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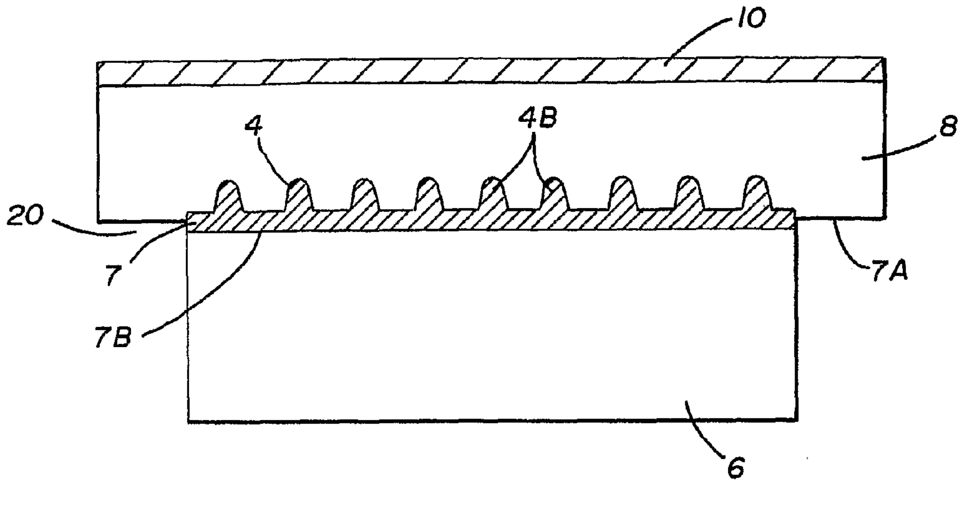
(54) Title: BRITTLE MATERIAL SPUTTERING TARGET ASSEMBLY AND METHOD OF MAKING SAME



(57) Abstract: A method for producing a sputtering target assembly made from a material with a low coefficient of thermal expansion solder bonded to a backing plate with a coefficient of thermal expansion similar to that of the target assembly material. The method includes heat treating the target assembly material and backing plate, solder bonding the target assembly material and backing plate, and slowly cooling the assembly to room temperature. Matching the coefficients of thermal expansion of the target assembly material and backing plate minimizes distortion in the assembly caused from deflection and internal stress.

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BRITTLE MATERIAL SPUTTERING TARGET ASSEMBLY AND METHOD OF MAKING SAME

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 60/441,815 filed January 22, 2003.

FIELD OF THE INVENTION

[0002] The present invention relates to methods for preparing sputter target/backing plate assemblies, and to the target/backing plate assemblies prepared by these methods. More particularly, the invention relates to methods for solder bonding sputter targets to an associated backing plate, wherein the sputter target material and backing plate material each exhibit a similarly low coefficient of thermal expansion (CTE).

BACKGROUND OF THE INVENTION

[0003] Cathodic sputtering is widely used for depositing thin layers or films of materials from sputter targets onto desired substrates. Basically, a cathode assembly including the sputter target is placed together with an anode in a chamber filled with inert gas, preferably argon. The desired substrate is positioned in the chamber near the anode with a receiving surface oriented normally to a path between the cathode assembly and the anode. A high voltage electric field is applied across the cathode assembly and the anode.

[0004] Electrons ejected from the cathode assembly ionize the inert gas. The electrical field then propels positively charged ions of the inert gas against a sputtering surface of the sputter target. Material dislodged from the sputter target by the ion bombardment traverses the chamber and deposits to form the thin layer or film on the receiving surface of the substrate.

[0005] In order to achieve good thermal and electrical contact between the target and the backing plate, these members are commonly attached to each other by way of soldering, brazing, diffusion bonding, clamping, epoxy cements, or with interlocking annular members. High purity metal and metal alloy sputter targets historically have been solder bonded to copper alloy backing plates, for example as disclosed in U.S. Patent No. 5,593,082 entitled "Methods of Bonding Targets to

Backing Plate Members using Solder Pastes and Target/Backing Plate Assemblies Bonded Thereby" issued to Ivanov, et al. in January, 1997.

[0006] The relatively high coefficient of thermal expansion (CTE) associated with copper and copper alloy backing plates, compounded by the use of higher levels of sputtering power required to energize larger sputtering targets, has increased the material stresses imposed on the bonds joining the sputter targets to the backing plates. Under these conditions, the sputtering target assemblies tend to deflect or separate upon exposure to changing temperatures typically encountered during bonding, sputtering, and cooling processes. To a certain extent, soft shoulders have accommodated stresses exerted on the sputter target/backing plate assemblies as the assemblies are heated during the sputtering process and subsequently cooled. When weak solder bonds have been used to join materials with widely differing thermal expansion rates, however, the bonds have been susceptible to shear failure initiating at the extreme edges of the bond interfaces. Such shear failures commonly have resulted in debonding of the sputter targets from the backing plates during service.

[0007] Accordingly, there remains a need in the art for a method for bonding sputtering target materials, such as silicon (Si) or Si alloys, having a low CTE. Although sputtering target assemblies may be made by solder bonding backing plates of various materials to an associated target, solder bonding of low CTE brittle materials to a copper or aluminum alloy backing plate of a significantly different CTE has the disadvantage of not being able to withstand soldering procedures or high power during sputtering applications. Thus, sputtering target assemblies where the CTE of target material and the backing plate are similar are preferred, so as to allow for higher levels of sputtering power and larger sputter target designs without risk of deflection or debonding in use at elevated temperatures.

SUMMARY OF THE INVENTION

[0008] These and other objects of the invention are met by a method for producing a sputtering target assembly, whereby a sputtering target having a relatively low CTE is solder bonded to a backing plate having a CTE similar to that of the sputtering target, thereby enabling the assembly to withstand the stress and degradation typically encountered during sputtering. In a preferred embodiment, the backing plate comprises molybdenum or alloy thereof, and the sputtering target comprises silicon, silicon alloy, or silicon compound.

[0009] These and other features and advantages of this invention are described in, or are apparent from, the following detailed description, the accompanying drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Fig. 1 is a side elevational view of a sputter target/backing plate assembly fabricated according to the present invention;

[0011] Fig. 2 is a plan view of the interfacial surface of a backing plate for use in fabricating the sputter target/backing plate assembly of Fig. 1; and

[0012] Fig. 3 is a cross-sectional view showing the backing plate surface spiral channel on the surface to be bonded.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0013] Fig. 1 is a side view of a preferred sputtering target assembly in accordance with the inventive methods herein disclosed. The sputtering target assembly 20 includes a sputter target 6, superposed atop heat conductive backing plate 8. Cooling water (not shown) may be circulated in contact with the backing plate so as to dissipate heat resulting from the sputtering operation. To prevent corrosion from the cooling water, an anticorrosive layer 10 may be disposed on the rear surface of the backing plate.

[0014] Solder 4B, for example Indium solder, is disposed along the mating surfaces 7A and 7B of the backing plate and target respectively. The solder is used to bond the target 6 and backing plate 8 together, thereby forming a sputtering target assembly. Before the solder is applied, the mating surfaces of the target and backing plate may be covered by an intermediate or wetting layer (not shown) of metallic nickel or nickel alloy having a substantially uniform thickness, preferably approximately 5-30 μm, which may be deposited by conventional methods such as electroplating, sputtering, or electroless plating, so as to improve wetting of the bonded surfaces and to improve adherence of the solder material disposed thereon.

[0015] Referring now to Fig. 2, there is illustrated an exemplary grooved spiral pattern machined on the mating surface 7A of the backing plate. The groove pattern 4 may be provided, for example, by machining the surface 7A with a continuous spiral groove starting from an end of the surface toward the center as shown in Fig. 2. The groove pattern is effective to facilitate the formation of a strong seal between the target and backing plate. The skilled artisan will appreciate that many different shapes and sizes of targets, backing plates, and groove patterns or absence of groove patterns may be used to achieve the same results.

[0016] In operation, a backing plate is prepared for solder bonding by machining one continuous groove or spiral pattern on the mating backing plate surface 7A, followed by grit blasting and chemical cleaning both mating surfaces 7A, 7B of the backing plate and target respectively. Additional preparation of the mating surfaces 7A, 7B may include covering the mating surfaces with an appropriate metal layer, preferably nickel, in order to improve wetting of the mating surfaces and to improve adherence of the solder bond. Indium solder may be used for solder bonding, although the skilled artisan will appreciate that many other types of solder material may be used as well. Once the mating surfaces are prepared for bonding, the target 6 and backing plate 8 are assembled by positioning the mating surfaces together and creating a solder bond by pressing the combined assembly at a temperature sufficient to melt the solder material, for example 200°C in the case of indium.

[0017] A problem encountered in producing solder bonded low CTE sputtering target assemblies lies with the difficulty in producing a sputtering target assembly having minimized stress due to a difference in CTE between target material and the backing plate. An example of a sputtering target assembly system particularly vulnerable to this problem is an assembly with a copper alloy backing plate and, for example, a Si target which deflects upon exposure to elevated temperature encountered during the bonding process and again during sputtering. Although copper alloys are capable of being flattened to achieve required flatness, such treatments would render the solder bonded assembly vulnerable to delamination, cracking, distortion and/or other degradation of the target.

[0018] A solder bonded target assembly often combines materials having different CTE; that is, the target material often exhibits a relatively low CTE, while the backing plate exhibits a CTE substantially higher than the CTE of the target material. Consequently, cooling of such an assembly could cause undesirable distortion, cracking, or separation of the bonded materials due to the difference in thermal expansion between the target and backing plate. To overcome this problem, it has been discovered that by using the method of the present invention, it is possible to produce a low CTE sputtering target assembly that is capable of withstanding the stress and degradation typically encountered during sputtering. In other words, it is possible to minimize, or ideally eliminate, distortion and separation by producing a sputtering target assembly wherein a sputtering target having a relatively low CTE is solder bonded to a backing plate having a CTE similar to that of the sputtering target.

[0019] To illustrate one exemplary embodiment of the invention, described below is an example of producing a solder bonded silicon sputtering target assembly comprising a molybdenum backing plate with a chromium nitride anticorrosion layer on the back side, bonded to a silicon sputtering target. The anticorrosion layer may be provided on the water side of the backing plate via conventional techniques such as ion implantation. Although this example is of a molybdenum metal, it is apparent that the process may be usefully applied to backing plates of other materials such as alloys of tantalum, titanium, zirconium, vanadium, or niobium (e.g., Ti alloys, Zr alloys, V alloys, Nb alloys). Similarly, various target materials may be employed such as, p-type silicon, n-type silicon, silicides, silicon-germanium, tungsten, titanium-tungsten, tantalum and alloys thereof. Typically, solder bonded targets are produced by bonding metal backing plates to a target.

[0020] The table below lists the coefficient of thermal expansion (CTE) and thermal conductivity (TC) data associated with the following exemplary materials. The CTE are listed in 10E6 K(-1) for 0-100°C; the TC are listed in Wm(-1)K(-1):

MATERIAL	CTE	TC
Aluminum	23.5	237
Copper	17	401
Indium	24.8	81.8
Molybdenum	5.1	138
Niobium	7.2	53.7
Silicon*	4.7-7.6	80-150

Tantalum	6.5	57.5
Titanium	8.9	21.9
Tungsten	4.5	173
Zirconium	5.9	22.7

* Data depends on impurity level

[0021] In one example, a sputtering target assembly is made using a backing plate composed of molybdenum. In another example, a sputtering target assembly is made using a backing plate composed of titanium. Advantageously, a solder bonding process is used, including bonding a silicon target to the backing plate to allow control over the deflection of the assembly.

[0022] EXAMPLE 1: A backing plate is prepared for solder bonding by machining one continuous channel, for example a spiral pattern, on the surface to be bonded, followed by grit blasting and chemical cleaning the surface to be bonded. In order to improve wetting of the bonding surface and to improve adhesion of the solder material, both surfaces (Si target material and Mo backing plate) may be covered by an appropriate wetting or metal layer, preferably nickel, by appropriate technique, preferably sputtering. Once the interfacial surfaces are prepared for bonding, the target and backing plate are assembled by mating the described prepared surfaces and solder bonding them together by pressing the assembly at a temperature sufficient to melt the solder material, for example 200°C in the case of indium.

[0023] The shear strength for a solder bonded Si sputtering target assembly made with molybdenum is generally in the range of about 3,000 psi to 5,000 psi with the average being toward a value of 4,000 psi. As indicated previously, the process is also capable of producing sputtering target assemblies having backing plates with other alloys as well.

[0024] No delamination of target and backing plate was noted during processing in Example 1, which was confirmed by metallography.

[0025] EXAMPLE 2: A backing plate is prepared for solder bonding by machining one continuous channel, for example a spiral pattern, on the surface to be bonded, followed by grit blasting and chemical cleaning the surface to be bonded. In order to improve wetting of the bonding surface and to improve adhesion of the solder material, both surfaces (Si target material and Ti backing plate) may be covered by an appropriate wetting or metal layer, preferably nickel, by appropriate technique, preferably sputtering. Once the interfacial surfaces are prepared for bonding, the target and backing plate are assembled by mating the described prepared surfaces and solder bonding them together by pressing the assembly at a temperature sufficient to melt the solder material, for example 200°C in the case of indium.

[0026] The shear strength for a solder bonded Si sputtering target assembly made with titanium is generally in the range of about 3,000 psi to 5,000 psi with the average being toward a value of 4,000 psi. As indicated previously, the process is also capable of producing sputtering target assemblies having backing plates with other alloys as well.

[0027] No delamination of target and backing plate was noted during processing of Example 2, which was noted by metallography.

[0028] The percentage difference between the CTE of the target material and the CTE of the backing plate is preferably from -50% to +50%, more preferably in the range of about -25% to +25%. This difference is calculated as follows:

$$(1 - \text{CTE target} / \text{CTE backing plate}) \times 100$$

Most preferably, the percentage difference is between about -15% to about +15%.

[0029] While the methods described herein and the sputter target/backing plate assemblies produced in accordance with these methods constitute preferred embodiments of the invention, it is to be understood that the invention is not limited to these precise methods and sputter target/backing plate assembly structures, and that changes may be made in either without departing from the scope of the invention, which is defined in the following claims.

[0030] What is claimed is:

CLAIMS

1. A method of producing a sputtering target assembly, said method comprising the steps of:

a. providing a backing plate with a first mating surface, said backing plate composed of a first material having a first coefficient of thermal expansion (CTE);

b. providing a sputtering target with a second mating surface, said target composed of a second material having a second CTE;

c. solder bonding said backing plate to said target along said first and second mating surfaces, wherein the percentage difference between the CTE of the target and the CTE of the backing plate is from about -50% to about +50%.

2. The method of claim 1 wherein said first material is selected from the group consisting of molybdenum, zirconium, titanium, niobium, vanadium, tantalum, and alloys thereof.

3. The method of claim 2 wherein said second material is selected from the group consisting of silicon, silicon-germanium, silicide, tungsten, titanium-tungsten, tantalum, and alloys thereof.

4. The method of claim 3 wherein said second material is p-type silicon or n-type silicon.

5. The method of claim 1 wherein said first material is molybdenum or alloys thereof and said second material is silicon or alloys thereof.

6. The method of claim 1 wherein said first material is titanium or alloys thereof and said second material is silicon or alloys thereof.

7. The method of claim 1 wherein the percentage difference between the CTE of the target and the CTE of the backing plate is from about -25% to about +25%.

8. The method of claim 7 wherein the difference between the CTE of the target and the CTE of the backing plate is from about -15% to about +15%.

9. The method of claim 1 further comprising machining a continuous groove pattern in said first or second mating surface, said groove pattern being effective to facilitate a strong bond between said target and backing plate.

10. The method of claim 1 further comprising cooling said sputtering target assembly so as to avoid distortion and separation of said sputtering target assembly.

11. The method of claim 1 further comprising depositing a corrosion resistant layer onto a rear surface of said backing plate to protect said backing plate from corrosion.

12. The method of claim 1 further comprising depositing an intermediate metallic layer onto said first and second mating surfaces to improve adhesion of said solder bonding.

13. The method of claim 12 wherein said metallic layer is nickel or alloys thereof.

14. The method of claim 1 wherein said solder bonding is indium solder bonding.

15. A sputtering target assembly, comprising:

(a) a backing plate with a first mating surface, said backing plate composed of a first material having a first CTE;

(b) a sputtering target with a second mating surface, said target composed of a second material having a second CTE;

(c) said target being solder bonded to said backing plate along said first and second mating surfaces, wherein the percentage difference between the CTE of the target and the CTE of the backing plate is from about -50% to +50%.

16. The assembly of claim 15 wherein said first material is selected from the group consisting of molybdenum, zirconium, titanium, niobium, vanadium, tantalum, and alloys thereof.

17. The assembly of claim 16 wherein said second material is selected from the group consisting of silicon, silicon-germanium, tungsten, titanium-tungsten, tantalum, and alloys thereof.

18. The assembly of claim 17 wherein said second material is p-type silicon or n-type silicon.

19. The assembly of claim 15 wherein said first material is molybdenum or alloys thereof and said second material is silicon or alloys thereof.

20. The assembly of claim 15 wherein said first material is titanium or alloys thereof and said second material is silicon or alloys thereof.

21. The assembly of claim 15 wherein the percentage difference between the CTE of the target and the CTE of the backing plate is from about -25% to about +25%.

22. The assembly of claim 15 wherein the percentage difference between said CTE of the target and the CTE of the backing plate is from about -15% to about +15%.

23. The assembly of claim 15 wherein a continuous groove pattern is machined into a mating surface of said target or backing plate so as to facilitate a strong bond between said target and backing plate.

24. The assembly of claim 15 wherein a corrosion resistant layer is deposited onto a rear surface of said backing plate to protect said backing plate from corrosion.

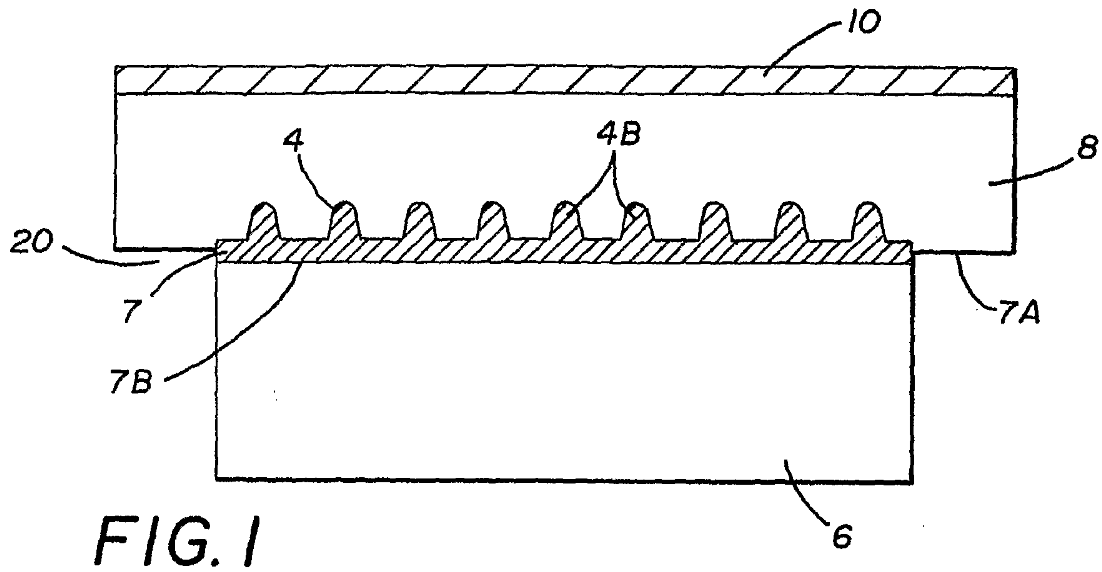

FIG. 1

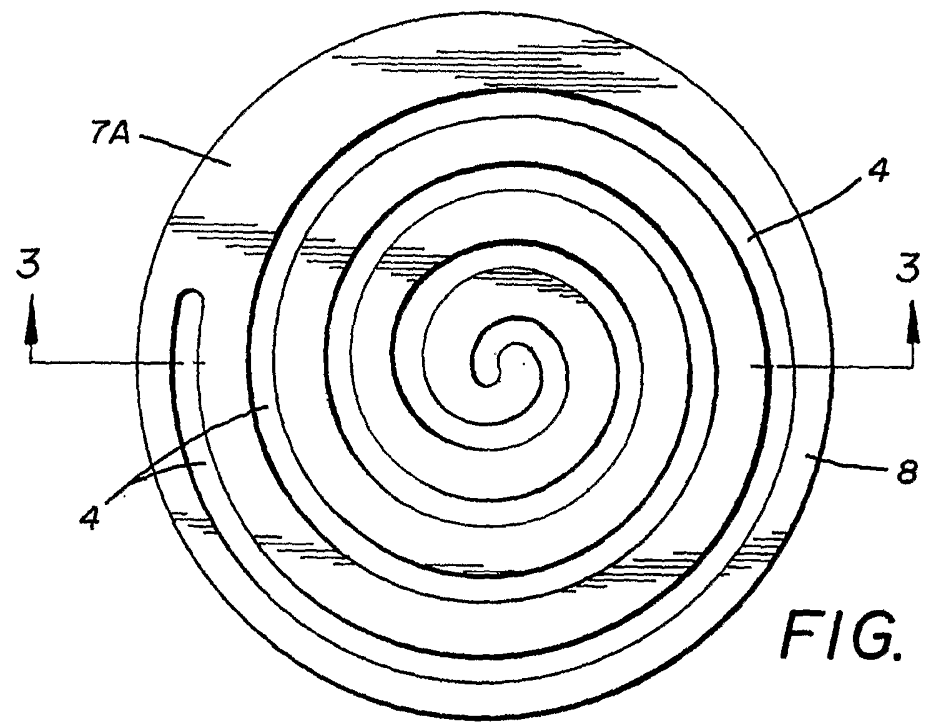

FIG. 2

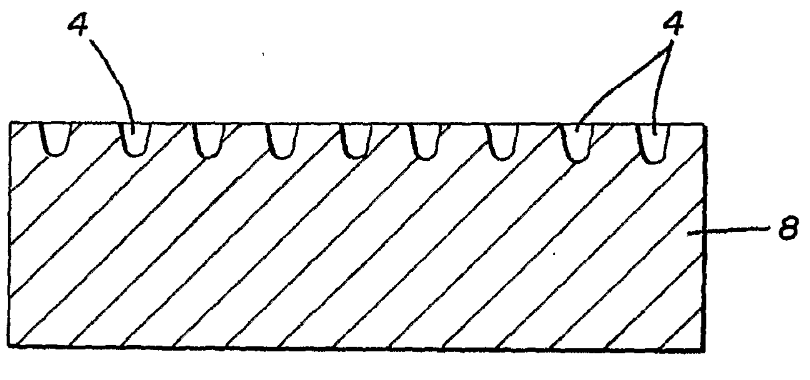

FIG. 3