | 0.1                                    | 900                                        | 0.8                                           | o                  |
| 5          | 3                                      | 0.1                                    | 900                                        | 1.0                                           | o                  |
| 6          | 3                                      | 0.1                                    | 400                                        | 0.5                                           | $\Delta$           |
| 7          | 3                                      | 0.1                                    | 700                                        | 0.5                                           | o                  |
| 8          | 3                                      | 0.1                                    | 1000                                       | 0.5                                           | o                  |
| 9          | 3                                      | 0.1                                    | -                                          | 0.5                                           | X                  |
| 10         | 1                                      | 0.1                                    | 900                                        | 0.5                                           | $\Delta$           |
| 11         | 5                                      | 0.1                                    | 900                                        | 0.5                                           | o                  |
| 12         | 7                                      | 0.1                                    | 900                                        | 0.5                                           | o                  |
| 13         | 5                                      | 0.2                                    | 900                                        | 0.5                                           | o                  |
| 14         | 5                                      | 1.0                                    | 900                                        | 0.5                                           | o                  |
| 15         | 4                                      | 0.2                                    | 900                                        | 0.5                                           | o                  |
| 16         | 4                                      | 0.2                                    | 900                                        | 0.5                                           | o                  |

Except the sample No. 9, heat treatment was carried out for 15 samples with different heating temperature in a current of hydrogen, to cause alloying reaction between the Ni plating layer and the Au plating layer. Finally, an Au plating layer was formed as the uppermost layer on each of the samples.

The tarnish of the uppermost Au plating layer of each sample was evaluated. The evaluation was carried out by heat-treating the finally obtained samples for 5 minutes in an atmosphere of  $450^{\circ}\text{C}$ , and the tarnish of the uppermost Au plating layer after heat treatment was examined. In Table 1, the mark o represents no tarnish, the mark  $\Delta$  represents slight tarnish and X represents serious tarnish.

On the sample No. 15, an Ni layer having the thickness of  $4\mu\text{m}$  was formed by sputtering and an Au plating layer having the thickness of  $0.2\mu\text{m}$  was formed thereon by plating. On the sample No. 16, an Ni layer having the thickness of  $4\mu\text{m}$  was formed by sputtering, and an Au layer having the thickness of  $0.2\mu\text{m}$  was formed thereon by sputtering. Although tarnish was not exhibited on the sample No. 14, color shade appeared.

As to the sample No. 9 which exhibited serious tarnish, heat treatment for alloying reaction was not carried out on this sample. This is the cause of the serious tarnish of the uppermost Au plating layer.

As to the sample No. 1, the thickness of the uppermost Au plating layer was considerably small compared with other samples. Since the uppermost Au plating layer was too small in thickness, slight tarnish occurred.

As to the sample No. 6, the heating temperature for the alloying reaction was lower compared with other samples. The lower temperature is considered to be the cause of tarnish.

As to the sample No. 10, the thickness of the Ni plating layer was considerably smaller than other samples. This is considered to be the cause of tarnish of the uppermost Au plating layer.

Although the present invention has been described and illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation.

## Claims

1. A surface structure of a ceramics substrate (11), comprising a metallized layer (12) of a refractory metal, a Ni layer (13) formed on said metallized layer (12), and an Au plating layer (16) formed thereon  
characterized in that  
a NiAu layer (15) is provided on said Ni layer (13) and below said Au plating layer (16).
2. A surface structure of a ceramics substrate according to claim 1, wherein a thickness of said Au plating layer (16) is not larger than 1.0  $\mu\text{m}$ .
3. A surface structure of a ceramics substrate according to claim 2, wherein a thickness of said Au plating layer (16) is in the range of 0.2  $\mu\text{m}$  to 1.0  $\mu\text{m}$ .
4. A surface structure of a ceramics substrate according to any of the preceding claims, comprising an AlN substrate (11).
5. A surface structure of a ceramics substrate according to any of the preceding claims, wherein said refractory metal is W, Mo or Ta.
6. A method of manufacturing a surface structure of a ceramics substrate, comprising the steps of forming a metallized layer (12) of a refractory metal, a Ni layer (13) and an Au layer (14) in this order on a surface of a ceramics substrate (11),  
characterized by  
heating said substrate in a non-oxidizing atmosphere to cause alloying reaction between the Ni layer (13) and the Au layer (14), and  
forming an Au plating layer (16) on the NiAu alloy layer (15).
7. A method according to claim 6, wherein said heat treatment for alloying reaction is carried out in a non-oxidizing atmosphere and at a temperature not less than 500°C.
8. A method according to claim 6 or 7, wherein a thickness of said Au plating layer (16) is not larger than 1.0  $\mu\text{m}$ .
9. A method according to claim 8, wherein a thickness of said Au plating layer (16) is in the range of 0.2  $\mu\text{m}$  to 1.0  $\mu\text{m}$ .
10. A method according to any of claims 6 to 9, wherein the ratio of the thickness of said Au layer (14) to that of said Ni layer (13) is not larger than 1/2.

## Patentansprüche

1. Oberflächenstruktur eines Keramiksubstrates (11) mit einer metallisierten Schicht (12) eines hitzebeständigen Metalls, einer Ni-Schicht (13), die auf der Metallschicht (12) vorgesehen ist, und einer Au-Plattierungsschicht (16), die darauf gebildet ist,  
dadurch gekennzeichnet, daß  
eine NiAu-Schicht (15) auf der Ni-Schicht (13) und unterhalb der Au-Plattierungsschicht (16) vorgesehen ist.



As to the sample No. 1, the thickness of the uppermost Au plating layer was considerably small compared with other samples. Since the uppermost Au plating layer was too small in thickness, slight tarnish occurred.

As to the sample No. 6, the heating temperature for the alloying reaction was lower compared with other samples. The lower temperature is considered to be the cause of tarnish.

As to the sample No. 10, the thickness of the Ni plating layer was considerably smaller than other samples. This is considered to be the cause of tarnish of the uppermost Au plating layer.

Although the present invention has been described and illustrated in detail, it is clearly understood that the same is by way of illustration and example only and is not to be taken by way of limitation.

## Claims

1. A surface structure of a ceramics substrate (11), comprising a metallized layer (12) of a refractory metal, a Ni layer (13) formed on said metallized layer (12), and an Au plating layer (16) formed thereon characterized in that a NiAu layer (15) is provided on said Ni layer (13) and below said Au plating layer (16).
2. A surface structure of a ceramics substrate according to claim 1, wherein a thickness of said Au plating layer (16) is not larger than 1.0  $\mu\text{m}$ .
3. A surface structure of a ceramics substrate according to claim 2, wherein a thickness of said Au plating layer (16) is in the range of 0.2  $\mu\text{m}$  to 1.0  $\mu\text{m}$ .
4. A surface structure of a ceramics substrate according to any of the preceding claims, comprising an AlN substrate (11).
5. A surface structure of a ceramics substrate according to any of the preceding claims, wherein said refractory metal is W, Mo or Ta.
6. A method of manufacturing a surface structure of a ceramics substrate, comprising the steps of forming a metallized layer (12) of a refractory metal, a Ni layer (13) and an Au layer (14) in this order on a surface of a ceramics substrate (11), characterized by heating said substrate in a non-oxidizing atmosphere to cause alloying reaction between the Ni layer (13) and the Au layer (14), and forming an Au plating layer (16) on the NiAu alloy layer (15).
7. A method according to claim 6, wherein said heat treatment for alloying reaction is carried out in a non-oxidizing atmosphere and at a temperature not less than 500°C.
8. A method according to claim 6 or 7, wherein a thickness of said Au plating layer (16) is not larger than 1.0  $\mu\text{m}$ .
9. A method according to claim 8, wherein a thickness of said Au plating layer (16) is in the range of 0.2  $\mu\text{m}$  to 1.0  $\mu\text{m}$ .
10. A method according to any of claims 6 to 9, wherein the ratio of the thickness of said Au layer (14) to that of said Ni layer (13) is not larger than 1/2.

## Patentansprüche

1. Oberflächenstruktur eines Keramiksubstrates (11) mit einer metallisierten Schicht (12) eines hitzebeständigen Metalls, einer Ni-Schicht (13), die auf der Metallschicht (12) vorgesehen ist, und einer Au-Plattierungsschicht (16), die darauf gebildet ist, dadurch gekennzeichnet, daß eine NiAu-Schicht (15) auf der Ni-Schicht (13) und unterhalb der Au-Plattierungsschicht (16) vorgesehen ist.



2. Oberflächenstruktur eines Keramiksubstrates gemäß Anspruch 1, worin eine Dicke der Au-Plattierungsschicht (16) nicht größer als 1,0 µm ist.
- 5 3. Oberflächenstruktur eines Keramiksubstrates gemäß Anspruch 2, worin eine Dicke der Au-Plattierungsschicht (16) in dem Bereich von 0,2 µm bis 1,0 µm liegt.
4. Oberflächenstruktur eines Keramiksubstrates gemäß einem der vorangegangenen Ansprüche, mit einem AlN-Substrat (11).
- 10 5. Oberflächenstruktur eines Keramiksubstrates nach einem der vorangegangenen Ansprüche, worin das hitzebeständige Metall W, Mo oder Ta ist.
- 15 6. Verfahren zur Herstellung einer Oberflächenstruktur eines Keramiksubstrates, umfassend die Schritte der Bildung einer metallisierten Schicht (12) aus hitzebeständigem Metall, einer Ni-Schicht (13) und einer Au-Schicht (14) in dieser Reihenfolge auf einer Oberfläche eines Keramiksubstrates (11), gekennzeichnet durch
  - Aufheizen des Substrates in einer nicht-oxidierenden Atmosphäre, um eine Legierungsreaktion zwischen der Ni-Schicht (13) und der Au-Schicht (14) herbeizuführen, und
  - 20 Bilden einer Au-Plattierungsschicht (16) auf der NiAu-Legierungsschicht (15).
7. Verfahren nach Anspruch 6, worin die Wärmebehandlung für die Legierungsreaktion in einer nicht-oxidierenden Atmosphäre und bei einer Temperatur von nicht weniger als 500°C ausgeführt wird.
- 25 8. Verfahren nach Anspruch 6 oder 7, worin die Dicke der Au-Plattierungsschicht (16) nicht größer als 1,0 µm ist.
9. Verfahren nach Anspruch 8, worin eine Dicke der Au-Plattierungsschicht (16) in dem Bereich von 0,2 µm bis 1,0 µm liegt.
- 30 10. Verfahren nach einem der Ansprüche 6 bis 9, worin das Verhältnis der Dicke der Au-Schicht (14) zu der der Ni Schicht (13) nicht größer als 1:2 ist.

### Revendications

- 35 1. Structure de surface d'un substrat céramique (11) comprenant une couche métallisée (12) d'un métal réfractaire, une couche Ni (13) formée sur cette couche métallisée (12) et une couche de placage Au (16) formée sur celle-ci, caractérisée en ce qu'une couche NiAu (15) est prévue sur la couche Ni (13) et au-dessous de cette couche de placage Au (16).
- 40 2. Structure de surface d'un substrat céramique selon la revendication 1, dans laquelle une épaisseur de la couche de placage Au (16) n'est pas supérieure à 1,0 µm.
- 45 3. Structure de surface d'un substrat céramique selon la revendication 2, dans laquelle l'épaisseur de la couche de placage Au (16) se situe dans la plage de 0,2 à 1 µm.
4. Structure de surface d'un substrat céramique selon l'une quelconque des revendications précédentes, comprenant un substrat AlN (11).
- 50 5. Structure de surface d'un substrat céramique selon l'une quelconque des revendications précédentes, dans laquelle le métal réfractaire est W, Mo ou Ta.
- 55 6. Procédé de fabrication d'une structure de surface d'un substrat céramique comprenant les étapes consistant à
  - former une couche métallisée (12) d'un métal réfractaire, une couche Ni (13) et une couche Au (14) dans cet ordre sur une surface d'un substrat céramique (11),
  - caractérisé par le fait
  - de chauffer le substrat dans une atmosphère non oxydante pour provoquer la réaction d'alliage



entre la couche Ni (13) et la couche Au (14), et  
former une couche de placage Au (16) sur la couche d'alliage NiAu (15).

- 5      7. Procédé selon la revendication 6, dans lequel le traitement thermique pour la réaction d'alliage s'effectue dans une atmosphère non oxydante et à une température non inférieure à 500°C.
8. Procédé selon la revendication 6 ou 7, dans lequel une épaisseur de la couche de placage Au (16) n'est pas supérieure à 1,0  $\mu\text{m}$ .
- 10    9. Procédé selon la revendication 8, dans lequel l'épaisseur de la couche de placage Au (16) se situe dans la plage de 0,2  $\mu\text{m}$  à 1,0  $\mu\text{m}$ .
- 15    10. Procédé selon l'une quelconque des revendications 6 à 9, dans lequel le rapport entre l'épaisseur de la couche Au (14) et l'épaisseur de la couche Ni (13) n'est pas supérieur à 1/2.

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