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(54) Title: METHODS AND APPARATUS FOR HIGH REFLECTIVITY ALUMINUM LAYERS

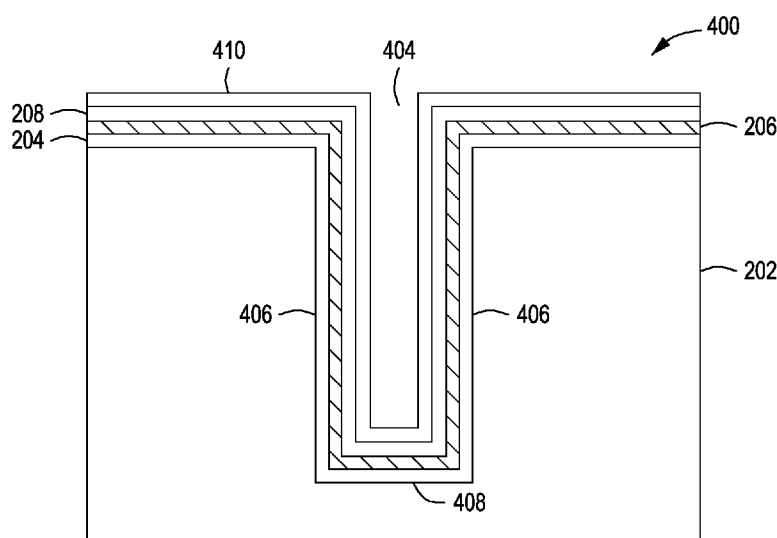


FIG. 4

(57) Abstract: Methods and apparatus for increasing reflectivity of an aluminum layer on a substrate. In some embodiments, a method of depositing an aluminum layer on a substrate comprises depositing a layer of cobalt or cobalt alloy or a layer of titanium or titanium alloy on the substrate with a chemical vapor deposition (CVD) process, pre-treating the layer of cobalt or cobalt alloy with a thermal hydrogen anneal at a temperature of approximately 400 degrees Celsius if a top surface of the layer of cobalt or cobalt alloy is compromised, and depositing a layer of aluminum on the layer of cobalt or cobalt alloy or the layer of titanium or titanium alloy with a CVD process at a temperature of approximately 120 degrees Celsius. Pre-treatment of the layer of cobalt or cobalt alloy may be accomplished for a duration of approximately 60 seconds to approximately 120 seconds.



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METHODS AND APPARATUS FOR HIGH REFLECTIVITY ALUMINUM LAYERS

FIELD

[0001] Embodiments of the present principles generally relate to semiconductor processing.

BACKGROUND

[0002] Semiconductors are formed in one or more process chambers which have the capability to process substrates (e.g., semiconductor wafers) in a controlled processing environment. Some of the process chambers are used to deposit materials onto a substrate such as, for example, aluminum. Due to the conductive and reflective properties of aluminum, aluminum has been incorporated into many different elements of semiconductor designs. Image sensors often use aluminum to provide reflective properties necessary for a sensor's operation. The semiconductor processes typically deposit an aluminum layer on a substrate made of silicon, usually on a titanium nitride (TiN) layer deposited on the substrate. However, the inventors have observed that the reflectivity of the aluminum when deposited on TiN has been generally poor at less than 50% reflectivity across a wide band of wavelengths. The poor reflectivity adversely affects the performance of the image sensors.

[0003] Thus, the inventors have provided improved methods and apparatus for deposition of an aluminum layer with high reflectivity.

SUMMARY

[0004] Methods and apparatus provide increased aluminum reflectivity for semiconductor processes.

[0005] In some embodiments, a method of depositing an aluminum layer on a substrate comprises depositing a layer of cobalt or cobalt alloy or a layer of titanium or titanium alloy on the substrate and depositing a layer of aluminum on the layer of cobalt or cobalt alloy or the layer of titanium or titanium alloy.

[0006] In some embodiments, the method may further include pre-treating the layer of cobalt or cobalt alloy with a thermal hydrogen anneal before depositing the layer of aluminum; pre-treating the layer of cobalt or cobalt alloy at a temperature of approximately 300 degrees Celsius to approximately 400 degrees Celsius; pre-

treating the layer of cobalt or cobalt alloy for a duration of approximately 60 seconds to approximately 120 seconds; wherein the layer of aluminum has a reflectivity of at least approximately 80% for wavelengths between approximately 250 nm and approximately 900 nm; depositing the layer of cobalt or cobalt alloy or the layer of titanium or titanium alloy to a thickness of approximately 20 angstroms to approximately 30 angstroms; depositing the layer of cobalt or cobalt alloy or the layer of titanium or titanium alloy with a chemical vapor deposition (CVD) process, a metal-organic chemical vapor deposition (MOCVD) process or a physical vapor deposition (PVD) process; wherein the layer of cobalt or cobalt alloy includes cobalt or cobalt silicon and wherein the layer of titanium or titanium alloy includes titanium, titanium silicon, or titanium aluminum; depositing the layer of aluminum to a thickness of approximately 300 angstroms to approximately 1,000 angstroms; depositing the layer of aluminum at a temperature of approximately 60 degrees Celsius to approximately 250 degrees Celsius; depositing the layer of aluminum using a hydrogen gas, an ammonia gas, a hydrazine compound gas, a hydrogen and ammonia mixed gas, or a hydrogen and hydrazine compound gas as a reactant gas; depositing the layer of aluminum using an alane type precursor or an alkyl type precursor; wherein the alane type precursor includes trimethylamine-alane borane (TMAAB), methyl pyridine aluminum, or dimethylethylamine-alane; wherein the alkyl type precursor includes dimethylaluminum hydride (DMAH); and/or depositing the layer of cobalt or cobalt alloy or the layer of titanium or titanium alloy on a layer of titanium nitride deposited on the substrate.

[0007] In some embodiments, a method of depositing an aluminum layer on a substrate comprises depositing a layer of cobalt or cobalt alloy or a layer of titanium or titanium alloy on the substrate with a chemical vapor deposition (CVD) process to a thickness of approximately 20 angstroms to approximately 30 angstroms, pre-treating the layer of cobalt or cobalt alloy with a thermal hydrogen anneal at a temperature of approximately 400 degrees Celsius if a top surface of the layer of cobalt or cobalt alloy is compromised, and depositing a layer of aluminum on the layer of cobalt or cobalt alloy or the layer of titanium or titanium alloy with a CVD process at a temperature of approximately 120 degrees Celsius and to a thickness of approximately 300 angstroms to approximately 1,000 angstroms.

[0008] In some embodiments, the method further comprises pre-treating the layer of cobalt or cobalt alloy for a duration of approximately 60 seconds to approximately 120 seconds; depositing the layer of cobalt or cobalt alloy or the layer of titanium or titanium alloy on a layer of titanium nitride deposited on the substrate; and/or wherein the layer of aluminum has a reflectivity of at least approximately 80% for wavelengths between approximately 250 nm and approximately 900 nm.

[0009] In some embodiments, an apparatus for reflecting varying wavelengths in a semiconductor device comprises a substrate formed from a silicon-based material, a titanium nitride layer deposited on the silicon-based material of the substrate, a cobalt or cobalt alloy layer or a titanium or titanium alloy layer deposited on the titanium nitride layer, and an aluminum layer deposited on the cobalt or cobalt alloy layer or a titanium or titanium alloy layer.

[0010] In some embodiments, the apparatus may further include a high aspect ratio feature having an opening with sides and a bottom formed in the substrate, wherein the aluminum layer is conformal to the sides and the bottom of the high aspect ratio feature and/or wherein the aluminum layer has a reflectivity of at least 80%.

[0011] Other and further embodiments are disclosed below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Embodiments of the present principles, briefly summarized above and discussed in greater detail below, can be understood by reference to the illustrative embodiments of the principles depicted in the appended drawings. However, the appended drawings illustrate only typical embodiments of the principles and are thus not to be considered limiting of scope, for the principles may admit to other equally effective embodiments.

[0013] Figure 1 is a method of forming high reflectivity aluminum layers in accordance with some embodiments of the present principles.

[0014] Figure 2 depicts a cross-sectional view of a structure formed from the method of Figure 1 in accordance with some embodiments of the present principles.

[0015] Figure 3 depicts a cross-sectional view of a structure with an aluminum layer formed from the method of Figure 1 in accordance with some embodiments of the present principles.

[0016] Figure 4 depicts a cross-sectional view of a high-aspect ratio feature with an aluminum layer in accordance with some embodiments of the present principles.

[0017] Figure 5 depicts a graph of reflectivity of an aluminum layer over a range of wavelengths in accordance with some embodiments of the present principles.

[0018] Figure 6 depicts a graph of comparative grain size of an aluminum layer in accordance with some embodiments of the present principles.

[0019] Figure 7 depicts a graph of comparative reflectivity of an aluminum layer after undergoing an annealing process in accordance with some embodiments of the present principles.

[0020] To facilitate understanding, identical reference numerals have been used, where possible, to designate identical elements that are common to the figures. The figures are not drawn to scale and may be simplified for clarity. Elements and features of one embodiment may be beneficially incorporated in other embodiments without further recitation.

DETAILED DESCRIPTION

[0021] The methods and apparatus provide a high reflectivity aluminum layer on a semiconductor substrate. A cobalt or cobalt alloy underlayer or titanium or titanium alloy underlayer advantageously increases the smoothness of the aluminum layer which, in turn, increases the reflectivity over a wide band of wavelengths. The methods and apparatus also provide a highly conformal aluminum layer while maintaining the increased reflectivity. The high reflectivity is also beneficially maintained after subsequent semiconductor processes that require thermal processing.

[0022] The inventors have found that using underlayers such as tungsten (W), Ruthenium (Ru), or titanium nitride (TiN) yield reflectivity numbers of less than 50% across a wide band of wavelengths. The tungsten, Ru, and TiN do not provide a good underlayer for aluminum deposition, causing poor reflectivity. The inventors

have discovered that underlayers of cobalt or cobalt alloy or titanium or titanium alloy provide a much higher reflectivity (e.g., approximately 85% across the band of wavelengths) and greater deposition rates for aluminum layers. The inventors have also found that lowering the deposition temperature of the aluminum layer yields a higher reflectivity for the aluminum layer and provides better step coverage and gap fill. The methods and apparatus of the present principles provide improved nucleation of the aluminum deposition on a cobalt or cobalt alloy or titanium or titanium alloy underlayer due to agglomeration at the substrate interface, yielding smoother and more continuous aluminum films and increased reflectivity.

[0023] Figure 1 is a method 100 of forming high reflectivity aluminum layers in accordance with some embodiments. At block 102, the method begins by depositing a cobalt or cobalt alloy layer or titanium or titanium alloy layer 208 on a substrate 202 as illustrated in Figure 2 which depicts a cross-sectional view of a structure 200 formed from the method of Figure 1. In some embodiments, a cobalt or cobalt alloy layer may include cobalt or a cobalt alloy such as, but not limited to, cobalt silicon (CoSi) and the like. In some embodiments, a titanium or titanium alloy layer may include titanium or a titanium alloy such as, but not limited to, titanium aluminum (TiAl), titanium silicon (TiSi), and the like. In some embodiments, the TiAl layer may be deposited using TiCl_4 (titanium tetrachloride) + TEA (triethylaluminium). The aluminum and/or chloride concentration may vary between approximately 10% to approximately 40% depending on process conditions and/or applications. In some embodiments, the substrate 202 may be formed from a silicon-based material and may have a layer of silicon oxide layer 204 on an upper surface of the substrate 202. In some embodiments, the substrate 202 may also have a titanium nitride (TiN) layer 206 deposited on the substrate 202 prior to the deposition of the cobalt or cobalt alloy layer or titanium or titanium alloy layer 208. In some embodiments, the cobalt or cobalt alloy layer or titanium or titanium alloy layer 208 may be approximately 20 angstroms to approximately 30 angstroms. In some embodiments, the cobalt or cobalt alloy layer or titanium or titanium alloy layer 208 may be deposited with a chemical vapor deposition (CVD) process, a metal-organic CVD (MOCVD) process or a physical vapor deposition (PVD) process using a cobalt or cobalt alloy or titanium or titanium alloy material.

[0024] At block 104, a pre-treatment may be optionally performed on the cobalt or cobalt alloy layer to clean the cobalt or cobalt alloy layer before deposition of an aluminum layer. In some environments, the cobalt or cobalt alloy layer may be exposed to oxygen which can form an oxide on the cobalt or cobalt alloy layer. The oxide and/or other contaminants are removed by the pre-treatment process. In some embodiments, the pre-treatment is a thermal hydrogen anneal process. In some embodiments, the pre-treatment is performed with hydrogen at a temperature of 400 degrees Celsius (C) for approximately 60 seconds. In some embodiments, the pre-treatment is performed with hydrogen for a time duration of approximately 60 seconds to approximately 120 seconds. In some embodiments, the pre-treatment is performed with hydrogen at a temperature of approximately 300 degrees C to approximately 400 degrees C. The pre-treatment of the cobalt or cobalt alloy layer may allow the aluminum to be better deposited on the cobalt or cobalt alloy layer by removing any contaminants on the surface of the cobalt or cobalt alloy layer. In some embodiments, the deposition of the cobalt or cobalt alloy layer is performed in a first semiconductor process tool and then moved to a second semiconductor process tool for pre-treatment. The inventors have found that hydrogen provides better aluminum deposition results than ammonium and that the duration of the pre-treatment did not have a strong impact due to the thinness of the treated cobalt or cobalt alloy layer.

[0025] At block 106, an aluminum layer 310 is deposited on the cobalt or cobalt alloy layer or titanium or titanium alloy layer 208 as illustrated, for example, in Figures 2 and 3. In some embodiments, the aluminum layer 310 may be deposited in a third semiconductor process tool (e.g., MOCVD or CVD chamber) other than the first and second semiconductor process tools used for the cobalt or cobalt alloy layer or titanium or titanium alloy layer 208 and the pre-treatment, respectively. The aluminum layer 310 has an interface nucleation 308 with the cobalt or cobalt alloy layer or titanium or titanium alloy layer 208. The intermixing between the aluminum layer 310 and the cobalt or cobalt alloy layer or titanium or titanium alloy layer 208 helps the nucleation of the aluminum layer 310 which allows for better deposition of the aluminum layer 310. In some embodiments, deposition of the aluminum layer 310 may have an increased deposition rate of approximately 80% to approximately 95% over tungsten and TiN underlayers. The interface nucleation provides a higher film continuity that allows for thinner aluminum layers with high reflectivity. In some

embodiments, the aluminum deposition temperatures may range from approximately 60 degrees C to approximately 250 degrees C. The inventors have found that decreasing the temperature may help in increasing reflectivity of the deposited aluminum layer 310. In some embodiments, the aluminum deposition temperature may be approximately 120 degrees C to yield a higher level of reflectivity (at least approximately 85%) for the aluminum deposition layer.

[0026] In some embodiments, the reflectivity of the aluminum layer 310 may be more than 50% to approximately 90% or greater. The inventors have found that the deposition precursor used, the thickness of the deposition, and the deposition temperature may affect the reflectivity of the aluminum layer. In some embodiments, the aluminum deposition precursor may be an alane type precursor such as, for example, trimethylamine-alane borane (TMAAB), methyl pyridine aluminum, or dimethylethylamine-alane (DMEAA). In some embodiments, the aluminum deposition precursor may be an alkyl type precursor such as, for example, dimethylaluminum hydride (DMAH). The DMAH may prove difficult to handle due to the DMAH having high viscosity. In some embodiments, the DMAH may have a small amount (approximately 0.1% to approximately 5%) of solvent or additive added to the DMAH to make it easier to handle. In some embodiments, the aluminum deposition process may use a reactant gas such as, for example, a hydrogen gas (H_2), an ammonia gas (NH_3), a hydrazine compound gas, or a mixed gas (e.g., $H_2 + NH_3$, $H_2 +$ hydrazine compound gas, etc.).

[0027] In some embodiments, aluminum reflectivity of at least 85% may be obtained over wavelengths ranging from approximately 250 nm to approximately 900 nm. In some embodiments, the thickness of the aluminum layer may be approximately 300 angstroms to approximately 1,000 angstroms. A smaller thickness helps to make the aluminum layer more conformal, especially on high-aspect ratio features of a substrate. Tungsten and TiN underlayers require a thick layer of aluminum before the aluminum becomes continuous. The cobalt or cobalt alloy underlayer or titanium or titanium alloy underlayer allows a higher continuity with a thinner layer of aluminum, yielding thin, conformal aluminum layers with high reflectivity and a greater range of applications. The properties of the aluminum layer according to the methods and apparatus of the present principles makes the aluminum layer ideal for use on high-aspect ratio features and redistribution layers (RDL) where high-resolution conductive

patterning is used over varying step-heights and also in applications where subsequent processing uses additional heating steps (e.g., back-end-of-line (BEOL) processes, etc.).

[0028] Figure 4 illustrates a cross-sectional view of a high-aspect ratio feature 400 with a conformal aluminum layer 410 in accordance with some embodiments. The high-aspect ratio feature 400 has an opening 404, sides 406, and a bottom 408. The substrate 202 is made of a silicon-based material that may have a silicon oxide layer 204 on a surface of the substrate 202. A cobalt or cobalt alloy layer or titanium or titanium alloy layer 208 is deposited on a TiN layer 206 which is deposited on the substrate 202. The conformal aluminum layer 410 is deposited on the cobalt or cobalt alloy layer or titanium or titanium alloy layer 208 such that the conformal aluminum layer 410 conforms to the high-aspect ratio feature 400 on the bottom 408 and sides 406 while maintaining high reflectivity, even in the high-aspect ratio feature 400. In some embodiments the conformal aluminum layer 410 may have a thickness of approximately 500 angstroms. The thinness afforded by the methods and apparatus of the present principles allows aluminum to be deposited in a conformal manner even when features have high-aspect ratios. The conformal characteristic of the methods and apparatus of the present principles also permits deposition of aluminum layers over varying step-heights such as those encountered during construction of redistribution layers (RDL).

[0029] Figure 5 depicts a graph 500 of reflectivity of an aluminum layer over a range of wavelengths in accordance with some embodiments. The graph 500 illustrates the high level of reflectivity discovered by the inventors for a wide range of wavelengths using methods and apparatus of the present principles. In some embodiments, the wavelengths exhibited reflectivity on an aluminum layer of at least approximately 85%. Figure 6 depicts a graph 600 of comparative grain size of an aluminum layer in accordance with some embodiments. The inventors found that cobalt (Co) 606 produced a much smaller aluminum grain size compared to tungsten (W) 604 or Ruthenium (Ru) 602. The smaller grain size of cobalt 606 is believed by the inventors to help in providing high film continuity for the aluminum layer with reduced thickness. Figure 7 depicts a graph 700 of comparative reflectivity of an aluminum layer after undergoing an annealing process in accordance with some embodiments. The inventors subjected an aluminum layer with high reflectivity to an annealing process

to illustrate the effect of subsequent semiconductor thermal processing steps on the reflectivity of the aluminum layer deposited according to the present principles. The after-anneal reflectivity 704 was within a negligible percentage of the pre-anneal reflectivity 702 over the band of wavelengths tested. Due to the advantageous robustness of the methods and apparatus of the present principles, subsequent semiconductor processes that use thermal heating will have little negative impact on the reflectivity.

[0030] While the foregoing is directed to embodiments of the present principles, other and further embodiments of the principles may be devised without departing from the basic scope thereof.

CLAIMS

1. A method of depositing an aluminum layer on a substrate, comprising:
depositing a layer of cobalt or cobalt alloy or a layer of titanium or titanium alloy on the substrate; and
depositing a layer of aluminum on the layer of cobalt or cobalt alloy or the layer of titanium or titanium alloy.
2. The method of claim 1, further comprising:
pre-treating the layer of cobalt or cobalt alloy with a thermal hydrogen anneal before depositing the layer of aluminum.
3. The method of claim 2, further comprising:
pre-treating the layer of cobalt or cobalt alloy at a temperature of approximately 300 degrees Celsius to approximately 400 degrees Celsius.
4. The method of claim 2, further comprising:
pre-treating the layer of cobalt or cobalt alloy for a duration of approximately 60 seconds to approximately 120 seconds.
5. The method of claim 1, wherein the layer of aluminum has a reflectivity of at least approximately 80% for wavelengths between approximately 250 nm and approximately 900 nm.
6. The method of claim 1, further comprising:
depositing the layer of cobalt or cobalt alloy or the layer of titanium or titanium alloy to a thickness of approximately 20 angstroms to approximately 30 angstroms.
7. The method of claim 1, further comprising:
depositing the layer of aluminum to a thickness of approximately 300 angstroms to approximately 1,000 angstroms.

8. The method of claim 1, further comprising:
depositing the layer of aluminum at a temperature of approximately 60 degrees Celsius to approximately 250 degrees Celsius.
9. The method of claim 1, further comprising:
depositing the layer of aluminum using an alane type precursor or an alkyl type precursor, wherein the alane type precursor includes trimethylamine-alane borane (TMAAB), methyl pyridine aluminum, or dimethylethylamine-alane, and wherein the alkyl type precursor includes dimethylaluminum hydride (DMAH).
10. The method of claim 1, further comprising:
depositing the layer of cobalt or cobalt alloy or the layer of titanium or titanium alloy on a layer of titanium nitride deposited on the substrate.
11. A method of depositing an aluminum layer on a substrate, comprising:
depositing a layer of cobalt or cobalt alloy or a layer of titanium or titanium alloy on the substrate with a chemical vapor deposition (CVD) process to a thickness of approximately 20 angstroms to approximately 30 angstroms;
pre-treating the layer of cobalt or cobalt alloy with a thermal hydrogen anneal at a temperature of approximately 400 degrees Celsius if a top surface of the layer of cobalt or cobalt alloy is compromised; and
depositing a layer of aluminum on the layer of cobalt or cobalt alloy or the layer of titanium or titanium alloy with a CVD process at a temperature of approximately 120 degrees Celsius and to a thickness of approximately 300 angstroms to approximately 1,000 angstroms.
12. The method of claim 11, further comprising:
pre-treating the layer of cobalt or cobalt alloy for a duration of approximately 60 seconds to approximately 120 seconds.
13. The method of claim 11, further comprising:
depositing the layer of cobalt or cobalt alloy or the layer of titanium or titanium alloy on a layer of titanium nitride deposited on the substrate.

14. The method of claim 11, wherein the layer of aluminum has a reflectivity of at least approximately 80% for wavelengths between approximately 250 nm and approximately 900 nm.

15. An apparatus for reflecting varying wavelengths in a semiconductor device, comprising:

- a substrate formed from a silicon-based material;
- a titanium nitride layer deposited on the silicon-based material of the substrate;
- a cobalt or cobalt alloy layer or a titanium or titanium alloy layer deposited on the titanium nitride layer; and
- an aluminum layer deposited on the cobalt or cobalt alloy layer or a titanium or titanium alloy layer, wherein the aluminum layer has a reflectivity of at least 80%.

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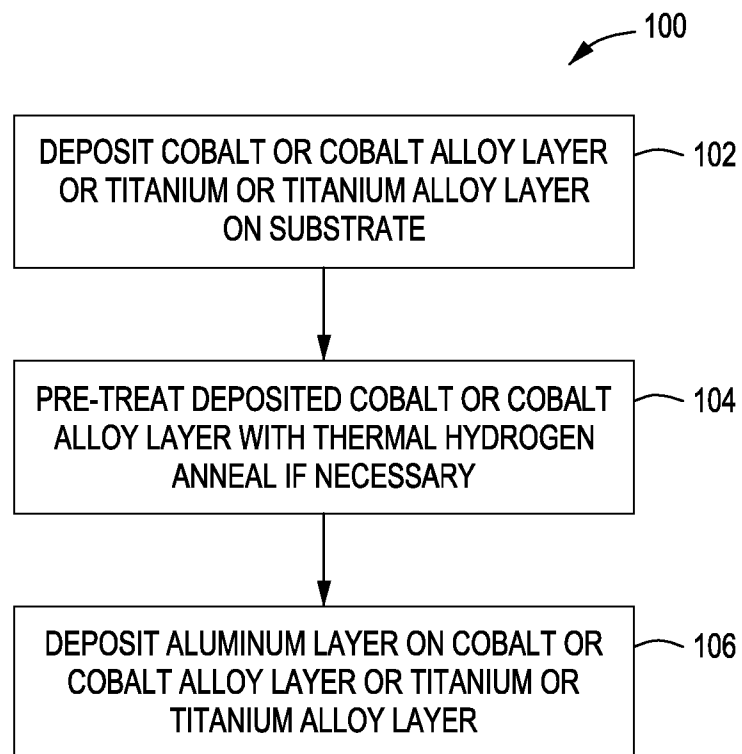


FIG. 1

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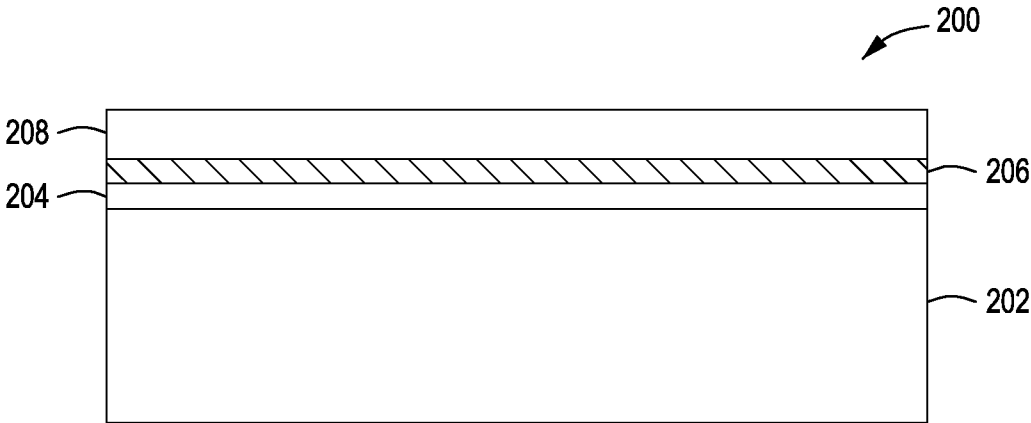


FIG. 2

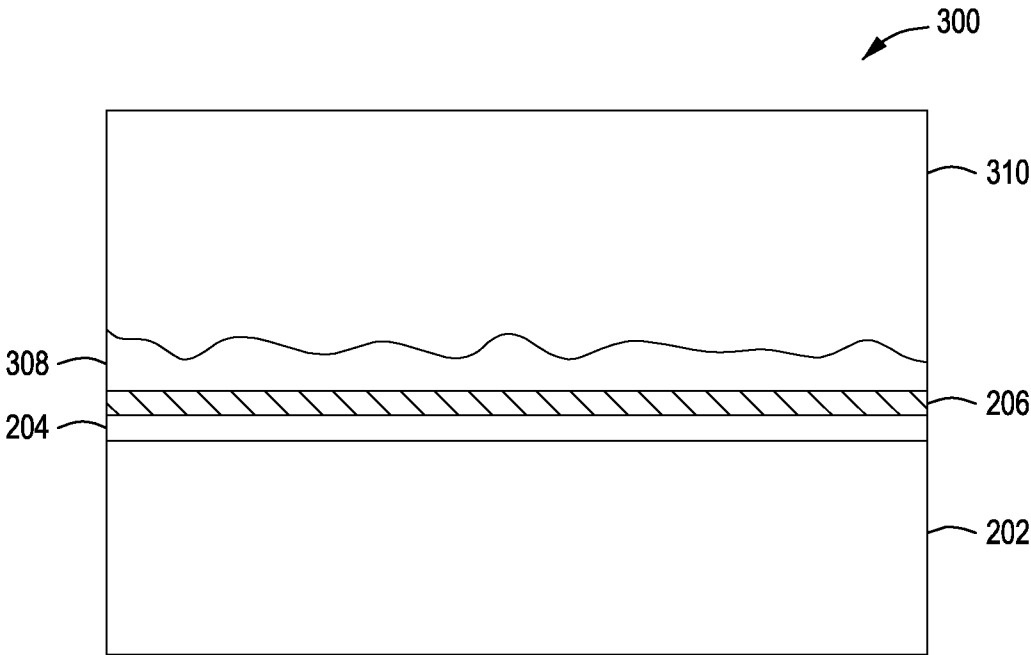


FIG. 3

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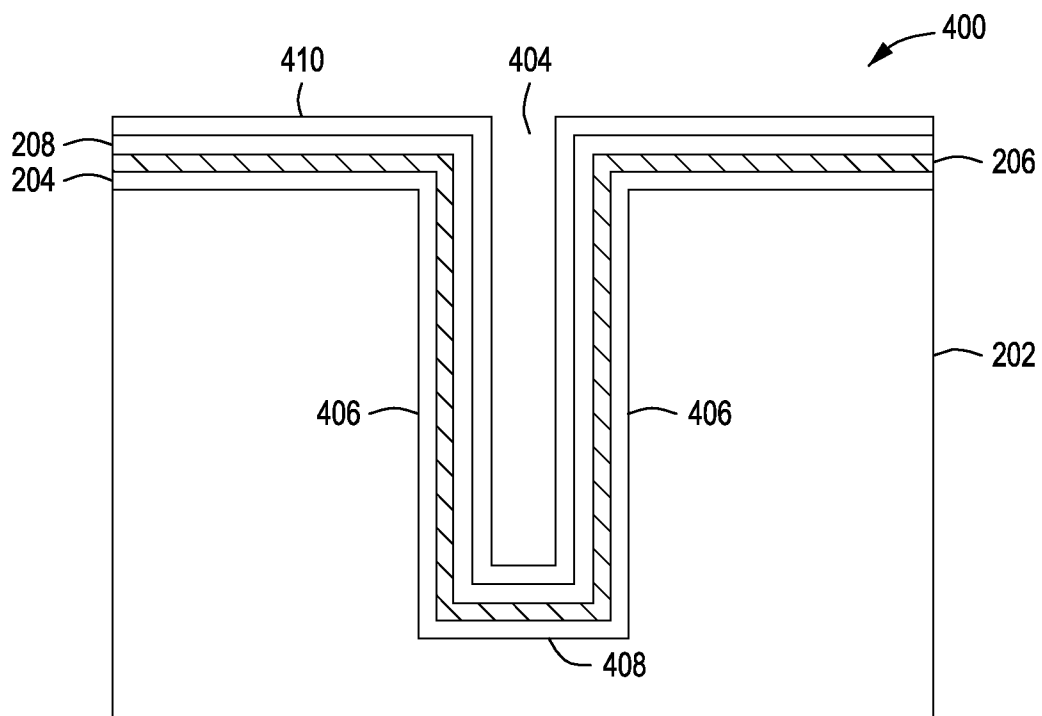


FIG. 4

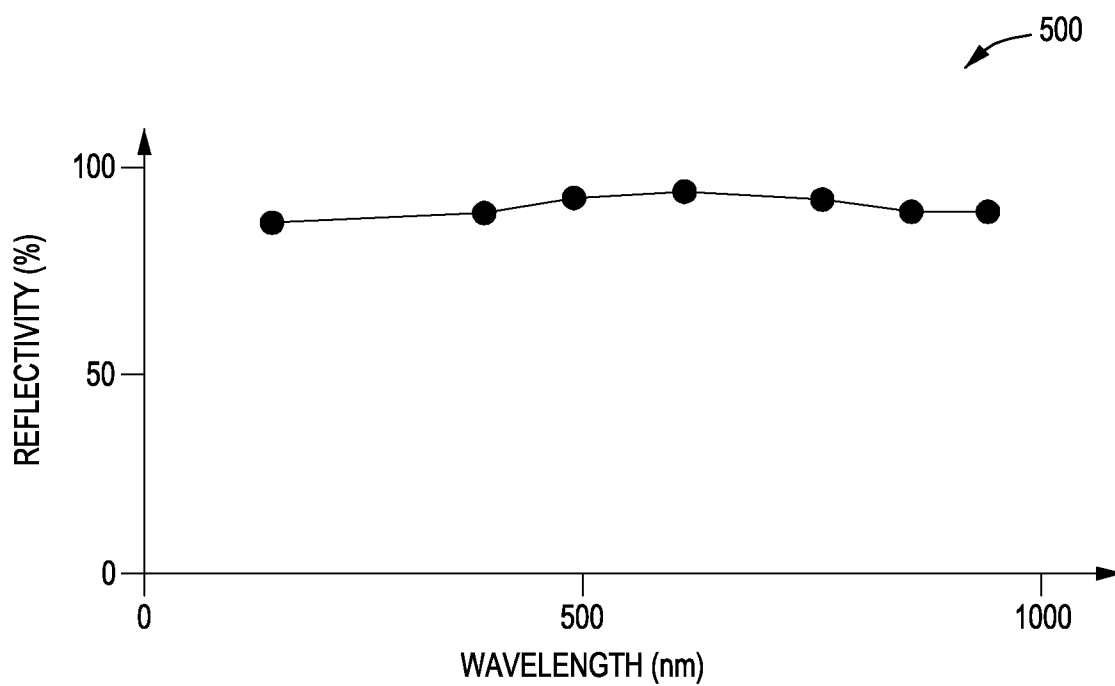


FIG. 5

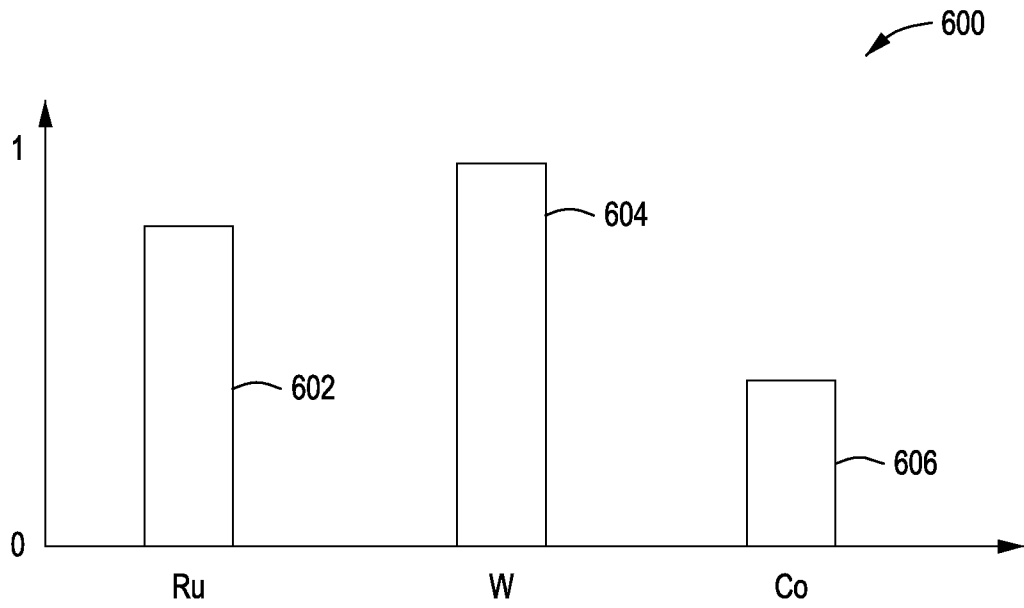


FIG. 6

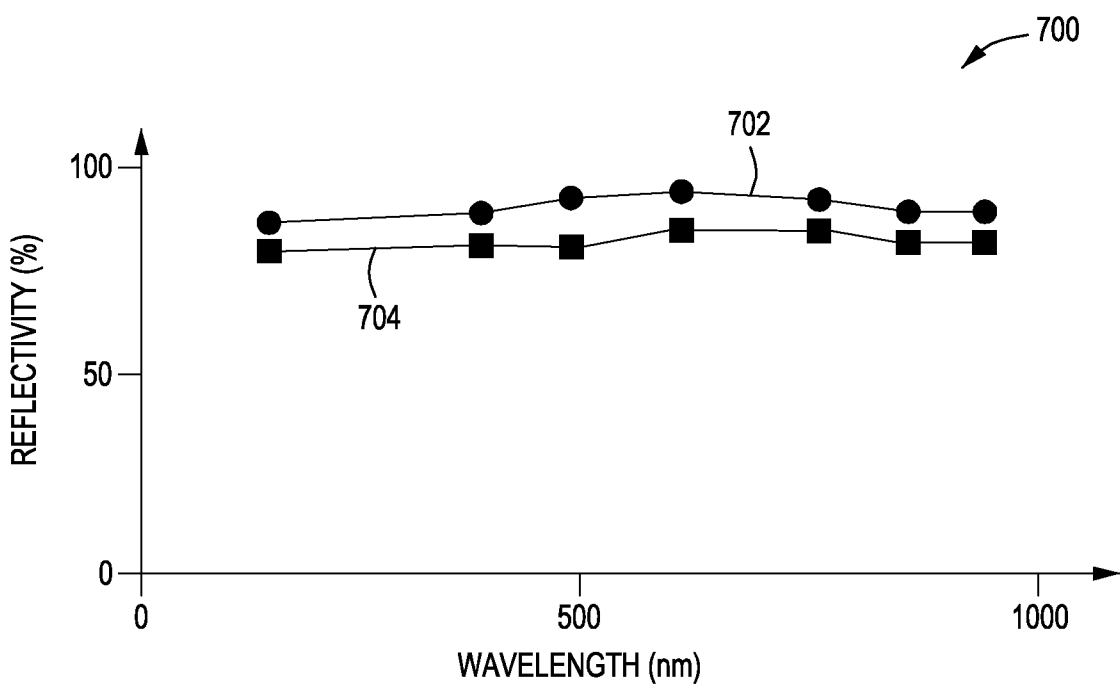


FIG. 7

A. CLASSIFICATION OF SUBJECT MATTER**H01L 21/67(2006.01)i, H01L 21/683(2006.01)i, H01S 3/00(2006.01)i, H01L 21/02(2006.01)i, H01L 21/311(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H01L 21/67; H01L 21/28; H01L 21/285; H01L 21/3105; H01L 21/3205; H01L 21/44; H01L 21/4763; H01L 33/00; H01L 21/683; H01S 3/00; H01L 21/02; H01L 21/311

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) & keywords: reflectivity, aluminum layer, deposition, cobalt, titanium, image sensor, thermal hydrogen anneal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6383915 B1 (SU et al.) 07 May 2002 See column 10, lines 48-49 and claims 1-2, 4, 15, 24, 26, 28.	1,5-8,10
Y		2-4,9,11-15
Y	US 5047367 A (WEI et al.) 10 September 1991 See column 3, lines 20-33 and claims 1, 3, 9.	2-4,11-14
Y	JP 09-115908 A (MOTOROLA INCORPORATED) 02 May 1997 See paragraph [0021].	9
Y	US 2009-0134419 A1 (ZHOU) 28 May 2009 See paragraphs [0003], [0039], [0046], [0051], [0054], [0058], [0068] and claim 12.	15
A	US 2015-0262823 A1 (TAIWAN SEMICONDUCTOR MANUFACTURING COMPANY, LTD.) 17 September 2015 See paragraph [0010] and claims 5, 16-17.	1-15



Further documents are listed in the continuation of Box C.



See patent family annex.

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Date of the actual completion of the international search

16 August 2019 (16.08.2019)

Date of mailing of the international search report

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Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2019/030307

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6383915 B1	07/05/2002	EP 1032032 A2 EP 1032032 A3 JP 2000-299322 A KR 10-0753289 B1 KR 10-2000-0062522 A TW 501231 B	30/08/2000 11/07/2001 24/10/2000 29/08/2007 25/10/2000 01/09/2002
US 5047367 A	10/09/1991	JP 05-102078 A	23/04/1993
JP 09-115908 A	02/05/1997	CN 1150325 A EP 0766302 A2 EP 0766302 A3 KR 10-1997-0018001 A SG 42438 A1	21/05/1997 02/04/1997 13/05/1998 30/04/1997 15/08/1997
US 2009-0134419 A1	28/05/2009	CN 101454907 A CN 101454907 B EP 2030254 A2 EP 2030254 B1 JP 2007-318157 A JP 5406436 B2 TW 200807761 A TW I469390 B US 2007-0275489 A1 US 7501295 B2 US 7612384 B2 WO 2007-138527 A2 WO 2007-138527 A3	10/06/2009 02/05/2012 04/03/2009 18/07/2018 06/12/2007 05/02/2014 01/02/2008 11/01/2015 29/11/2007 10/03/2009 03/11/2009 06/12/2007 12/09/2008
US 2015-0262823 A1	17/09/2015	TW 201535746 A TW I536576 B US 9396953 B2	16/09/2015 01/06/2016 19/07/2016