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COMPONENTS HAVING A FILM STRUCTURE AND METHODS OF FORMING COMPONENTS HAVING A FILM STRUCTURE

Field of the invention

The present invention relates to methods of forming components having a film structure, micro-electro-mechanical systems (MEMS) devices formed according to such methods, components having a film structure and MEMS devices comprising such components.

Background of the invention

In the design of silicon-based micro-actuators and advanced micro-electro-mechanical systems (MEMS), it is important to minimise the vibration and noise produced due to the high operational speed and/or impact loading. This is described in various publications, for example in the publication by Y. Fu, H. Du, W. Huang, S. Zhang, and M. Hu, in Sens. Actuators A 112, 395 (2004), in the publication by P. Krulevitch, A. P. Lee, P. B. Ramsey, J. C. Trevino, J. Hamilton, and M. A. Northrup, J. in Microelectromech. Syst. 5, 270 (1996), in the publication by H. Kahn, M. A. Huff, and A. H. Heuer, J. in Micromech. Microeng. 8, 213 (1998), in the publication by X.-G. Ma and K. Komvopoulos, in Appl. Phys. Lett. 83, 3773 (2003) and in the publication by X.-G. Ma and K. Komvopoulos, in Appl. Phys. Lett. 84, 4274 (2004).

Conventionally, the noise and vibration have been reduced by damping the motions of the mechanisms using shape memory alloy (SMA) bulk materials and SMA fibre-reinforced composite polymers. Nickel titanium (NiTi) shape memory alloy (SMA) thin films have also been found to be effective in this regard due to their very good shape-memory effects, superelasticity, high corrosion resistance and biocompatibility. Moreover, bulk NiTi alloys are reported to exhibit high mechanical damping with relatively high strength properties and are promising for energy dissipation applications. This is



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described in the publication by I. Schmidt and R. Lammering in *Mater. Sci. Eng. A* 378, 70 (2004) and in the publication by N. Igata, N. Urahashi, Y. Kogo, and M. Sasaki, J. in *Alloys Compd.* 355, 85-89 (2003).

The high damping performance of bulk NiTi alloys originates from the stress-induced martensitic transition between the high-temperature phase austenite (B2) and the low-temperature phase martensite (B19'), as well as from the intrinsic damping generated in the B2 and B19' phases. The intrinsic damping of the B19' phase is quite high due to the stress-induced reorientation of martensite. By contrast, the intrinsic damping of the B2 phase is relatively low. However, the intrinsic damping of the B2 phase can demonstrate high energy dissipation if the applied stress is high enough to induce the martensitic transition.

It has been reported in, for example, the publication by C. Craciunescu and M. Wuttig, in *Thin Solid Films* 379, 173 (2000) and the publication by Q. Su, S. Z. Hua, and M. Wuttig, J. in *Alloys Compd.* 211-212, 460 (1994), that an SMA/Silicon (Si) composite structure could exhibit damping and modulus softening if a film several microns thick could be achieved. The feasibility of this was demonstrated using SMA-coated Copper (Cu) beams as the passive damping solution to MEMS inertial-guidance systems. This is described in the publication by D. A. Ruggles, E. Gans, K. P. Mohanchandra, G. P. Carman, E. Ngo, W. Nothwang, and M. W. Cole, in *SPIE* 5387, 156 (2004).

Typically, NiTi films are sputtered onto Si wafers from a NiTi alloy target, either at room temperature followed by post-annealing process under high vacuum, or at the heated substrate above 450°C in order to improve its crystallinity. However, there is a problem due to the large mismatch in the coefficient of thermal expansion (CTE) between Si (4.15×10^{-6} /°C) and NiTi (11×10^{-6} /°C in austenite). This would induce a large tensile thermal stress in NiTi films, which may lead to severe cracking and delaminating when a

certain thickness is achieved. Experimentally, it has not proved possible to deposit polycrystalline NiTi films on bare Si substrates over thickness of $4\text{ }\mu\text{m}$.

Thus there is a need for a process enabling the deposition of thick (that is more than around $10\text{ }\mu\text{m}$) SMA films for MEMS devices.

Summary of the invention

In broad terms, a first aspect of the present invention relates to a method of forming a component having a film structure in which a nickel-titanium layer is applied to a substrate with an interleaved compressive layer therebetween to increase the thickness of the film.

More particularly, according to a first aspect of the present invention there is provided a method of forming a component having a film structure comprising:

applying a first layer to a substrate to form a compressive layer;
and

applying a layer comprising a nickel-titanium alloy to the first layer such that the first layer is located between the layer comprising a nickel-titanium alloy and the substrate.

Preferably, the substrate comprises silicon and the step of applying a first layer to the substrate comprises thermally oxidising a first layer of the silicon substrate to form the compressive layer, the compressive layer comprising a thermal oxidation silicon dioxide layer.

The compressive layer is advantageous as it acts to compensate the thermal stress of the NiTi layer.

Preferably, the method further comprises applying a second layer of material to the compressive layer prior to applying the layer comprising a nickel-

titanium alloy such that the second layer is located between the layer comprising a nickel-titanium alloy and the compressive layer.

Preferably, a further layer is applied to the second layer.

In a preferred embodiment, the second layer comprises a noble metal, for example platinum or gold.

Preferably, a layer comprising titanium is applied as the second layer to the compressive layer, and a layer comprising platinum is applied as the further layer to the second layer comprising titanium prior to applying the layer comprising a nickel-titanium alloy to the second layer comprising platinum.

In an alternative preferred embodiment, a layer comprising chromium is applied as the second layer to the compressive layer, the method further comprising applying as the further layer a layer comprising gold to the second layer comprising chromium prior to applying the layer comprising a nickel-titanium alloy to the second layer comprising gold.

The inclusion of the noble metal layer with the additional titanium or chromium layer (for example as layers formed of Pt/Ti or Au/Cr) is particularly advantageous as these layers act to enhance the adhesion to the substrate thereby reducing or inhibiting the likelihood of delamination.

Preferably, the layer comprising a nickel-titanium alloy is applied by sputtering.

The substrate is preferably maintained at a temperature of more than around 400 degrees Celsius during the steps of applying the first layer to the substrate and applying the layer comprising a nickel-titanium alloy.

Preferably, the layer comprising a nickel titanium alloy has a thickness of more than around 10 μ m.

According to a second aspect of the present invention there is provided a high speed rotary MEMS device formed according to the above-described method.

According to a third aspect of the present invention there is provided a component having a film structure comprising:

a substrate having a compressive first layer; and

a layer of a nickel-titanium alloy.

Preferably, the substrate comprises silicon, and the first layer comprises a compressive thermal oxidization silicon dioxide layer.

The component may further comprise a second layer of material applied to the compressive layer such that the second layer is located between the layer comprising a nickel-titanium alloy and the compressive layer.

In a preferred embodiment a further layer is applied to the second layer and preferably, the further layer comprises a noble metal.

In a preferred embodiment, the second layer comprises titanium, and the further layer comprises platinum, the further layer being applied to the layer comprising titanium such that the layer comprising platinum is located between the layer comprising a nickel-titanium alloy and the layer comprising titanium and the compressive layer is located between the layer comprising titanium and the substrate.

In an alternative further preferred embodiment, the second layer comprises chromium, and the further layer comprises gold, the further layer being applied to the layer comprising chromium such that the layer comprising gold is located between the layer comprising a nickel-titanium alloy and the layer comprising chromium and the compressive layer is located between the layer comprising chromium and the substrate.

Preferably, the layer comprising a nickel titanium alloy has a thickness of more than around $10\text{ }\mu\text{m}$.

According to a fourth aspect of the present invention there is provided a high speed rotary MEMS device comprising the above-defined component.

It is particularly advantageous to form a MEMS device having the above-described component as vibration and noise due to the high speed operation or impact loading in rotary MEMS devices is reduced using the component which has a good damping capability in such devices.

According to a fifth aspect of the present invention, there is provided a method of forming a component having a film structure comprising:

applying a first layer to a substrate to form an adhesive layer;
and

applying a layer comprising a nickel-titanium alloy to the first layer such that the first layer is located between the layer comprising a nickel-titanium alloy and the substrate.

Preferably, the method further comprises applying a second layer to the first layer prior to applying the layer comprising a nickel-titanium alloy such that the second layer is located between the layer comprising a nickel-titanium alloy and the first layer.

In a preferred embodiment, the step of applying the first layer comprises applying a layer comprising chromium, and the step of applying a second layer comprises applying a layer comprising gold.

In a further preferred embodiment, the step of applying the first layer comprises applying a layer comprising titanium, and the step of applying a second layer comprises applying a layer comprising platinum.

Preferably, the substrate comprises stainless steel.

According to a sixth aspect of the present invention there is provided a component having a film structure comprising:

a substrate having a first layer applied thereto;

a second layer applied to the first layer; and

a layer of a nickel-titanium alloy applied to the second layer, wherein the first and second layers are arranged to increase the adhesion of the layer of nickel-titanium alloy to the substrate.

Preferably, the first layer comprises chromium and the second layer comprises gold.

In a further preferred embodiment, the first layer comprises titanium and the second layer comprises platinum.

Preferably, the substrate comprises stainless steel (SUS).

Brief Description of the drawings

The present invention will now be described by way of example and with reference to the accompanying drawings in which:

Figure 1a is a schematic diagram showing the structure of a NiTi coated specimen of NiTi on a thermal oxidized Si wafer according to a first preferred embodiment of the invention;

Figure 1b is a schematic diagram showing the structure of a NiTi coated specimen of NiTi on an Au/Cr coated thermal oxidized Si wafer according to a second preferred embodiment of the invention;

Figure 1c is a schematic diagram showing the structure of a NiTi coated specimen of NiTi on a Pt/Ti coated thermal oxidized Si wafer according to a third preferred embodiment of the invention;

Figure 2 is a representation of an X-ray diffraction pattern of thick NiTi films sputtered from an Ni-49%Ti alloy target on a thermal oxidized Si wafer with a magnification of 10, on a thermal oxidized Si wafer coated with a gold/chromium (Au/Cr) adhesive layer at 400°C, and on a thermal oxidized Si wafer coated with a platinum/titanium (Pt/Ti) adhesive layer at 450°C, according to various preferred embodiments of the present invention;

Figure 3 is a representation of an X-ray diffraction pattern of 10 µm-thick NiTi films deposited at 450°C on Pt/Ti-coated thermal oxidized silicon wafers from an Ni-49%Ti alloy target and from an Ni-50%Ti alloy target, according to various preferred embodiments of the present invention;

Figure 4 is a schematic of an apparatus of an experimental setup for a cantilever noise measurement for use in testing specimens embodying the present invention;

Figure 5 is a schematic diagram showing the structure of a NiTi coated specimen on a substrate according to a further preferred embodiment of the invention;

Figure 6 is a representation of an X-ray diffraction pattern of 10 µm-thick NiTi films deposited at 650°C on a Pt/Ti-coated stainless steel (SUS) substrate from a NiTi (51/49) alloy target, according to the further preferred embodiment of the present invention illustrated in Figure 5;

Figure 7a is a schematic diagram showing the structure of a NiTi coated stainless steel (SUS) substrate; and

Figure 7b is a representation of an X-ray diffraction pattern of a 4 µm-thick NiTi film deposited at 650°C on a stainless steel (SUS) substrate from a NiTi (51/49) alloy target such as that shown in Figure 7a.

Detailed description of preferred embodiments

Figures 1a, 1b and 1c show schematically the preferred embodiments of a first aspect of the present invention. The same reference numerals have been used in each of these figures to denote identical components.

According to a preferred embodiment of the present invention, a method of compensating for the tensile thermal stress introduced into NiTi films is to place a layer of another material which has a compressive stress between the film and the substrate. Thermally oxidised silicon dioxide (SiO₂) has this property and Figure 1a shows schematically the structure of a layer 2 of 1.8 μ m-thick thermal oxidized SiO₂ between a NiTi film 4 and a silicon substrate 6 according to a first preferred embodiment of the present invention.

To improve the adhesion between the NiTi layer 4 and the silicon dioxide layer 2, in a second preferred embodiment a further layer 10 of a noble metal may be added between the NiTi film layer 4 and the silicon dioxide layer 2. Figure 1b shows schematically the structure of a specimen having a layer 8 of chromium film (with a preferred thickness of around 100 nm) on top of a thermally oxidised SiO₂ layer 2, a layer of gold (Au) 10 having a preferred thickness of around 1 μ m over the chromium layer 8 to enhance the adhesion and a layer 4 of NiTi film over the gold layer 10.

Figure 1c shows schematically the structure of a specimen according to a third preferred embodiment having a layer 12 of titanium film (having a preferred thickness of around 20 nm) on top of the thermally oxidised SiO₂ layer 2, a layer 14 of platinum (Pt) having a preferred thickness of around 200 nm over the titanium layer 12 to enhance the adhesion, and a layer 4 of NiTi film over the platinum layer 14. These layers 12 and 14 were introduced to improve the surface morphology and adhesion at higher deposition temperatures.

The specimens of Figures 1a to 1c may be produced, for example, in the following manner. The metal films may be deposited on the Si wafers 6 using a conventional multi-cathode DC/RF sputtering system. The targets for the NiTi films 4 may be, for example, Ni-49%Ti and Ni-50%Ti alloy. Before the deposition, the chamber may be evacuated to a vacuum level of around 1×10^{-6} Torr, then argon (Ar) gas may be introduced. The pressure during the process may be around 2 mTorr and an applied DC power of around 300W may be used. The substrate temperature range for NiTi process may be between around 400°C and 450°C, and the films may be cooled down at a preferred ramping rate of lower than 5°C/min.

Film structures produced in the above manner were measured using a Phillips X-ray diffraction analyzer (Cu $K\alpha$ 1.54 Å) and Figure 2 shows results of these measurements.

The X-ray diffraction pattern of a thick NiTi film of the type shown in Figure 1a was sputtered from a Ni-49%Ti alloy target on a thermal oxidized Si wafer with a magnification of 10, and is shown as pattern 20 in Figure 2. A 6 µm-thick NiTi film at high temperature was achieved with a Ni-49%Ti alloy target. It was found that its intensity was very weak and thus its crystallinity was very poor as shown in Figure 2. In poorly crystallized film, the transition behaviour would be deteriorated because the energy barrier of the martensitic transition would increase with decreasing grain size and ultimately the martensitic transition would be completely suppressed. This concept is described in the publications by T. Waitz, V. Kazykhanov, and H. P. Karnthaler, in *Acta Mater.* 52, 137 (2004) and X. Huang, Y. Liu, S. F. Ling, H. H. Zhang, and W. M. Huang, in *Surf. Coat. Technol.* 167, 148 (2003).

Furthermore, it will be seen from Figure 2 that, in the pattern 20 shown in this figure, there were three peaks in this weak signal. The peak at 42.6° corresponds to (110) of B2 and the peak at 43.6° is (002) of B19'. However

the peak at 47.9° corresponds to anatase TiO_2 (200) and this may indicate that the oxygen in silicon dioxide layer may lead to severe oxidization of the NiTi film during deposition.

On the other hand, it will be seen from the pattern 22 in Figure 2 that the introduction of the Au/Cr layers between the NiTi and SiO_2 layers markedly improves the crystallinity and in this pattern 22 there was no peak corresponding to anatase TiO_2 (200). The enhanced crystallinity may be due to the chemical inertness of gold, which may prevent the oxidization of Ti in the films. This specimen also consisted of B2 and B19' phases.

The pattern 24 in Figure 2 relates to the specimen shown in Figure 1c having Pt/Ti layers in place of the Au/Cr layers. It will be seen that the NiTi film deposited on Pt/Ti layer at 450°C exhibits enhanced crystallinity, similar to that on the Au/Cr layer shown in pattern 22 in Figure 2. In particular, the development of B2 grains was promoted on the surface of the platinum layer. With the Pt/Ti interlayers, it was found possible to deposit a $10\ \mu\text{m}$ -thick NiTi film without degradation of the surface morphology, or delamination.

In further experiments, the crystalline phase in NiTi films was changed by changing the composition of the sputtering target. The results of this are shown in Figure 3. Figure 3 is a representation of an X-ray diffraction pattern 26 of $10\ \mu\text{m}$ -thick NiTi films deposited at 450°C on Pt/Ti-coated thermal oxidized silicon wafers from an Ni-49%Ti alloy target, and an X-ray diffraction pattern 28 of $10\ \mu\text{m}$ -thick NiTi films deposited at 450°C on Pt/Ti-coated thermal oxidized silicon wafers from an Ni-50%Ti alloy target. As will be seen from Figure 3, using a Ni-49%Ti alloy target, the NiTi film was composed of B2+B19' phases. In contrast, using a Ni-50%Ti alloy target the film was composed of the B19' phase.

To estimate the damping behaviour of NiTi thick films on MEMS devices, the noise measurement of silicon cantilever vibration was carried out in an enclosed cavity at room temperature. Figure 4 is a schematic illustration of the apparatus used. Within the enclosed cavity 30, an SUS (stainless steel) shaft 32 positioned below a silicon cantilever 34 was vibrated at 120 Hz by an oscillator 35 to impart an impact to a NiTi-coated Si surface 36. The impact noise was collected by a microphone 38 located in the enclosed cavity at a position above the cantilever 34. The dimensions of the tested specimens were 20 mm long, 10 mm wide and 0.5 mm thick. This measurement configuration is similar to the contact between two surfaces through the NiTi damping layer.

Firstly, the Si cantilever 34 having a 1.8- μ m thick thermal oxidized SiO₂ layer without NiTi film was measured as a reference. Its noise level was found to be 58.6 dBA. The noise level of the specimen coated with an 8 μ m-thick B2+B19' NiTi film on a Pt/Ti/SiO₂ interlayer was found to be 57.3 dBA, and the noise level of the specimen coated with 5- μ m-thick B19' NiTi film on a Pt/Ti/SiO₂ interlayer was found to be 55.9 dBA

With both types of NiTi film mentioned above, the damping level, that is the difference between the noise levels with and without NiTi film, was found to be clearly distinguishable, especially with 5- μ m-thick B19' NiTi film, where the difference in noise was found to be 2.7dBA. This may be due to its elastic Young's modulus and higher viscoelastic properties.

Figure 5 shows schematically a preferred embodiment of a further aspect of the present invention. In this embodiment, the compressive layer 2 of silicon dioxide which was present in the embodiments shown in Figures 1a to 1c has been omitted so that the component comprises a substrate 100 onto which is applied an interlayer formed of a first layer 102 and a second layer 103 applied to the first layer 102. A NiTi layer 104 is then applied to the second

layer 103. In one preferred embodiment according to this aspect of the present invention, the first layer 102 is comprised of chromium and the second layer 103 is comprised of gold. In an alternative preferred embodiment, the first layer 102 is comprised of titanium and the second layer 103 is comprised of platinum. The substrate 100 in this construction may, for example, be formed of stainless steel (SUS) or another material preferably having a coefficient of thermal expansion close to that of NiTi.

In a preferred embodiment of the component shown in Figure 5, the platinum layer 103 may be around 100nm in thickness, the titanium layer 102 may be around 20nm in thickness and the NiTi (51/49) layer 104 may be around 10 μ m.

The advantages of a construction and method such as that shown in Figure 5 are that the adhesion of the NiTi layer 104 may be improved and deposition of a thick NiTi layer may be achieved without delamination. Also, the crystallinity of the NiTi may be improved.

Figure 6 is a representation of an X-ray diffraction pattern 120 of a 10 μ m-thick NiTi film deposited at 650°C on Pt/Ti-coated thermal oxidized silicon wafers from a NiTi (51/49) alloy target.

By contrast, Figure 7a is a schematic diagram showing the structure of a NiTi coated stainless steel (SUS) substrate with the Pt/Ti layers 102, 103 omitted and Figure 7b is a representation of an X-ray diffraction pattern of a 4 μ m-thick NiTi film deposited at 650°C on a stainless steel (SUS) substrate from a NiTi (51/49) alloy target such as that shown in Figure 7a. It will be seen from a comparison of Figures 6 and 7b that the component having the Pt/Ti interlayers 102, 103 has better crystallinity than a component such as that of Figure 7a in which the NiTi layer is applied directly to the substrate 100.

.In conclusion, the structures and methods according to the present invention may be particularly useful in the construction of MEMS devices and silicon-based micro-actuators. The structures and methods according to one or more preferred embodiments of the present invention enable a reduction in the likelihood of delamination of thick NiTi films by introducing, according to a first aspect of the present invention, a compressive thermal oxidation SiO_2 layer which compensates for the thermal stress of the NiTi films. Furthermore, the adhesion of thick NiTi films may be improved by the inclusion of one or more noble metal adhesive interlayers (such as Pt/Ti or Au/Cr). The noble metal layer(s) may also promote the development of crystalline NiTi grains during the deposition process due to their inert chemical nature. In particular, a Pt/Ti buffer layer may be more stable during high-temperature deposition than layers such as Au/Cr and a thickness of up to around $10\ \mu\text{m}$ may be achieved for polycrystalline NiTi films by a sputtering process deposited at 450°C . By slightly changing the target composition, B2+B19' and B19' structure films may be deposited onto Pt/Ti/ SiO_2 -coated Si wafers for damping characterization.

In summary, a minimization of vibration and noise due to the high speed operation or impact loading in rotary MEMS devices may be realized through one or more preferred embodiments of the present invention.

Various modifications to the embodiments of the present invention described above may be made. For example, other components and method steps can be added or substituted for those above. In particular, although the invention has been described as applying a compressive layer in the form of a silicon dioxide layer to a silicon substrate, in further alternative preferred embodiments, the substrate and compressive layer may be formed of other materials, compounds or alloys. Thus, although the invention has been described above using particular embodiments, many variations are possible

within the scope of the claims, as will be clear to the skilled reader, without departing from the scope of the invention.

Claims

1. A method of forming a component having a film structure comprising:

applying a first layer to a substrate to form a compressive layer;

and

applying a layer comprising a nickel-titanium alloy to the first layer such that the first layer is located between the layer comprising a nickel-titanium alloy and the substrate.
2. A method according to claim 1, wherein the substrate comprises silicon and the step of applying a first layer to the substrate comprises thermally oxidising a first layer of the silicon substrate to form the compressive layer, the compressive layer comprising a thermal oxidation silicon dioxide layer.
3. A method according to claim 1, further comprising applying a second layer of material to the compressive layer prior to applying the layer comprising a nickel-titanium alloy such that the second layer is located between the layer comprising a nickel-titanium alloy and the compressive layer.
4. A method according to claim 3, further comprising applying a further layer to the second layer.
5. A method according to claim 4, wherein the step of applying a further layer comprises applying a layer comprising a noble metal.
6. A method according to claim 4, wherein the step of applying a second layer comprises applying a layer comprising titanium to the compressive layer, and the step of applying a further layer comprises applying a layer comprising platinum to the layer comprising titanium prior to applying the layer comprising a nickel-titanium alloy to the layer comprising platinum.

7. A method according to claim 4, wherein the step of applying a second layer comprises applying a layer comprising chromium to the compressive layer, and the step of applying a further layer comprises applying a layer comprising gold to the layer comprising chromium prior to applying the layer comprising a nickel-titanium alloy to the layer comprising gold.
8. A method according to claim 1, wherein the step of applying the layer comprising a nickel-titanium alloy comprises applying the layer by sputtering.
9. A method according to claim 1, further comprising maintaining the substrate at a temperature of more than around 400 degrees Celsius during the steps of applying the first layer to the substrate and applying the layer comprising a nickel-titanium alloy.
10. A method according to claim 1, wherein the step of applying a layer comprising a nickel-titanium alloy comprises applying a layer having a thickness of more than around 10 μ m.
11. A high speed rotary MEMS device formed according to the method of claim 1.
12. A component having a film structure comprising:
 - a substrate having a compressive first layer; and
 - a layer of a nickel-titanium alloy.
13. A component according to claim 12, wherein the substrate comprises silicon, and the first layer comprises a compressive thermal oxidization silicon dioxide layer.
14. A component according to claim 12, further comprising a second layer of material applied to the compressive first layer such that the second layer is

located between the layer comprising a nickel-titanium alloy and the compressive first layer.

15. A component according to claim 12, further comprising a further layer applied to the second layer such that the further layer is located between the layer comprising a nickel-titanium alloy and the second layer and the compressive first layer is located between the second layer and the substrate.

16. A component according to claim 15, wherein the further layer comprises a noble metal.

17. A component according to claim 15, wherein the second layer comprises titanium, and the further layer comprises platinum.

18. A component according to claim 15, wherein the second layer comprises chromium, and the further layer comprises gold.

19. A component according to claim 12, wherein the layer comprising a nickel-titanium alloy is applied to the substrate by sputtering.

20. A component according to claim 12, wherein the substrate is maintained at a temperature of more than around 400 degrees Celsius during application of the compressive first layer to the substrate and application of the layer comprising a nickel-titanium alloy.

21. A component according to claim 12, wherein the layer comprising a nickel-titanium alloy has a thickness of more than around $10\ \mu\text{m}$.

22. A high speed rotary MEMS device comprising the component of claim 12.

23. A method of forming a component having a film structure comprising:

applying a first layer to a substrate to form an adhesive layer;
and

applying a layer comprising a nickel-titanium alloy to the first layer such that the first layer is located between the layer comprising a nickel-titanium alloy and the substrate.

24. A method according to claim 23, further comprising applying a second layer to the first layer prior to applying the layer comprising a nickel-titanium alloy such that the second layer is located between the layer comprising a nickel-titanium alloy and the first layer.

25. A method according to claim 24, wherein the step of applying the first layer comprises applying a layer comprising titanium, and the step of applying a second layer comprises applying a layer comprising platinum.

26. A method according to claim 24, wherein the step of applying the first layer comprises applying a layer comprising chromium, and the step of applying a second layer comprises applying a layer comprising gold.

27. A method according to claim 23, wherein the substrate comprises stainless steel.

28. A component having a film structure comprising:

a substrate having a first layer applied thereto;

a second layer applied to the first layer; and

a layer of a nickel-titanium alloy applied to the second layer, wherein the first and second layers are arranged to increase the adhesion of the layer of nickel-titanium alloy to the substrate.

- 29. A component according to claim 28, wherein the first layer comprises chromium and the second layer comprises gold.
- 30. A component according to claim 28, wherein the first layer comprises titanium and the second layer comprises platinum.
- 31. A component according to claim 28, wherein the substrate comprises stainless steel (SUS).