(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
23 October 2003 (23.10.2003)

PCT

(10) International Publication Number
WO 03/086955 A1

(51) International Patent Classification⁷: B81B 7/00, G02B 26/08

(21) International Application Number: PCT/EP02/04122

(22) International Filing Date: 12 April 2002 (12.04.2002)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicants *(for all designated States except US)*: **FRAUNHOFER-GESELLSCHAFT ZUR FÖRDERUNG DER ANGEWANDTEN FORSCHUNG E.V.** [DE/DE]; Leonrodstrasse 54, 80636 München (DE). **MICRONIC LASER SYSTEMS AB** [SE/SE]; P.O. Box 3141, 183 03 Täby (SE).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **DAUDERSTÄDT, Ulrike** [DE/DE]; Förstereistr. 13 d, 01099 Dresden (DE). **LEONARDSSON, Lars** [SE/SE]; Vasseurs väg 30, S-182 39 Danderyd (SE).

(74) Agents: **SCHOPPE, Fritz** et al.; Schoppe, Zimmermann, Stöckeler & Zinkler, P.O. Box 246, 82043 Pullach b. München (DE).

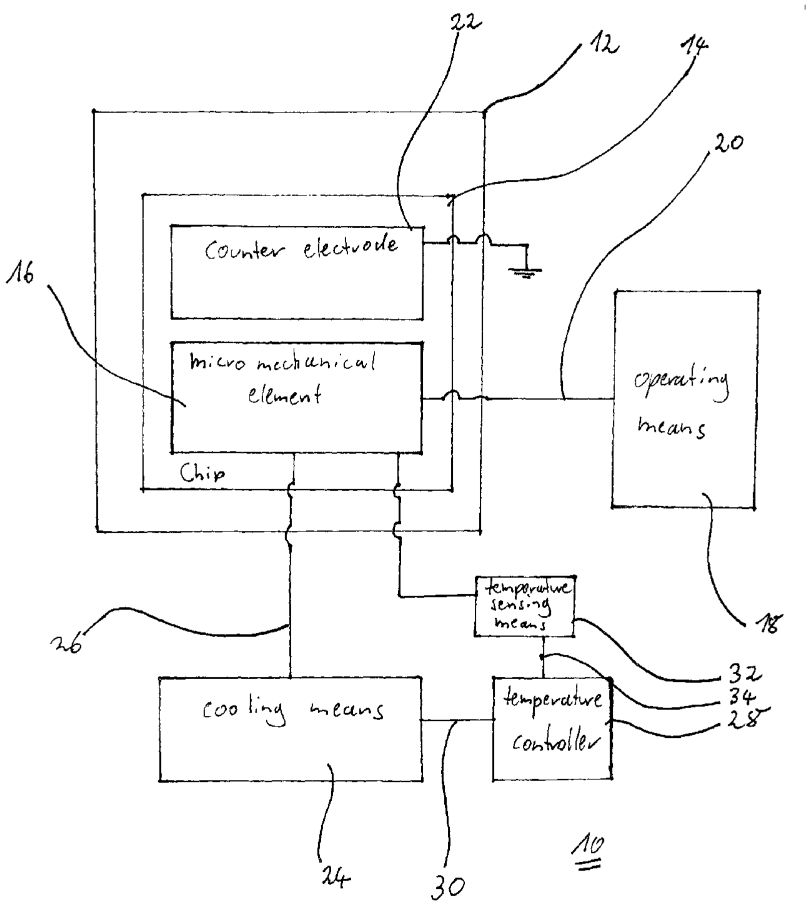
(81) Designated States *(national)*: JP, US.

(84) Designated States *(regional)*: European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR).

Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: METHOD AND DEVICE FOR OPERATING A MICROMECHANICAL ELEMENT



(57) Abstract: A method for operating a micromechanical element (16) containing metal or an alloy comprises cooling the mechanical element (16) to a temperature lower than the normal operating temperature of the micromechanical element (16) and operating the micromechanical element (16) at the temperature lower than the normal operating temperature of the micromechanical element (16).

WO 03/086955 A1

Method and device for operating a micromechanical element

Description

The present invention relates to the operating of a micromechanical element, and more specific to the operating of a deflectable micromechanical element containing a metal or an alloy.

Microelectromechanical systems (MEMS) comprising one or more deflectable micromechanical elements arranged on a chip are nowadays used in many applications. To give an example, microelectromechanical systems comprising one or more micromirrors are used for the spatial modulation of a light or an UV radiation beam (ultraviolet radiation beam) in image generating devices. For applications in the UV spectral region and in particular in the deep UV spectral range where most other materials are no longer reflective, aluminum is preferably used as material for the micromirrors because of its good optical reflection properties in this spectral region.

Furthermore, the use of aluminum is advantageous because standard processes known in the semiconductor industry can be used for the deposition and the structuring of the micromechanical elements avoiding the need of a special technology for manufacturing the micromechanical elements and allowing the integration into a semiconductor manufacturing process.

In typical systems, the micromirror is shaped as a thin plate which is deflectable arranged on the chip. In operation, radiation from a suitable radiation source is impinging on the micromirror and is reflected back to a projection surface.

Furthermore, an electrical signal is applied to the micromirror causing a deflection of same in response to the applied electrical signal. The deflection of the micromirror changes the phase of part of the reflected beam resulting in a spatial modulation of the reflected beam at the projection surface.

To obtain a stable operation, the deflection of the micromirror has to be controlled to a high degree of accuracy. Therefore, good mechanical properties and in specific a good elastic behavior are required for the material of the flexible elements such as hinges or torsional bars mechanically connecting the micromirror to the chip in such a way that the micromirrors can deflect appreciably.

In view of the above described mechanical requirements, the operation of microelements made of aluminum causes problems since microelements made of aluminum are known to behave in a non-elastic manner during the operation of same. To give an example, a deflected spring made of aluminum is not returning to its original position after being released from a deflected position in which it was kept for a longer time. Furthermore, if a constant force is applied to a spring made of aluminum or an aluminum alloy, the deflection increases with time. This known effect has time constants in the order of minutes to several hours and is partially reversible.

Details of the mechanical properties of aluminum with respect to tension and stress relaxation can for example be found in H. Lee, et. al., "Stress Relaxation of Free-Standing Aluminum Beams for Microelectromechanical Systems Applications", Applied Physics Letter, Vol. 76, No. 23, June 5 2000, pages 3415-17.

Mechanical properties of aluminum thin films used for MEMS application are described in S. Brown "Observations of Low-Cycle Fatigue of Aluminum Thin Films for MEMS Applications", MicroElectroMechanical Structures for Materials Research, symposium, 1998, pages 81-6.

The above described mechanical operation problem of the micromechanical element made of aluminum can be evaded by a non-analog operation of same wherein the position of the deflected micromechanical element is not required to be exact and variations of the element's deflection are allowed within a certain range or where end positions are determined by mechanical stops.

However, for certain applications, an analog mode of operation of the micromechanical element is mandatory. So far, no satisfying solution eliminating the above-described mechanical operation problems is known in the art for the analog mode of operation.

One approach to reduce the problem for analog operation at least to an acceptable level is to use a low-duty cycle operation for the MEMS-device wherein a long time deflection of the micromechanical element is avoided by deflecting same only for a small time period. However, low-duty cycle operation is restricted to a certain class of applications excluding applications requiring a static operation of the micromechanical element.

Another approach to improve the performance of analog operated MEMS-devices is to form the micromechanical element of an aluminum alloy instead of pure aluminum. Depending on the composition of the alloy, a certain improvement of the mechanical properties can be achieved by the replacement of pure aluminum with an aluminum alloy. However, although the mechanical operation is improved by forming the micromechanical element of an aluminum alloy, the mechanical problems are only reduced to a certain level but not solved.

So far, a stable operation of a micromechanical element made of aluminum or an aluminum alloy in applications which require a high accuracy of deflection is not known.

Starting from this prior art, it is the object of the present invention to provide a method and a device which enable an improved operation of a micromechanical element containing a metal or an alloy.

This object is solved by a method according to claim 1 and a device according to claim 12.

According to the present invention an improved operation for a micromechanical element made of a metal or an alloy, or a sandwich of at least two layers of dissimilar materials, wherein at least one is a metal or an alloy, is achieved by cooling the micromechanical element to a temperature lower than the normal operation temperature. By cooling the micromechanical element to a temperature lower than the normal operation temperature, an improved mechanical behavior of the micromechanical element is obtained resulting in a more stable operation compared to the operation of the micromechanical element at the normal operation temperature.

During the application of a constant force, the cooled micromechanical element maintains its deflected position with a better accuracy. Furthermore, a residual deflection observed in the normal temperature operation when the micromechanical element is released from a state in which same was deflected for a prolonged time is reduced by cooling the micromechanical element.

The present invention provides a method for operating a micromechanical element containing a metal or an alloy, the micromechanical element being arranged on a chip and being deflectable. The method comprises the steps of cooling the micromechanical element to a temperature lower than the normal operating temperature of the micromechanical element and operating the micromechanical element at the temperature lower than the normal operating temperature of the micromechanical element.

Furthermore, the present invention provides a device for operating a micromechanical element containing metal or an alloy, the micromechanical element being arranged on a chip and deflectable. The device comprises cooling means thermally connected to the micromechanical element and operable to cool the micromechanical element to a temperature lower than the normal operating temperature of the micromechanical element. Furthermore, the device comprises operating means for operating the micromechanical element while same is cooled to the temperature lower than the normal operating temperature of the micromechanical element.

In one embodiment of the present invention, the micromechanical element is a micromirror containing aluminum or an aluminum alloy. In operation, a UV radiation which is impinging on the micromirror is reflected by same and directed to a projection surface. The reflected radiation is modulated by an electrical signal applied to the micromirror by the operating means.

In a preferred embodiment, the inventive step of cooling the micromirror during the operation of same is achieved by means of one or more Peltier elements placed in a direct contact with the surface of the chip. Preferably, the micromirror is cooled to temperatures between +10° C and 25° C to avoid a condensation of moisture contained in the air surrounding the chip.

In another embodiment the chip is arranged so that it is cooled by circulating gas or a liquid such as water.

In still other embodiments the chip is arranged in an air-free surrounding or in an environment comprising air with a low degree of moisture or some other controlled atmosphere. In these embodiments, an operation of the micromechanical element at lower temperatures is enabled since a condensation of moisture is avoided or shifted to lower temperatures.

Preferred embodiments of the present invention are described in the following with respect to the attached drawings in which

Fig. 1 shows a block diagram of a device for operating a chip; and

Fig. 2 shows a diagram comprising deflection measurement data of micromirrors made from an aluminum alloy at different ambient temperatures during deflection-relaxation cycles.

In Fig. 1, a device 10 for operating a micromechanical element according to a preferred embodiment is shown. The device 10 comprises mounting means 12 for mounting a chip 14. In the described embodiment, the chip 14 comprises a microelectromechanical system (MEMS) including a micromechanical element 16 made of a metal or an alloy. The micromechanical element 16 includes for example a micromirror comprising a thin metal plate which is deflectably arranged on the chip 14. Operating means 18 are connected via an electrical connection 20 to the micromechanical element 16 for applying an operating signal to the micromechanical element 16. An electrostatic field is generated between a counter electrode 22 and the micromechanical element 16 in response to the operating signal causing the micromechanical element 16 to deflect.

In the preferred embodiment, the counter electrode 22 is arranged on the chip opposite to the micromechanical element 16 and connected to ground. However, it is intended in other embodiments to apply other constant voltages or electrical signals to the counter electrode 22 in order to generate the electric field. Furthermore, in one embodiment, the micromechanical element 16 is connected to ground and an electric field is generated by an electrical signal applied to the counter electrode. Preferably, the counter electrode 22 is arranged close to the micromechanical element 16 to achieve a high electrostatic field.

The device 10 comprises cooling means 24 operable to cool the micromechanical element 16 to a temperature lower than the normal operation temperature of the micromechanical element 16. The cooling means 24 is thermally connected to the micromechanical element 16 via a thermal conductor 26. The thermal conductor 26 can be any suitable thermal conductor, such as a massive metal block, a thermal-conducting gas, air, or liquid. Furthermore, cooling means 24 can be any suitable heat sink operable to achieve a heat transfer via the thermal conductor 26 from the micromechanical element 16 to the cooling means 24.

In one embodiment, cooling means 24 includes a Peltier element which is directly mounted on a surface of the chip 14. In this embodiment, heat from the micromechanical element 16 is conducted to the cooling means 24 via the surface of the chip 14 connected to the Peltier element.

The direct transmission of the heat from the chip 14 to the Peltier element enables in one embodiment the cooling of the micromechanical element 16 below 10° C without a condensation of the moisture of the surrounding air by arranging the chip and the Peltier element in a vacuum or a controlled atmosphere (e.g., a dry gas). In this embodiment, the chip 14 and the Peltier element are placed in a suitable air tight housing which is evacuated thereafter, or filled or flushed with a controlled atmosphere (e.g., a dry gas).

For applying a predetermined temperature to the micromechanical element 16, a temperature controller 28 is connected via a temperature control signal connection 30 to the cooling means 24. Furthermore, a temperature sensor 32 is thermally connected to the micromechanical element 16 to sense the temperature of the micromechanical element 16 and to provide a temperature signal indicative of the temperature of the micromechanical element 16 via a temperature signal connection 34 to the temperature controller 28. The temperature sensor and the cooling means, respectively, are connected to the chip on which the micromechanical element, the mirror, is arranged.

In the following the operation of the device 10 will be described with respect to a preferred embodiment wherein the micromechanical element 16 is a micromirror made of aluminum or an aluminum alloy used for a spatial modulation of UV radiation, and where the flexible elements that mechanically connect the micromirror to the chip are integrated parts of the micromirror.

In operation, at least a part of the micromirror 16 is illuminated by a suitable generator for UV radiation such as an excimer laser with a radiation in the UV spectral region and preferably with a radiation in the deep UV spectral region.

The UV radiation is directed to the micromirror 16 and impinges on same. Thereafter the radiation is reflected by the micromirror 16 due to the high degree of reflection provided by the micromirror's material containing aluminum or an aluminum alloy and is directed to a projection surface.

In one embodiment the micromirror 16 is used for maskless microlithography. In this embodiment the projection surface is the surface of a wafer covered with a photo resist layer and the reflected beam defines regions on the photo resist layer which are to be removed after a developing process. Other embodiments include the use of the micromirror for projection devices and for image generating systems.

An operating signal generated by the operating means 18 is applied via the connection 20 to the micromirror 16. In response to the applied operating signal, an electrostatic force is generated between the micromirror 16 and the counter electrode 22 which is connected to ground. In one embodiment, the micromirror 16 comprises a free standing aluminum plate deflectably connected to the chip 14 via a spring.

The electrostatic force acting on the micromirror 16 deflects the micromirror 16 in response to the applied operating signal. The deflection of the micromirror 16 changes the phase of part of the reflected beam resulting in a spatial modulation of the reflected beam at the projection surface.

For controlling the temperature of the micromirror 16, the temperature controller 28 generates a temperature control signal in response to the temperature signal provided by the temperature sensor 32. The temperature controller 28 applies the temperature control signal via the temperature control signal connection 30 to the Peltier element to cause same to apply a predetermined temperature to the micromirror 16 which is lower than the normal operation temperature of the micromirror 16.

In operation, if no cooling by the cooling means is provided, the normal operating temperature of the micromirror 16 is about 50° C due to the heat dissipation of the electric circuitry on the chip.

By cooling the micromirror 16 during the operation of same to a temperature lower than the normal operation temperature of the micromirror 16, a more accurate and stable deflection of the micromirror 16 is obtained compared to the operation at the normal operation temperature, as will be described in more detail below.

In the following, the influence of the micromirror's temperature on the mechanical properties is explained with respect to Fig. 2. In Fig. 2 measurement data of the electrostatic deflection of micromirrors made from an aluminum alloy are shown. The micromirrors were subjected to different ambient temperatures and for each temperature two cycles of deflection and relaxation were performed.

In the first cycle, the micromirrors were electrostatically deflected for three hours by the application of a constant voltage to the micromirrors and then released by turning off the applied voltage for one hour. Thereafter, in the second cycle, the procedure of deflecting for three hours and releasing for one hour was repeated. The deflection of the mirrors was monitored by means of a white-light interferometer (WLI).

In the diagram of Fig. 2, the y-axis shows the deflection Δz of the micromirrors relative to the starting position in nm. Furthermore, the x-axis shows the time t after starting the first relaxation cycle.

With respect to the measurement data indicated by triangles, the deflection of the micromirrors for a temperature of 50° C will be described in the following.

As can be seen from Fig. 2, after applying the constant voltage at the starting time t = 0 h, the deflection of the micromirrors almost instantly increases from 0 nm to about 50 nm. Thereafter, a rapid increase in deflection from 50 nm to about 80 nm followed by a slower increase in deflection from 80 nm to about 105 nm can be observed during a time period of three hours in which the constant voltage is applied to the micromirrors. After turning off the applied voltage, the micromirrors are released from their deflected state causing the deflection of the micromirrors to instantly decrease to a position of about 45 nm followed by a rapid decrease to about 32 nm. Within the one hour of relaxation, the residual deflection of about 32 nm is only reduced by a small amount.

After applying in the second cycle at the time t = 4 h again the constant voltage, the deflection of the micromirrors at the temperature of about 50° C returns to about 80 nm followed by a rapid increase to about 105 nm and further increases slowly to about 122 nm during the time period of three hours, in which the constant voltage is applied in the second cycle. At t = 7 h, when the applied voltage is turned off in the second cycle, the deflection of the micromirrors subjected to the temperature of 50° C instantly returns to about 55 nm, rapidly decreasing to 40 nm and showing a slight decrease within one hour after the release of the micromirrors.

As is apparent from the measurement data, the mechanical properties of the micromirrors subjected to the temperature of about 50° C do not allow a stable operation since same show a high residual deflection after the release of same and a significant increase of the deflection during the application of a constant voltage.

With respect to the measuring data indicated by dots, the behavior of the micromirrors subjected to a temperature of about 25° C will now be described. After applying the same voltage as in the measurement at 50°C, the deflection of the micromirrors instantly rises to about 52 nm, followed by a rapid increase to 70 nm and a slower increase during the three hours in which the applied voltage was kept constant to about 80 nm. After releasing the deflected micromirrors, the deflection of same returns instantly to about 25 nm, rapidly decreasing to about 10 nm, showing a slight additional reduction during the relaxation of a period of one hour in which no voltage was applied. After applying the constant voltage in the second cycle at t = 4 h, the deflection instantly rises again to about 60 nm, followed by a rapid increase to about 80 nm, showing a slight increase during the period of three hours in which the constant voltage was applied in the second cycle. After releasing the micromirror at t = 7 h, an instant decrease in deflection to about 25 nm is followed by a rapid decrease to the same residual deflection of about 10 nm that was observed after the first cycle and only a very small additional decrease is observed within the period of one hour of relaxation.

The mechanical behavior is significantly improved at 25° C compared to 50° C because of the small variations during the application of the constant voltage and the reduced residual deflection after releasing same from the deflected state.

With respect to the measuring data indicated by squares, the mechanical behavior of the micromirrors at a temperature of about 10° C is now explained. After applying the constant voltage, the micromirror at the temperature of 10° C instantly deflects to about 50 nm, which rapidly increase to about 60 nm. During the three hours in which the constant voltage is applied, the deflection of the micromirrors is then maintained within a range of 5 nm. After turning off the applied voltage, the micromirror at the temperature of 10° C instantly returns to about 8 nm deflection, rapidly decreasing to almost exactly the starting position of 0 nm deflection and maintains there with almost no variations. After applying the constant voltage a second time at t = 4 h, it instantly deflects to about 52 nm, rapidly increasing again to about 60 nm and maintains there with the same stability as in the first cycle.

In conclusion to the performed measurements described above, the mechanical behavior of the micromirrors made from a aluminum alloy can be significantly improved by cooling the micromirrors to a temperature lower than the normal operating temperature. A significant improvement of the mechanical behavior was observed for the temperature of 25° C and an almost perfect mechanical behavior with small variations of the deflection in the deflected state and no detectable residual deflection a short time after release was observed at the temperature of 10° C.

Again referring now to the device 10 of Fig. 1, in view of the above discussion, a more accurate positioning and stable operation of the micromirror 16 can be provided by cooling same during the operation.

The above discussion of the measurement data of Fig. 2 suggests to subject the micromirror 16 to a very low temperature, since it was observed that the mechanical behavior improves with decreasing temperature.

However, if the chip 14 is subjected to surrounding air, a limited temperature range from +25° C to +10° C is preferred to avoid a condensation of moisture contained in the air on the micromirror 16, as will be described below. The condensation has to be avoided since water droplets condensed on the chip are not only reducing the reflection properties of the micromirror 16 in optical applications but are also a source of contamination and can cause the mirrors to stick to the substrate. Furthermore, chemical reactions and in specific oxidation of components arranged on the chip is promoted by condensed water droplets. Depending on the moisture of the surrounding air, the condensation for a typical degree of moisture starts at a temperature of about 10° C resulting in a lower limit for a preferred temperature range. Furthermore, the upper limit of the preferred temperature range is at about 25° C since at this temperature significant improvements of the micromechanical behavior are achieved, as explained above. Consequently, if the micromechanical element 16 is used in air and no additional means are provided to shift the condensation to a lower temperature or to avoid the condensation, a preferred temperature range for the operation of the micromechanical element 16 extends from ±10° C to ±25°C.

The operation at lower temperatures as low as -10° C or even less is enabled if the chip is placed in a moisture free chamber. This is achieved for example by an air tight housing, in which the chip 14 is arranged and wherein a vacuum or a controlled atmosphere (e.g., a dry gas) is provided.

Furthermore, if the chip is surrounded by air, an operation at lower temperatures without a condensation of moisture can be obtained by reducing the degree of moisture of the surrounding air. This can for example be achieved by providing suitable chemicals such as silicat gel near the chip 14.

Although in the preferred embodiment the use of a chip comprising a micromirror containing aluminum is described, the present invention is not restricted to this particular use.

Rather, the present invention is directed to the operation of any deflectable micromechanical element containing any metal or alloy. Furthermore, the chip can comprise of one or more micromechanical elements operable in optical or non-optical applications.

In the above description of preferred embodiments, elements made of a metal or a metal alloy were described. However, the present invention is not limited to such embodiments. The present invention is also applicable to micromechanical elements containing an alloy that contains non-metals, e.g., silicon.

Claims

1. Method for operating a micromechanical element (16) containing a metal or an alloy, the micromechanical element (16) being arranged on a chip (14) and being deflectable, the method comprising the following steps:

   cooling the micromechanical element (16) to a temperature lower than the normal operating temperature of the micromechanical element (16); and

   operating the micromechanical element (16) at the temperature lower than the normal operating temperature of the micromechanical element (16).

2. Method according to claim 1, wherein the micromechanical element (16) comprises aluminum or an aluminum alloy.

3. Method according to claim 1 or 2, wherein the step of operating the micromechanical element (16) comprises the step of deflecting the micromechanical element (16) in response to an electrical signal applied to the micromechanical element (16).

4. Method according to any one of claims 1 to 3, wherein the micromechanical element (16) is a micromirror.

5. Method according to claim 4, wherein the step of operating the micromechanical element (16) further comprises the step of illuminating at least a part of the micromechanical element (16) by a radiation.

6. Method according to claim 4 or 5, wherein the radiation is an UV radiation.

7. Method according to any one of claims 1 to 6, wherein the temperature lower than the normal operating temperature is between +10° C and 25° C.

8. Method according to any one of claims 1 to 7, wherein the step of cooling the micromechanical element (16) comprises the following steps:

sensing the temperature of the micromechanical element (16); and

controlling the temperature of the micromechanical element (16) in response to the sensed temperature of the micromechanical element (16).

9. Method according to any one of claims 1 to 7, wherein the step of cooling the micromechanical element (16) comprises the step of operating a Peltier element mounted on the chip (14) for cooling the micromechanical element (16) to a temperature lower than the normal operating temperature of the micromechanical element (16).

10. Method according to any one of claims 1 to 9, further comprising the step of arranging the micromechanical element (16) in an air-free environment or in air comprising a low degree of moisture.

11. Method according to claim 10, wherein the temperature lower than the normal operating temperature is between -10° C and 25°C.

12. Device for operating a micromechanical element (16) containing metal or an alloy, the micromechanical element (16) being arranged on a chip (14) and being deflectable, the device comprising:

    cooling means (24) thermally connected to the micromechanical element (16), the cooling means (24) operable to cool the micromechanical element (16) to a temperature lower than the normal operating temperature of the micromechanical element (16); and

    operating means (18) for operating the micromechanical element (16) while same is cooled by the cooling means (24) to the temperature lower than the normal operating temperature of the micromechanical element (16).

13. Device according to claim 12, wherein the cooling means (24) is operable to cool the micromechanical element (16) to a temperature between -10° C and 25°C.

14. Device according to claim 12 or 13, wherein the chip (14) further comprises a counter electrode (22) arranged to generate an electrostatic field between the micromechanical element (16) and the counter electrode (22) in response to an electric signal applied to the micromechanical element (16), the electrostatic field causing a deflection of the micromechanical element (16).

15. Device according to claim 14, wherein the operating means (18) comprises means for applying an electrical signal to the micromechanical element (16) for causing a deflection of the micromechanical element (16).

16. Device according to any one of claims 12 to 15, wherein the micromechanical element (16) is a micromirror.

17. Device according to claim 16, further comprising a radiation source for illuminating at least a part of the micromirror (16) by radiation.

18. Device according to claim 17, wherein the radiation is an UV radiation.

19. Device according to any one of claims 12 to 18, wherein a plurality of micromechanical elements (16) is arranged on the chip (14).

20. Device according to any one of claims 12 to 19, wherein the cooling means (24) comprises one or more Peltier elements.

21. Device according to claim 20, wherein the cooling means (24) is arranged on a surface of the chip (14).

22. Device according to any one of claims 12 to 21, wherein the micromechanical element (16) is arranged in an environment free of air or in air comprising a low degree of moisture.

23. Device according to any one of claims 12 to 22, further comprising temperature controlling means (28, 32) connected to the cooling means (24) for controlling the temperature of the micromechanical element (16).

24. Device according to any one of claims 12 to 23, wherein the micromechanical element (16) contains aluminum or an aluminum alloy.

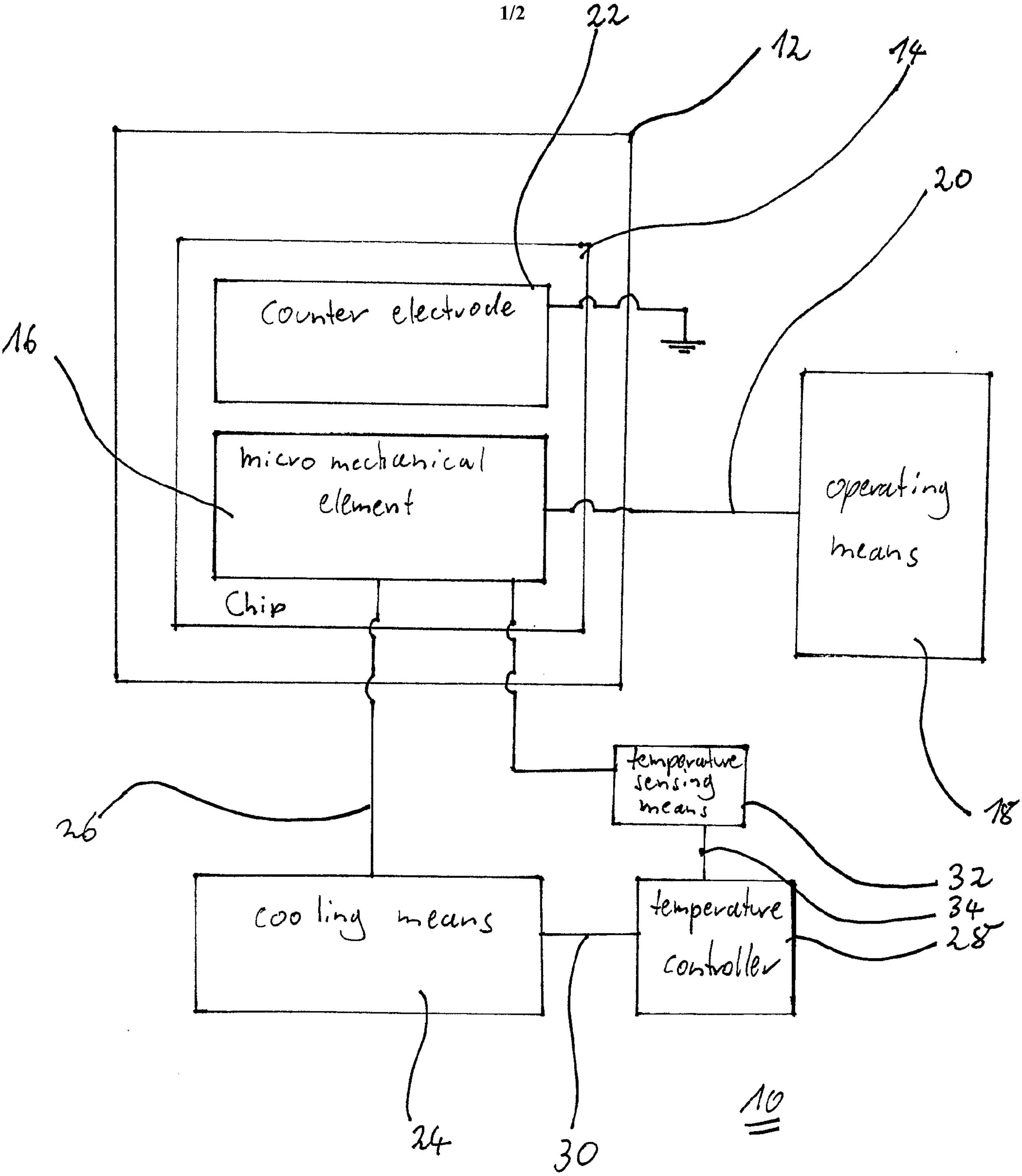

22
12
14
20
16
Counter electrode
micro mechanical element
Chip
operating means
18
temperature sensing means
26
cooling means
temperature controller
32
34
28
24
30
10

Fig. 1

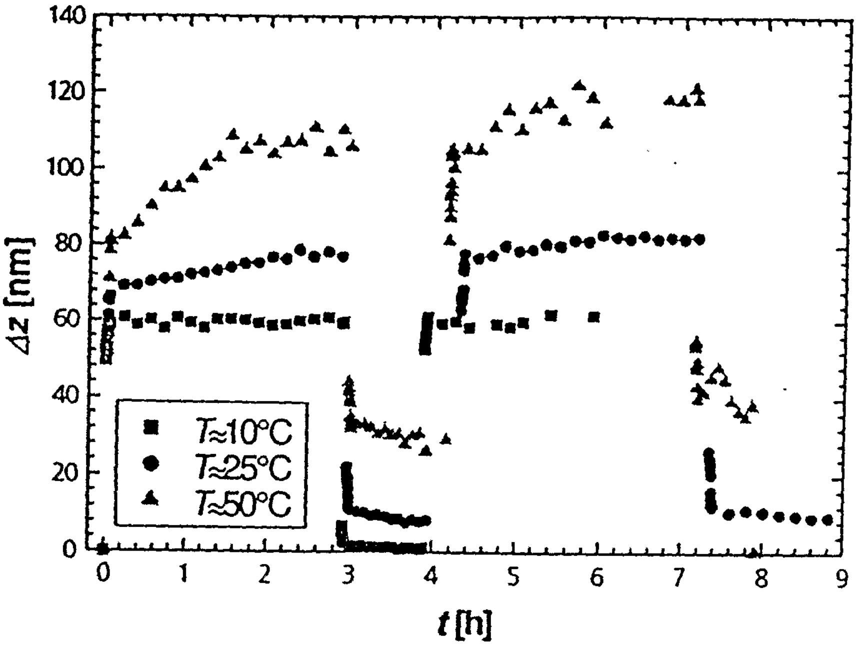


Fig. 2

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 02/04122

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B81B7/00 G02B26/08

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)
IPC 7 B81B G02B

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

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

EPO-Internal, WPI Data, PAJ, INSPEC, COMPENDEX

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 02 19027 A (SANNOHE SHINYA ;MATSUSHITA ELECTRIC IND CO LTD (JP); TABUCHI TOSHI) 7 March 2002 (2002-03-07) figures 2,3,15	1,4-6,8, 10-12, 16-19, 22,23
Y		2,3,9, 11,14, 15,24
A		7,13,20, 21
	-& US 2002/163625 A1 (T. TABUCHI ET AL.) 7 November 2002 (2002-11-07) paragraphs ‘0075!-‘0106!,‘0185!-‘0206! ---	
Y	EP 0 738 910 A (TEXAS INSTRUMENTS INC) 23 October 1996 (1996-10-23) figures 2-15 column 7, line 14 -column 14, line 17 ---	2,3,14, 15,24
	-/--	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search
14 January 2003

Date of mailing of the international search report
20/01/2003

Name and mailing address of the ISA
European Patent Office, P.B. 5818 Patentlaan 2
NL – 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer
Polesello, P

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 02/04122

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	WO 01 59363 A (LIGHT & SOUND DESIGN INC) 16 August 2001 (2001-08-16) figures 1-4 page 1, line 16 -page 2, line 10 page 3, line 2 -page 7, line 18	1,4,7,8, 12,13, 16,23
Y		11
A		2,3,5,6, 10,14, 15, 17-22,24

X	DE 39 35 610 A (MESSERSCHMITT BOELKOW BLOHM) 2 May 1991 (1991-05-02) figures 1-6 column 1, line 47 -column 3, line 29	12,13, 20,21,23
Y		9
A		1-8,10, 11, 14-19, 22,24

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/EP 02/04122

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 0219027 A	07-03-2002	WO 0219027 A1	07-03-2002
		US 2002163625 A1	07-11-2002
EP 0738910 A	23-10-1996	US 5535047 A	09-07-1996
		CA 2173637 A1	19-10-1996
		CN 1160218 A	24-09-1997
		EP 0738910 A2	23-10-1996
		JP 8334709 A	17-12-1996
WO 0159363 A	16-08-2001	EP 1255949 A1	13-11-2002
		WO 0159363 A1	16-08-2001
		US 2002124573 A1	12-09-2002
		US 2001029740 A1	18-10-2001
DE 3935610 A	02-05-1991	DE 3935610 A1	02-05-1991
		DE 8915890 U1	16-01-1992