

55 50 45 40 35 30 25 20 15 10

Table 7

Sample No.	Target	Substrate temperature (°C)	Surrounding gas composition, oxygen/ argon (vol%)	Titanium oxide film		
				Crystallinity	Triolein-decomposing ability, residual amount (%)	Contact angle with water (degree)
Comparative Sample 5	titanium metal	230	100/0	anatase	89	22
Comparative Sample 6	titanium metal	350	100/0	anatase	75	19

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5 [0067] The above results show that in order for the conventional reactive sputtering method using titanium metal as a target to obtain a titanium oxide film having photocatalytic activity, the substrate should be heated to a temperature as high as 350°C, and that the photocatalytic activity thus obtained is not so high. The results further show that a titanium oxide film having photocatalytic activity cannot be obtained at a substrate temperature of 230°C, i.e., a titanium oxide film having high catalytic activity cannot be obtained at low temperatures.

[0068] The above Examples and Comparative Examples demonstrate that according to the process of the present invention for producing a multilayer structure, films having high catalytic activity can be obtained at relatively low substrate temperatures of 270°C or lower. The Examples further demonstrate that the photocatalytically active titanium oxide films obtained have antifouling properties and are practically useful.

10 [0069] According to the process of the present invention for producing a multilayer structure, a photocatalytically active titanium oxide film is formed on a substrate by sputtering in an atmosphere capable of having a regulated vacuum using a conductive sinter target obtained by sintering a mixture of particles of titanium oxide and particles of at least one metal oxide selected from the group consisting of niobium oxide, tantalum oxide, vanadium oxide, zirconium oxide, tin oxide, chromium oxide and copper oxide. Consequently, a multilayer structure having a photocatalytically active film can be produced at high rate without the necessity of heating the substrate at high temperature.

15 [0070] As a result, it has become possible to produce a multilayer structure using a large glass plate as a substrate, such as a window glass, using a sputtering apparatus having a simplified heating mechanism. The equipment cost can hence be reduced.

[0071] Since lower substrate temperatures can be used in substrate heating, a photocatalytically active film can be formed on organic resin substrates and the like.

20 [0072] Furthermore, by regulating the conductivity of the sinter target so that the surface resistance thereof is 500 Ω/□ or lower, not only a multilayer structure can be produced with a direct current glow discharge continuing stably, but also a film having enhanced catalytic activity can be obtained when the substrate is heated to 170 to 270°C.

25 [0073] The multilayer structure of the present invention has a titanium oxide film which contains as a minor component at least one metal oxide selected from the group consisting of niobium oxide, tantalum oxide, vanadium oxide, zirconium oxide, tin oxide, chromium oxide and copper oxide, and which is substantially amorphous when analyzed by the X-ray diffraction method. Due to this constitution, the multilayer structure has high photocatalytic activity.

[0074] By regulating the content of the metal oxide(s) as the minor component to 1 to 10% by weight, the titanium oxide film can be an amorphous film having high photocatalytic activity.

30 [0075] Furthermore, by interposing, between the substrate and the titanium oxide film, a primer film which serves to prevent any alkali component of the substrate from dissolving in the titanium oxide film, the photocatalytic activity of the multilayer structure can be made to last over long period of time. Moreover, by partly or wholly coating the titanium oxide film with a hydrophilic film, the surface of the multilayer structure can be made more hydrophilic and the antifouling properties can be enhanced.

## 35 Claims

- 40 1. A process for producing a multilayer structure comprising a substrate and formed thereon a film mainly comprising titanium oxide and having photocatalytic activity, which comprises forming the film by sputtering a conductive sinter target obtained by sintering a mixture of particles of titanium oxide and particles of at least one metal oxide selected from the group consisting of niobium oxide, tantalum oxide, vanadium oxide, zirconium oxide, tin oxide, chromium oxide and copper oxide, in an atmosphere capable of having a regulated vacuum.
- 45 2. The process for producing a multilayer structure as claimed in claim 1, wherein the target has a conductivity such that the surface resistance thereof is 500 Ω/□ or lower, and the sputtering is conducted with a direct current glow discharge.
- 50 3. The process for producing a multilayer structure as claimed in claim 1, wherein the film mainly comprising titanium oxide is formed while heating the substrate at a temperature of from 170 to 270°C.
4. The process for producing a multilayer structure as claimed in claim 3, wherein the film mainly comprising titanium oxide is formed while heating the substrate at a temperature of from 200 to 250°C.
- 55 5. The process for producing a multilayer structure as claimed in claim 1, wherein the metal oxide is niobium oxide.
6. A multilayer structure comprising a substrate and formed thereon a film mainly comprising titanium oxide and having photocatalytic activity, said film containing as a minor component at least one metal oxide selected from

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the group consisting of niobium oxide, tantalum oxide, vanadium oxide, zirconium oxide, tin oxide, chromium oxide and copper oxide, and being substantially amorphous when analyzed by the X-ray diffraction method.

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7. The multilayer structure as claimed in claim 6, wherein the substantially amorphous film mainly comprising titanium oxide comprises an amorphous matrix containing microcrystals.
8. The multilayer structure as claimed in claim 6, wherein the content of the metal oxide as the minor component in the film mainly comprising titanium oxide is from 1 to 10% by weight.
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9. The multilayer structure as claimed in claim 8, wherein the metal oxide as the minor component is niobium oxide.
10. The multilayer structure as claimed in claim 6, which has, interposed between the substrate and the film consisting mainly of titanium oxide, a primer film which serves to prevent any alkali component of the substrate from dissolving in the film mainly comprising titanium oxide.
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11. The multilayer structure as claimed in claim 6, wherein the film mainly comprising titanium oxide is coated with a hydrophilic film.
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12. The multilayer structure as claimed in claim 11, wherein the primer film and the hydrophilic film each is a film of silicon dioxide.
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FIG. 1

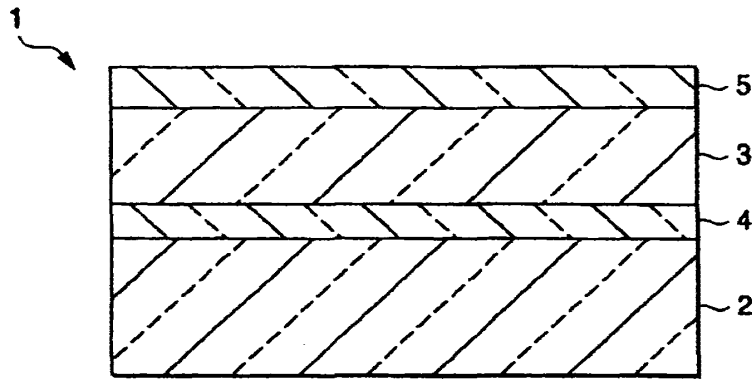


FIG. 2

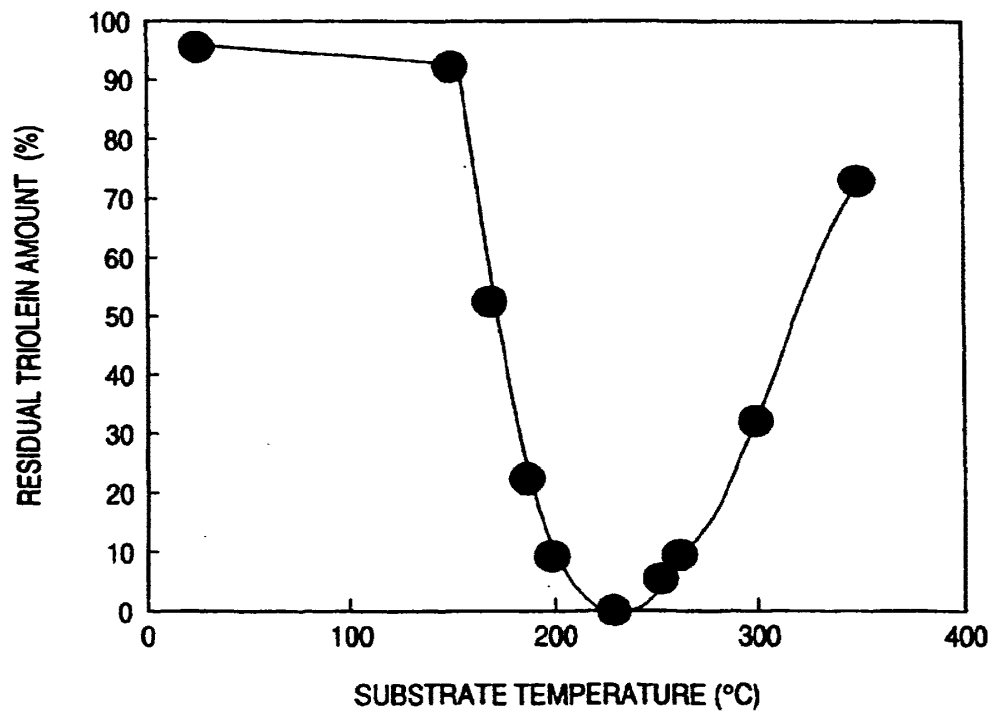
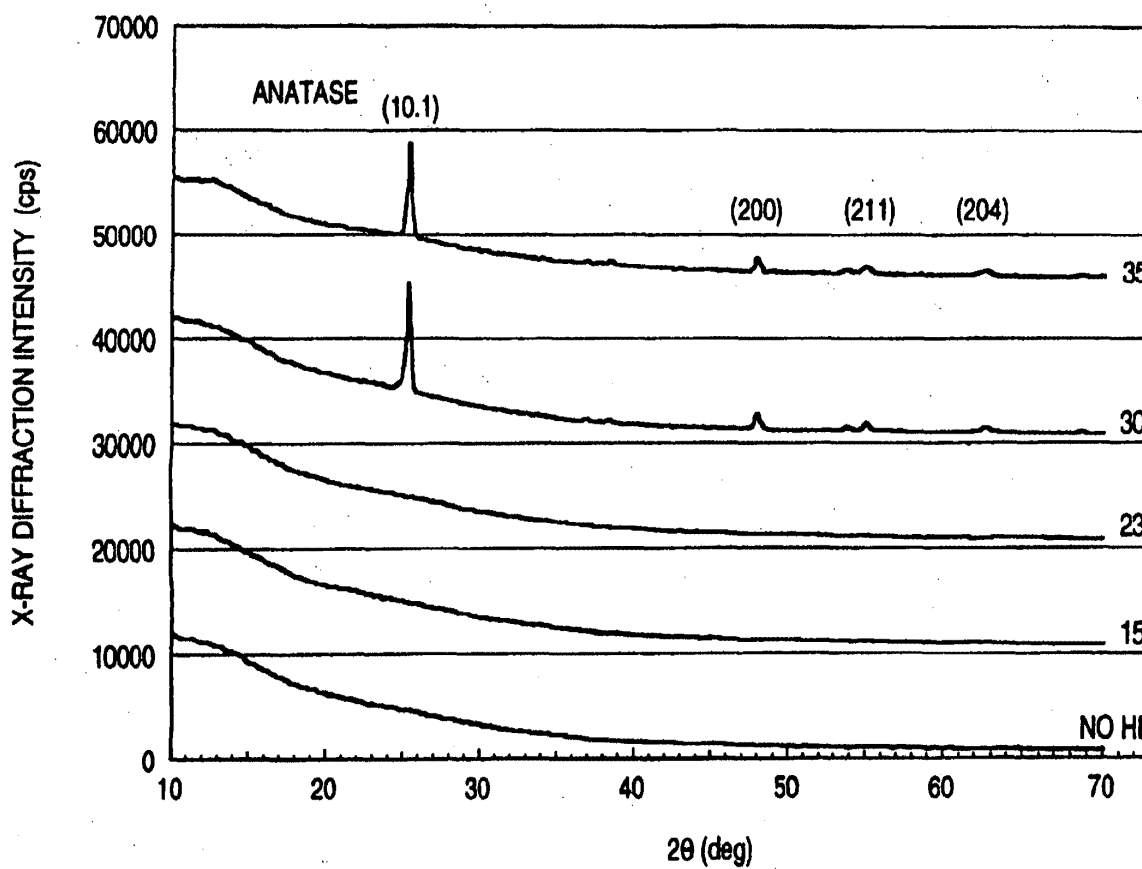


FIG. 3



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