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(54) HEATED CANTILEVER

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(60) Provisional application No. 61/052,864, filed on May 13, 2008, provisional application No. 61/167,853, filed on Apr. 8, 2009.

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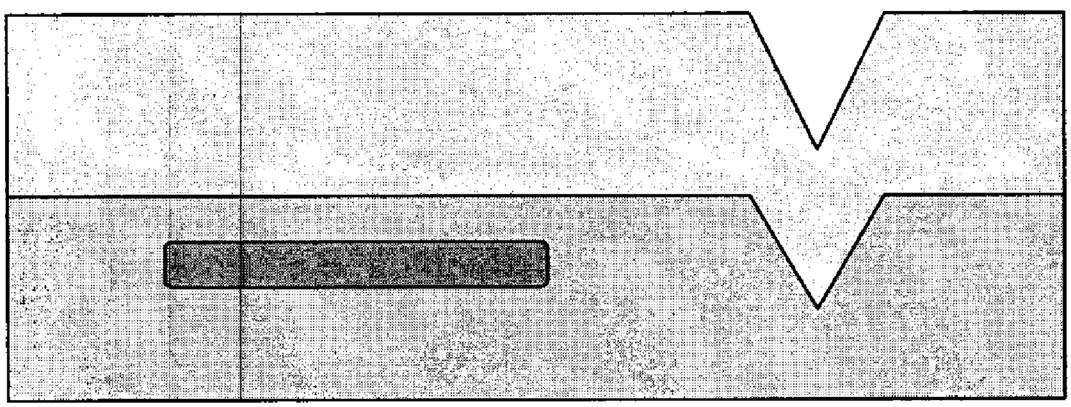
(57) ABSTRACT

A device is provided comprising at least one cantilever comprising at least one tip and at least one heating element. Methods for making and using such a device are also provided.



Strip Ox. Tip Sharpen Ox.

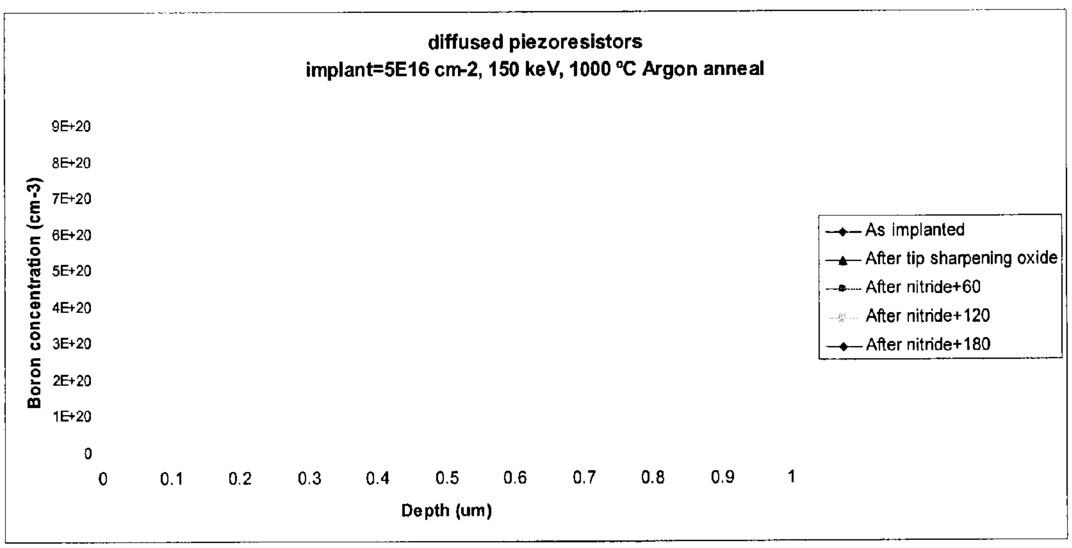

diffused piezoresistors
implant=5E16 cm-2, 150 keV, 1000 °C Argon anneal
Boron concentration (cm-3)
9E+20
8E+20
7E+20
6E+20
5E+20
4E+20
3E+20
2E+20
1E+20
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Depth (um)
As implanted
After tip sharpening oxide
After nitride+60
After nitride+120
After nitride+180

Figure 1

Fig. 2A. Tip Definition: Grow 100 nm oxide; pattern.

Fig. 2C. Tip Etch

Fig. 2B. Resistive Region Implant

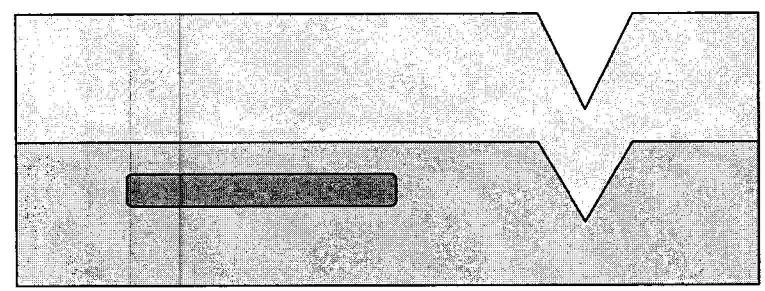


Fig. 2D. Strip Ox. Tip Sharpen Ox.

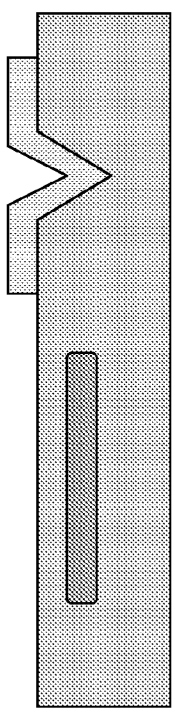


Fig 2E. Etch Tip Sharpen Ox. Remove resist.

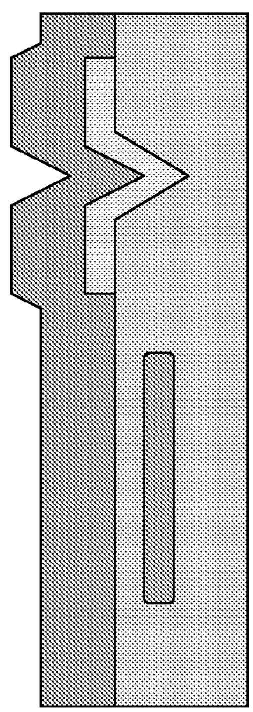


Fig 2F. Deposit Nitride.

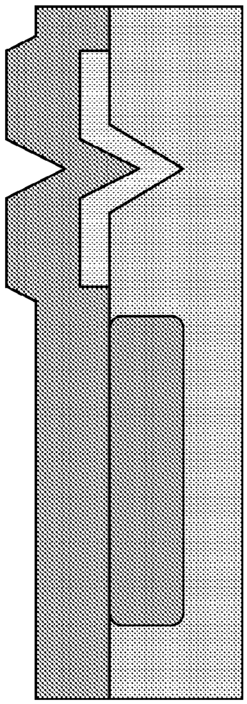


Fig 2G. Resistive Region Anneal.

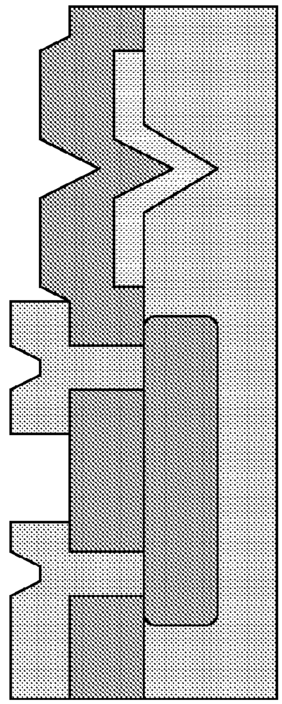


Fig 2H. Cantilever and Contact Etch. Gold Dep and Lift-Off.

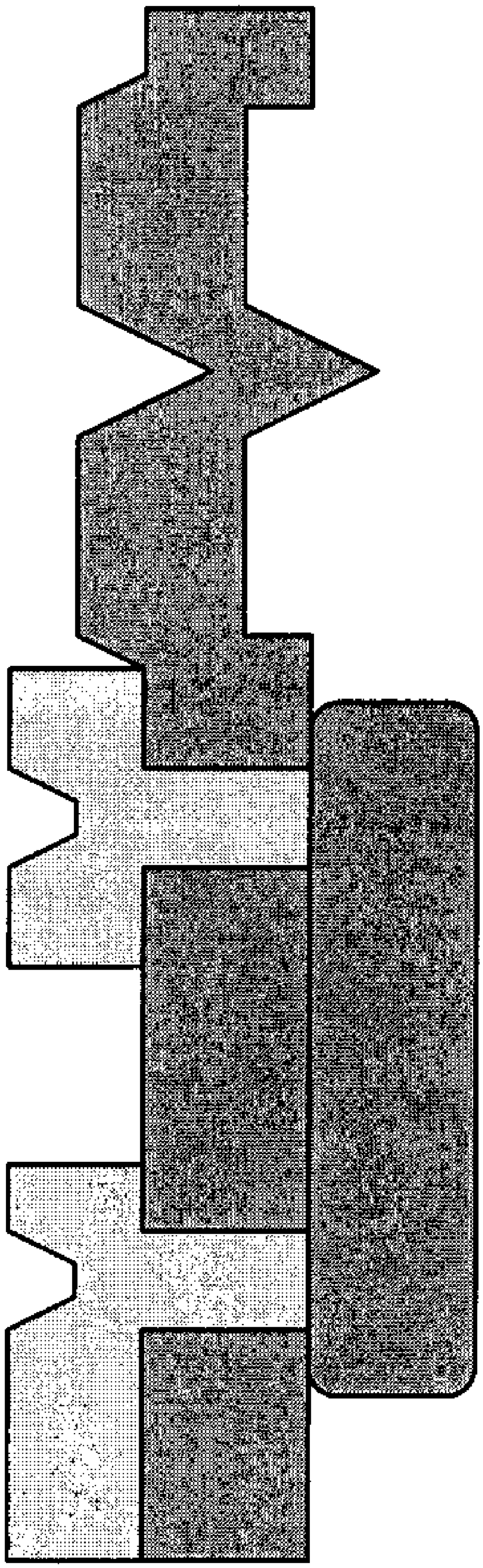


Fig. 2I. Wafer Bond. TMAH. Oxide etch.

HEATED CANTILEVER

RELATED APPLICATION

[0001] This application claims the benefit of U.S. Provisional Applications No. 61/052,864, filed May 13, 2008, and U.S. Provisional Application No. 61/167,853, filed Apr. 8, 2009, each of which are incorporated by reference in their entirety.

BACKGROUND

[0002] These exists a need to provide improved designs for heated cantilevers, as well as methods for making and using such heated cantilevers.

SUMMARY

[0003] Provided herein are devices, apparatuses, compositions, methods of making same, and methods of using same.

[0004] One embodiment provides a device comprising at least one cantilever comprising at least one tip and at least one heating element, said cantilever comprising silicon nitride or silicon carbide, said heating elements comprising gold, titanium, tungsten, doped silicon, or doped silicon carbide. In some embodiments, at least one heating element may be an electrical heating element, an electromagnetic inductive heating element, or an electromagnetic resonance heating element. In some embodiments, at least one tip may comprise at least one metal, at least one semiconductor, at least one insulator, at least one oxide, silicon nitride, or silicon nitride. In some embodiments, at least one cantilever may be an insulator. In some embodiments, the temperature of a tip can be substantially higher than the temperature at another location on the cantilever.

[0005] Another embodiment provides a method comprising forming at least one resistive region in a handle wafer, forming at least one cantilever disposed on the handle wafer, annealing the handle wafer for a time sufficient to allow at least one resistive region to contact the at least one cantilever, and separating the at least one cantilever and at least one resistive region from at least a portion of the handle layer, so that the at least one cantilever and at least one resistive region remain in contact. Some embodiments further comprise forming at least one tip disposed on said at least one cantilever. Some embodiments further comprise forming at least one metal contact on said at least one cantilever, where the at least one metal contact is in contact with the at least one resistive region. In some embodiments, such metal contacts may be chromium, platinum, or gold. In some embodiments, said forming at least one resistive region comprises ion implantation or ion diffusion. In some embodiments, the handle wafer may comprise single crystal silicon or polycrystalline silicon. In some embodiments at least one resistive region comprises single crystal silicon, polycrystalline silicon, silicon carbide, or boron. In some cases at least one resistive region comprises at least about 0.5×10^{20} atoms/cc of boron. In some embodiments, the at least one cantilever comprises silicon nitride or silicon carbide. In some cases, annealing is performed in argon at about 1000° C.

[0006] Yet another embodiment provides a method comprising providing a device comprising at least one cantilever comprising at least one tip and at least one heating element, said cantilever comprising silicon nitride or silicon carbide, said heating elements comprising gold, titanium, tungsten, doped silicon, or doped silicon carbide, providing at least one composition on at least one tip, heating at least one tip to a temperature using at least one heating tip, where the temperature is greater than at least one melting temperature of the at least one composition, and depositing the at least one composition on the surface.

[0007] Still another embodiment provides a method comprising providing a device comprising at least one cantilever comprising at least one tip and at least one heating element, said cantilever comprising silicon nitride or silicon carbide, said heating elements comprising gold, titanium, tungsten, doped silicon, or doped silicon carbide, providing a surface with at least one composition disposed thereon, heating at least one tip to at least one temperature using at least one heating element, so that at least one temperature is greater than at least one melting temperature of the at least one composition, and contacting at least one tip to at the at least one composition for a time sufficient to melt at least a portion of the at least one composition.

[0008] Yet still another embodiment provides a method comprising providing a device comprising at least one cantilever comprising at least one tip and at least one heating element, said cantilever comprising silicon nitride or silicon carbide, said heating elements comprising gold, titanium, tungsten, doped silicon, or doped silicon carbide, providing a surface with at least one composition disposed thereon, heating at least one tip to at least one temperature using at least one heating element, so that at least one temperature is greater than at least one decomposition temperature of the at least one composition, and contacting at least one tip to at the at least one composition for a time sufficient to decompose at least a portion of the at least one composition.

[0009] At least one advantage of at least one embodiment includes the ability to achieve high tip temperatures without requiring the remainder of the cantilever to be so heated.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. **1** shows the depth wise concentration profile of boron in the handle wafer in one embodiment.

[0011] FIGS. **2**A-**2**I provides schematics of a process flowchart of a fabrication procedure in one embodiment.

DETAILED DESCRIPTION

[0012] All references cited herein are incorporated by reference in their entirety.

Introduction

[0013] For practice of the various embodiments described herein, lithography, microlithography, and nanolithography instruments, pen arrays, active pens, passive pens, inks, patterning compounds, kits, ink delivery, software, and accessories for direct-write printing and patterning can be obtained from NanoInk, Inc., Chicago, Ill. Instrumentation includes the NSCRIPTOR. Software includes INKCAD software (NanoInk, Skokie, Ill.), providing user interface for lithography design and control. E-Chamber can be used for environmental control. Dip Pen Nanolithography® and DPN® are trademarks of NanoInk, Inc.

[0014] The following patents and co-pending applications related to direct-write printing with use of cantilevers, tips, and patterning compounds are hereby incorporated by reference in their entirety and can be used in the practice of the various embodiments described herein, including inks, patterning compounds, software, ink delivery devices, and the like:

[0015] U.S. Pat. No. 6,635,311 to Mirkin et al., which describes fundamental aspects of DPN printing including inks, tips, substrates, and other instrumentation parameters and patterning methods;

[0016] U.S. Pat. No. 6,827,979 to Mirkin et al., which further describes fundamental aspects of DPN printing including software control, etching procedures, nanoplotters, and complex and combinatorial array formation.

[0017] U.S. patent publication number 2002/0122873 A1 published Sep. 5, 2002 ("Nanolithography Methods and Products Produced Therefor and Produced Thereby"), which describes aperture embodiments and driving force embodiments of DPN printing.

[0018] U.S. Pat. No. 7,279,046 to Eby et al. ("Methods and Apparatus for Aligning Patterns on a Substrate"), which describes alignment methods for DPN printing.

[0019] U.S. Pat. No. 7,060,977 to Dupeyrat et al. ("Nanolithographic Calibration Methods"), which describes calibration methods for DPN printing.

[0020] U.S. Patent Publication 2003/0068446, published Apr. 10, 2003 to Mirkin et al. ("Protein and Peptide Nanoarrays"), which describes nanoarrays of proteins and peptides.

[0021] U.S. Pat. No. 7,361,310 to Mirkin et al. ("Direct-Write Nanolithographic Deposition of Nucleic Acids from Nanoscopic Tips"), which describes nucleic acid.

[0022] U.S. Pat. No. 7,273,636 to Mirkin et al. ("Patterning of Solid State Features by Direct-Write Nanolithographic Printing"), which describes reactive patterning and sol gel inks (now published Aug. 28, 2003 as 2003/0162004).

[0023] U.S. Pat. Nos. 6,642,129 and 6,867,443 to Liu et al. ("Parallel, Individually Addressable Probes for Nanolithography"), describing active pen arrays.

[0024] U.S. Patent Publication 2003/0007242, published Jan. 9, 2003 to Schwartz ("Enhanced Scanning Probe Microscope and Nanolithographic Methods Using Same").

[0025] U.S. Patent Publication 2003/0005755, published Jan. 9, 2003 to Schwartz ("Enhanced Scanning Probe Microscope").

[0026] U.S. Pat. No. 7,093,056 to Demers et al., describing catalyst nanostructures and carbon nanotube applications.

[0027] U.S. Pat. No. 7,199,305 to Cruchon-Dupeyrat et al., and U.S. Pat. No. 7,102,656 to Mirkin et al., describing printing of proteins and conducting polymers respectively.

[0028] U.S. Pat. No. 7,005,378 to Crocker et al., describing conductive materials as patterning compounds.

[0029] U.S. patent application Ser. No. 10/689,547 filed Oct. 21, 2003, now published as 2004/0175631 on Sep. 9, 2004, describing mask applications including photomask repair.

[0030] U.S. Pat. No. 7,034,854 Cruchon-Dupeyrat et al., describing microfluidics and ink delivery.

[0031] U.S. patent application Ser. No. 10/788,414 filed Mar. 1, 2004, now published as 2005/0009206 on Jan. 13, 2005 describing printing of peptides and proteins.

[0032] U.S. Pat. No. 7,326,380 to Mirkin et al., describing ROMP methods and combinatorial arrays.

[0033] U.S. Pat. No. 7,491,422 to Zhang et al., describing stamp tip or polymer coated tip applications.

[0034] U.S. patent application Ser. No. 11/065,694 filed Feb. 25, 2005, now published as 2005/0235869 on Oct. 27, 2005, describing tipless cantilevers and flat panel display applications.

[0035] US Patent publication 2006/001,4001 published Jan. 19, 2006 describing etching of nanostructures made by DPN methods.

[0036] WO 2004/105046 to Liu & Mirkin published Dec. 2, 2004 describes scanning probes for contact printing.

[0037] U.S. patent application "Active Pen Nanolithography," Ser. No. 11/268,740 to Shile et al. filed Nov. 8, 2005 describes for example thermcompression bonding and silicon handle wafers.

[0038] DPN methods are also described in Ginger et al., "The Evolution of Dip-Pen Nanolithography," *Angew. Chem. Int. Ed.* 2004, 43, 30-45, including description of high-throughput parallel methods. See also Salaita et al., "Applications of Dip-Pen Nanolithography," Nature Nanotechnology, 2007, Advanced On-line publication (11 pages).

[0039] Direct write methods, including DPN printing and pattern transfer methods, are described in for example *Direct-Write Technologies, Sensors, Electronics, and Integrated Power Sources,* Pique and Chrisey (Eds), 2002.

[0040] The direct-write nanolithography instruments and methods described herein are of particular interest for use in preparing bioarrays, nanoarrays, and microarrays based on peptides, proteins, nucleic acids, DNA, RNA, viruses, biomolecules, and the like. See, for example, U.S. Pat. No. 6,787,313 for mass fabrication of chips and libraries; U.S. Pat. No. 5,443,791 for automated molecular biology laboratory with pipette tips; U.S. Pat. No. 5,981,733 for apparatus for the automated synthesis of molecular arrays in pharmaceutical applications. Combinatorial arrays can be prepared. See also, for example, U.S. Pat. Nos. 7,008,769; 6,573,369; and 6,998,228 to Henderson et al.

[0041] Scanning probe microscopy is reviewed in Bottomley, *Anal. Chem.,* 1998, 70, 425R-475R. Also, scanning probe microscopes are known in the art including probe exchange mechanisms as described in, for example, U.S. Pat. No. 5,705,814 (Digital Instruments).

[0042] Microfabrication methods are described in for example Madou, *Fundamentals of Microfabrication,* 2^{nd} Ed., 2002, and also Van Zant, *Microchip Fabrication,* 5^{th} Ed., 2004.

[0043] See for example U.S. Pat. No. 6,827,979 to Mirkin et al. is also incorporated by reference in its entirety.

[0044] US Patent Publication 2003/0022470 and Publication 2006/0228873 to Liu et al. describe cantilever fabrication methods.

[0045] US Patent Publication 2006/0040057 to King, Sheehan et al. describes thermal DPN printing methods.

[0046] U.S. Provisional Applications No. 61/052,864, filed May 13, 2008, and U.S. Provisional Application No. 61/167,853, filed Apr. 8, 2009, are also both incorporated by reference in their entireties.

[0047] Companion U.S. applications "Piezoresistor Height-Sensing Cantilever" and "Dual-Tip Cantilever", both filed May 13, 2009 as Ser. No. ______ and Ser. No. ______ respectively, are both incorporated by reference in their entireties.

Cantilevers

[0048] Some embodiments comprise devices comprising one or more cantilevers. Some cantilevers may be of microscopic dimension. Some cantilevers may be of nanoscopic dimension. Some cantilevers may be used in such devices as atomic microscopes, scanning microscopes, or nanoscopes. Some cantilevers may be used to deposit materials on surfaces, measure local heights of surfaces, perform local heating or cooling of surfaces, and the like.

[0049] In some embodiments, cantilevers may comprise silicon nitride. Alternatively, they may comprise silicon carbide. These materials are tough polycrystalline ceramics, having high wear resistances. Both silicon nitride and silicon carbide are electrical insulators. Cantilevers made from these materials do not become electrically charged as silicon cantilevers do. Control over electrostatic fields in these cantilevers is improved over those made from silicon. Because these materials are also chemically inert, cantilevers made from them may also be used with biological materials. Silicon nitride may be more readily commercially available than silicon carbide.

[0050] Some cantilevers may be configured into arrays. Such arrays may be one-dimensional. Some arrays may have more than one dimension. In some embodiments, cantilevers are configured into two-dimensional arrays.

Tips

[0051] Some cantilevers may comprise one or more tips. Some tips may comprise the same materials as the rest of their cantilevers. In some embodiments, tips may comprise different materials than the rest of their cantilevers. Tips may comprise one or more metals, such as gold, gold alloys, titanium, tungsten, titanium-tungsten alloys, and the like. Tips may comprise semiconductors or insulators. Tips may comprise oxides, such as metal oxides, nitrides, such as silicon nitride, or carbides, such as silicon carbide.

[0052] In some embodiments, tips may be able to be heated. Such tips are useful for use in such applications as thermal active pens. Heating may be accomplished by inductive heating, resonance heating, resistive heating, and the like. Where cantilevers comprise insulating materials, such as silicon nitride or silicon carbide, tips may be maintained at temperatures substantially higher than those of locations on the cantilever removed from such heated tips. By "substantially higher", we mean temperatures that are at least 50° C. higher, preferably at least 100° C. higher.

[0053] In some embodiments, tip temperatures may be about 1000° C. In some embodiments, tip temperatures may be between about 400° C. and about 1000° C. In some cases, tip temperatures may be below about 400° C.

Cantilevers Heated by Heating Elements

[0054] In some embodiments, cantilevers and/or tips may be heated by heating elements disposed on or in the cantilevers. In some embodiments, tips themselves may comprise heating elements. Examples of such heating elements include layers disposed on the cantilevers, where the layers comprise electrically resistive heaters, electromagnetic inductive heaters, or electromagnetic resonance heaters. For temperatures below about 400° C., gold heating elements may be suitable. For temperatures above about 400° C., higher-melting materials may be used, such as titanium-tungsten alloys.

[0055] In some embodiments, heating elements may comprise resistive regions comprising heavily-doped silicon or silicon carbide. A preferred dopant is boron.

Fabricating Cantilevers, Tips, Heating Elements

[0056] Some cantilevers are prepared by a method of: (i) providing an oxidized silicon wafer comprising a silicon dioxide layer on silicon, (ii) patterning the silicon dioxide layer to generate etch openings adapted for formation of one or more tips, (iii) etching the silicon wafer anisotropically, (iv) and depositing and patterning silicon nitride to form the cantilever.

[0057] Fabrication of the pen can be carried out by adapting a process flow developed by Quate's group during the 1990's (1, 2). In one embodiment, this process starts with a highly accurate e-beam written mask to pattern one or more square openings onto an oxidized silicon surface, which will become one or more tips. The openings can be of any size. For example, they can be between about 1 micron to about 60 microns, such as between about 2 microns to about 50 microns. The size of the one or more openings can be the same or different from one another.

[0058] Subsequently, the wafer can be immersed in a KOH etch solution to etch anisotropically pyramidal pits into the silicon wafer to form the basic tip mold(s) and the optional v-trenches. The masking oxide can then be stripped and the wafers re-oxidized at 950° C. for 360 minutes to grow about 3900 Å of silicon oxide. At this time and temperature, the oxide at the bottom of the pit is hindered with respect to growth, and thus when a cast film is deposited in this pit, the tip sharpness can approach a 10 nm tip radius or smaller. No maximum limit of the tip size need to be imposed. For instance, the tip size can be increased by increasing the pit size.

[0059] Silicon nitride with low stress gradient can then be deposited onto the mold wafer to form a cantilever. In one embodiment, the nitride thickness is about 600 nm. Accordingly, with this thickness and a width of 25 um and a length of 200 um, a rectangular cantilever in this embodiment can have a spring constant of about 0.04 N/m. While this is a value that is commonly used for contact mode AFM probes and can work well for DPN, other spring constants may also be obtained and used. Not to be bound by any particular theory, the spring constant changes linearly with width w and with the third power of length L such that for a given thickness t, a wide range of spring constants K can be obtained: $K=Ewt^3/4L^3$, where E will depend on the materials of construction. In one alternative embodiment, the thickness of the nitride may also be changed on a batch basis to have a larger variation in spring constant. For example, nitride thicknesses from 400 nm to 1000 nm for cantilevers (with spring constant ranging from 0.0015 to over 1 N/m) have been used by NanoInk for different applications.

[0060] The nitride can be oxidized, patterned, and etched to form the cantilevers.

[0061] After the nitride is patterned, a photoresist layer is patterned for lift-off, and any metal layers are deposited and then lifted off the nitride wafer

[0062] Resistive regions may be fabricated by a process comprising (i) forming at least one resistive region in a handle wafer; (ii) forming at least one cantilever disposed on the handle wafer; (iii) annealing the handle wafer such that at least a portion of each resistive region is attached to the cantilever; and (iv) selectively removing the handle wafer such that at least the cantilever and the resistive regions remain.

[0063] The silicon can be doped with a n-type dopant, such as boron. The concentration of the boron can be for example greater than 0.5×10^{20} atoms cm^{-3}, such as at least 3×10^{20} atoms cm^{-3}. The dose of the dopant can vary with the thickness. For instance, in one embodiment, wherein the thickness is about 2 microns, the dose can be about 5×10^{16} atoms cm^{-2}. The dopant can be introduced into the silicon by ion implantation or diffusion. In one embodiment, wherein ion implantation is employed, the ion implantation can be performed at 150 keV.

[0064] In some embodiments, some resistive regions can serve to provide an etch stop for the subsequent KOH etch used to remove the undesired portions of the silicon handle wafer. In other embodiments, the use of heavily boron-doped silicon can help ensure the resistance of the structure remains substantially constant, even in the presence of a longer etching time, such as a doubling in etching time. The electrical and mechanical properties of such a structure can be highly resilient to process variations.

[0065] In one embodiment, after the tip is sharpened, such as by the oxidation process discussed above, a wafer or layer of silicon nitride can be deposited onto the tip and the handle wafer. In one embodiment, after the sharpening of the tip, about 0.1 microns to about 0.4 microns, such as about 0.22 microns of the silicon handle wafer was consumed. The silicon nitride can later become the cantilever. Alternatively, silicon carbide can be deposited. The handle wafer, with the newly formed cantilever and tip, can subsequently be annealed. Any suitable annealing conditions can be applied. In embodiment wherein the cantilever comprises silicon nitride, the structure is annealed in an Argon atmosphere at about 1000° C.

[0066] During annealing, the dopant implanted into the handle wafer can migrate. Annealing time will therefore generally affect the depth wise concentration of the dopant in the wafer. Although the dopant may not be in contact with the cantilever prior to annealing, the concentration profile can broaden during annealing to reach the interface between the wafer and the cantilever, finally being in contact with the cantilever. As shown in FIG. **1**, the dopant concentration is confined to a certain depth in the as-implanted sample, and it is not until after two or even three hours of annealing that the dopant profile broadens to a desirable depth. In this embodiment, after three hours of annealing at about 1000° C. in Argon, a dopant implanted at 3×10^{20} atoms cm^{-3} extends to depths of about 0.22 μm to about 0.6 μm, averaging about 0.4 μm.

REFERENCES

[0067] (1) T. R. Albrecht, S. Akamine, T. E. Carver, and C. F. Quate, "Microfabrication of cantilever styli for the atomic force microscope," *J. Vac. Sci. Technol. A, Vac. Surf. Films* (*USA*), 1990

[0068] (2) S. Akamine, and C. F. Quate, "Low temperature oxidation sharpening of microcast tips," *J. Vac. Sci. Technol B.,* vol. 10, No. 5, Sep/Oct 1992.

NON-LIMITING WORKING EXAMPLE

Thermal Active Pen with Piezoresistors Fabrication Procedure

[0069] A Schematic flowchart of the procedure is provided in FIGS. **3**A-**3**I.

[0070] 1) Starting material
[0071] 2) Clean
[0072] 3) Oxidation
[0073] 4) Clean
[0074] 5) Tip lithography
[0075] 6) Descum
[0076] 7) Oxide Etch
[0077] 8) Strip Resist/Clean
[0078] 9) Resistive region implant lithography
[0079] 10) Resistive region implant
[0080] 11) Tip Etch
[0081] 12) Clean
[0082] 13) Strip Oxide
[0083] 14) Clean
[0084] 15) Oxidize
[0085] 16) Sharpen Lithography
[0086] 17) Inspect
[0087] 18) Oxide Etch
[0088] 19) Strip Resist/Clean
[0089] 20) Deposit Silicon Nitride
[0090] 21) Resistive Region Anneal/Drive-in
[0091] 22) Cantilever Lithography
[0092] 23) Frontside Nitride etch
[0093] 24) Backside Lithography
[0094] 25) Backside Nitride Etch
[0095] 26) Strip Resist/Clean
[0096] 27) Actuator Lithography
[0097] 28) Descum
[0098] 29) Deposit Metal
[0099] 30) Liftoff Metal
[0100] 31) Clean

What is claimed is:

1. A device comprising at least one cantilever comprising at least one tip and at least one heating element, wherein said cantilever further comprises silicon nitride or silicon carbide, and wherein said one or more heating elements comprises gold, titanium, tungsten, doped silicon, or doped silicon carbide.

2. The device according to claim **1**, wherein the said at least one heating element comprises at least one electrical heating element.

3. The device according to claim **1**, wherein the said at least one heating element comprises at least one electromagnetic inductive heating element.

4. The device according to claim **1**, wherein the said at least one heating element comprises at least one electromagnetic resonance heating element.

5. The device according to claim **1**, wherein said at least one tip comprises at least one metal.

6. The device according to claim **1**, wherein said at least one tip comprises at least one semiconductor.

7. The device according to claim **1**, wherein said at least one tip comprises at least one insulator.

8. The device according to claim **1**, wherein said at least one tip comprises at least one oxide.

9. The device according to claim **1**, wherein said at least one tip comprises silicon nitride.

10. The device according to claim **1**, wherein said at least one tip comprises silicon carbide.

11. The device according to claim **1**, wherein said at least one cantilever is an insulator.

12. The device according to claim **1**, wherein said at least one cantilever comprises at least one location removed from said at least one tip, further wherein said at least one tip comprises at least one first temperature and said at least one location removed from said at least one tip comprises at least one second temperature, wherein said at least one first temperature is substantially higher than said at least one second temperature.

13. A method comprising:

(i) forming at least one resistive region in a handle wafer;

(ii) forming at least one cantilever disposed on said handle wafer;

(iii) annealing said handle wafer for a time, wherein said time is sufficient to allow said at least one resistive region to contact said at least one cantilever; and

(iv) separating at least a part of said handle wafer, so that said at least one cantilever and said at least one resistive region remain in contact.

14. The method according to claim **13**, further comprising forming at least one tip disposed on said at least one cantilever.

15. The method according to claim **13**, further comprising forming at least one metal contact on said at least one cantilever, wherein said at least one metal contact contacts said at least one resistive region.

16. The method according to claim **13**, further comprising forming at least one metal contact on said at least one cantilever, wherein said at least one metal contact contacts said at least one resistive region, further wherein said at least one metal contact comprises one or more of chromium, platinum, or gold.

17. The method according to claim **13**, wherein said forming at least one resistive region comprises ion implantation or ion diffusion.

18. The method according to claim **13**, wherein said handle wafer comprises single crystal silicon.

19. The method according to claim **13**, wherein said handle wafer comprises polycrystalline silicon.

20. The method according to claim **13**, wherein said at least one resistive region comprises single crystal silicon.

21. The method according to claim **13**, wherein said at least one resistive region comprises polycrystalline silicon.

22. The method according to claim **13**, wherein said at least one resistive region comprises silicon carbide.

23. The method according to claim **13**, wherein said at least one resistive region comprises boron.

24. The method according to claim **13**, wherein said at least one resistive region comprises at least about 0.5×10^{20} atoms/cm^3 of boron.

25. The method according to claim **13**, wherein said at least one cantilever comprises silicon nitride.

26. The method according to claim **13**, wherein said at least one cantilever comprises silicon carbide.

27. The method according to claim **13**, wherein said annealing said handle wafer is performed in an Argon atmosphere at about 1000° C.

28. A method comprising:

(i) providing a device comprising at least one cantilever comprising at least one tip and at least one heating element, wherein said cantilever further comprises silicon nitride or silicon carbide, and wherein said one or more heating elements comprises gold, titanium, tungsten, doped silicon, or doped silicon carbide,

(ii) providing at least one composition on said at least one tip, said at least one composition comprising at least one melting temperature,

(iii) heating said at least one tip to at least one temperature using said at least one heating element, said at least one temperature being greater than said at least one melting temperature, and

(iv) depositing said at least one composition on a surface.

29. A method comprising:

(i) providing a device comprising at least one cantilever comprising at least one tip and at least one heating element, wherein said cantilever further comprises silicon nitride or silicon carbide, and wherein said one or more heating elements comprises gold, titanium, tungsten, doped silicon, or doped silicon carbide,

(ii) providing a surface with at least one composition disposed thereon, said at least one composition comprising at least one melting temperature,

(iii) heating said at least one tip to at least one temperature using said at least one heating element, said at least one temperature being greater than said at least one melting temperature, and

(iv) contacting said at least one tip to said at least one composition for a time sufficient to melt at least a portion of said at least one composition.

30. A method comprising:

(i) providing a device comprising at least one cantilever comprising at least one tip and at least one heating element, wherein said cantilever further comprises silicon nitride or silicon carbide, and wherein said one or more heating elements comprises gold, titanium, tungsten, doped silicon, or doped silicon carbide,

(ii) providing a surface with at least one composition disposed thereon, said at least one composition comprising at least one decomposition temperature,

(iii) heating said at least one tip to at least one temperature using said at least one heating element, said at least one temperature being greater than said at least one decomposition temperature, and

(iv) contacting said at least one tip to said at least one composition for a time sufficient to decompose at least a portion of said at least one composition.

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