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Flexure and disk drive suspension

Abstract

A flexure includes a body portion including a first metal base, a terminal portion electrically connected to an actuator, and a connection portion connecting the body portion with the terminal portion and not including the first metal base. The wiring portion includes a base insulating layer, a conductor layer provided on the base insulating layer, and a cover insulating layer covering the conductor layer. The cover insulating layer includes a first cover portion provided on the connection portion, and the base insulating layer includes a first base portion provided on the connection portion and having a thickness smaller than a thickness of the first cover portion.

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References Cited

U.S. PATENT DOCUMENTS

Patent No.	Issued Date	Patentee Name	U.S. Cl.	CPC
7218481	12/2006	Bennin	N/A	G11B 5/5552
8149542	12/2011	Ando	360/245.9	H10N 30/875
8199442	12/2011	Okawara et al.	N/A	N/A
8810972	12/2013	Dunn	360/294.4	G11B 5/4873
9076957	12/2014	Ikeji	N/A	G11B 5/4873
2002/0089793	12/2001	Nakagawa	N/A	H05K 3/328
2011/0051290	12/2010	Inoue	N/A	H10N 30/875
2011/0141624	12/2010	Fuchino	29/603.07	G11B 5/4873
2013/0133939	12/2012	Ishii	174/262	G11B 5/486
2013/0314821	12/2012	Arai	360/244.5	G11B 5/4873
2013/0319748	12/2012	Ishii	174/262	H05K 1/0298
2013/0321958	12/2012	Ikeji	228/8	B23K 3/0638
2014/0362467	12/2013	Nojima	360/97.13	G11B 5/4873
2017/0179005	12/2016	Yamada	N/A	H01L 21/4828
2017/0236540	12/2016	Kawao	360/244.1	G11B 5/4853
2022/0097357	12/2021	Nakano	N/A	G11B 5/483
2023/0282230	12/2022	Sugiyama	360/294.4	G11B 5/4853
2023/0419991	12/2022	Nishida	N/A	G11B 5/4846

FOREIGN PATENT DOCUMENTS

Patent No.	Application Date	Country	CPC
3626688	12/2004	JP	G11B 5/4873
5318703	12/2012	JP	N/A

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Background/Summary

CROSS-REFERENCE TO RELATED APPLICATIONS

(1) This application is based upon and claims the benefit of priority from prior Japanese Patent Application No. 2023-043367, filed Mar. 17, 2023, the entire contents of which are incorporated

herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

(2) The present invention relates to a flexure and a disk drive suspension.

2. Description of the Related Art

(3) A disk drive is used in an information processing apparatus such as a personal computer. The disk drive includes a magnetic disk rotatable about a spindle, a carriage pivotable about a pivot, and the like. A disk drive suspension is provided on an arm of the carriage. The disk drive suspension comprises a baseplate, a load beam, a flexure arranged along the load beam, and the like.

(4) A slider is provided on a gimbal portion formed near a distal end of the flexure. The slider is provided with elements for performing access such as reading and writing of data stored in a disk. In order to increase recording density of the disk, a magnetic head needs to be positioned more quickly and precisely relative to a recording surface of the disk.

(5) For improving positioning accuracy of the magnetic head, a dual stage actuator (DSA) suspension using a positioning motor (voice coil motor) and an actuator mounted on a baseplate side together and a triple stage actuator (TSA) suspension in which an actuator is further mounted on a magnetic head side are known.

(6) Conventionally, various proposals have been made on power supply to the actuator. JP 5318703 B discloses an electrical connection structure to piezoelectric element functioning, for example, as the actuator.

(7) Even in consideration of JP 5318703 B described above, the connection between the piezoelectric element and the flexure has room for improvement in various ways.

BRIEF SUMMARY OF THE INVENTION

(8) One of objects of the present invention is to provide a flexure and a disk drive suspension capable of increasing reliability.

(9) A flexure according to one of embodiments includes a first metal base and a wiring portion overlapping with the first metal base. The flexure includes a body portion including the first metal base, a terminal portion electrically connected to an actuator, and a connection portion connecting the body portion with the terminal portion and not including the first metal base.

(10) The wiring portion includes a base insulating layer including a first surface formed over the body portion, the connection portion, and the terminal portion and facing the first metal base, and a second surface on a side opposite to the first surface, a conductor layer provided on the second surface, and a cover insulating layer covering the conductor layer. The cover insulating layer includes a first cover portion provided on the connection portion, and the base insulating layer includes a first base portion provided on the connection portion and having a thickness smaller than a thickness of the first cover portion.

(11) The base insulating layer may include a second base portion provided on the body portion and having a thickness greater than the thickness of the first base portion. The base insulating layer may include a third base portion provided on the terminal portion and having a thickness greater than the thickness of the first base portion.

(12) The cover insulating layer may include a first layer formed over the body portion, the connection portion, and the terminal portion, and a second layer formed on the connection portion and overlapping with the first layer. The cover insulating layer may include a second cover portion provided on the body portion and having a thickness smaller than the thickness of the first cover portion. The insulating cover layer may include a third cover portion provided on the terminal portion and having a thickness smaller than the thickness of the first cover portion.

(13) A disk drive suspension according to one of embodiments comprises a load beam, the flexure overlapping with the load beam, and an actuator electrically connected to the terminal portion.

(14) The disk drive suspension may further comprise an adhesive member, the actuator may include an electrode facing the first surface, and the adhesive member may electrically connect the

electrode with the conductor layer located on the terminal portion.
(15) The flexure may further include a second metal base located between the base insulating layer located on the terminal portion and the electrode, and a through hole connecting the electrode with the conductor layer may be formed in the base insulating layer located on the second metal base and the terminal portion.
(16) The base insulating layer may be provided on the body portion and include a second base portion having a thickness greater than the thickness of the first base portion. A surface located on the first base portion of the second surface may be located closer to the load beam than a surface located on the second base portion.
(17) The base insulating layer may be provided on the body portion and include a second base portion having a thickness greater than the thickness of the first base portion. A surface located on the first base portion of the first surface may be farther from the load beam than a surface located on the second base portion.
(18) According to the above configuration of the flexure and the disk drive suspension, reliability can be increased.
(19) Additional objects and advantages of the invention will be set forth in the description which follows, and in part will be obvious from the description, or may be learned by practice of the invention. The objects and advantages of the invention may be realized and obtained by means of the instrumentalities and combinations particularly pointed out hereinafter.

Description

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING
(1) The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate embodiments of the invention, and together with the general description given above and the detailed description of the embodiments given below, serve to explain the principles of the invention.
(2) FIG. **1** is a schematic perspective view showing an example of a disk drive according to a first embodiment.
(3) FIG. **2** is a schematic cross-sectional view showing a part of the disk drive according to the first embodiment.
(4) FIG. **3** is a schematic plan view of a suspension according to the first embodiment.
(5) FIG. **4** is a schematic plan view of the suspension according to the first embodiment.
(6) FIG. **5** is a schematic partially enlarged view showing the flexure located on a V portion in FIG. **3**.
(7) FIG. **6** is a schematic cross-sectional view of the flexure along line VI-VI in FIG. **5**.
(8) FIG. **7** is a schematic cross-sectional view of the flexure along line VII-VII in FIG. **5**.
(9) FIG. **8** is a schematic cross-sectional view showing a connection portion of the flexure according to the comparative example.
(10) FIG. **9** is a schematic cross-sectional view showing the connection portion of the flexure according to the comparative example.
(11) FIG. **10** is a schematic cross-sectional view of a flexure according to a second embodiment.
(12) FIG. **11** is a chart showing an analysis result.
(13) FIG. **12** is a chart showing an analysis result.
(14) FIG. **13** is a schematic cross-sectional view showing a connection portion of a flexure according to a third embodiment.
DETAILED DESCRIPTION OF THE INVENTION
(15) Embodiments of the present invention will be hereinafter described with reference to the accompanying drawings. In order to make the description clearer, the sizes, shapes and the like of

the respective parts may be changed and illustrated schematically in the drawings as compared with those in an accurate representation.

First Embodiment

(16) FIG. **1** is a schematic perspective view showing an example of a disk drive (HDD) **1** of the present embodiment. In the example shown in FIG. **1**, the disk drive **1** comprises a casing **2**, a plurality of magnetic disks (hereinafter simply referred to as a disk **4**) rotatable about a spindle **3**, a carriage **6** pivotable about a pivot **5**, and a positioning motor (voice coil motor) **7** for driving the carriage **6**. The case **2** is sealed by a lid (not shown).

(17) FIG. **2** is a schematic cross-sectional view showing a part of the disk drive **1** of the present embodiment. The carriage **6** is provided with a plurality of (for example, three) arms **8**. At a distal end portion of each of the plurality of arms **8**, a disk drive suspension (hereinafter simply referred to as a suspension **10**) is mounted. A slider **11**, which constitutes a magnetic head, is provided at a distal end portion of the suspension **10**. When the disk **4** rotates at high speed, an air bearing is formed as air flows in between the disk **4** and the slider **11**.

(18) When the carriage **6** is rotated by the positioning motor **7**, the suspension **10** moves radially relative to the disk **4**, and the slider **11** thereby moves to a desired track of the disk **4**. Elements capable of converting magnetic signals and electrical signals, such as MR elements are provided at a distal end portion of the slider **11**, for example. By these elements, access such as writing data to the disk **4** or reading data from the disk **4** is performed.

(19) FIG. **3** and FIG. **4** are schematic plan views of the suspension **10** of the present embodiment. FIG. **5** is a schematic partially enlarged view showing the flexure located on a V portion in FIG. **3**. In FIG. **4**, the suspension **10** is viewed in a direction opposite to that in FIG. **3**. In the present embodiment, a TSA type suspension is disclosed as an example of the suspension **10**. The suspension **10** comprises a baseplate **20**, a load beam **30**, and a flexure **40**.

(20) The baseplate **20**, the load beam **30**, and the flexure **40** all extend in the longitudinal direction of the suspension **10**. In the following descriptions, the longitudinal direction of each of the suspension **10**, the baseplate **20**, the load beam **30**, and the flexure **40** is defined as the first direction X. In the first direction X, with reference to the baseplate **20**, a side on which the slider **11** is mounted is referred to as a distal end side in some cases.

(21) A direction intersecting (for example, orthogonal to) the first direction X is defined as the second direction Y of the suspension **10**, the baseplate **20**, the load beam **30**, the flexure **40**, and the like. A direction intersecting (for example, orthogonal to) the first direction X and the second direction Y is defined as the third direction Z of the suspension **10**, the baseplate **20**, the load beam **30**, the flexure **40**, and the like.

(22) A direction of the third direction Z is referred to as up or above and an opposite direction of the third direction Z is referred to as down or below in some cases. The length along the third direction Z is hereinafter referred to as the thickness in some cases. A sway direction S (shown in FIG. **3**) is defined as represented by an arcuate arrow in the vicinity of the distal end of the load beam **30**.

(23) The baseplate **20** is connected to the arm **8** (shown in FIG. **2**). The baseplate **20** can be formed of a metal material such as stainless steel, for example. For example, the thickness of the baseplate **20** is 100 μm or less, but is not limited to this example.

(24) The baseplate **20** includes a circular boss portion **21**. The baseplate **20** is attached to the arm **8** through the boss portion **21**. The baseplate **20** further includes apertures **23** and **25**, as shown in FIG. **4**. The apertures **23** and **25** penetrate the baseplate **20**.

(25) The load beam **30** can be formed of a metal material such as stainless steel. The thickness of the load beam **30** is smaller than the thickness of the baseplate **20**. For example, the thickness of the load beam **30** is 20 to 80 μm, but is not limited to this example.

(26) The load beam **30** has a tapered shape toward a distal end (left side in FIG. **3** and FIG. **4**). The load beam **30** is elastically supported by the baseplate **20** through a spring portion **31**. The load

beam **30** is fixed to the baseplate **20** by spot welding using laser, for example. The load beam **30** has a surface **33**A on which the flexure **40** is arranged and a surface **33**B on a side opposite to the surface **33**A.
(27) The load beam **30** includes a portion overlapping with the baseplate **20**. Apertures **35** and **37** are formed in this portion. The aperture **35** is aligned with the aperture **37** at an interval in the second direction Y. The apertures **35** and **37** penetrate the surface **33**A and the surface **33**B.
(28) In the third direction Z, the aperture **35** overlaps with the aperture **23**, and the aperture **37** overlaps with the aperture **25**. The apertures **35** and **37** and the apertures **23** and **25** form actuator mounting portions **15**A and **15**B.
(29) The flexure **40** is arranged along the baseplate **20** and the load beam **30**. A part of the flexure **40** overlaps with the load beam **30**. The flexure **40** is fixed to the baseplate **20** and the load beam **30** by spot welding using laser, for example.
(30) The flexure **40** includes a metal base **41** (first metal base) formed of a thin stainless steel plate, and a wiring portion **50** overlapping with the metal base, for example. The thickness of the metal base **41** is smaller than the thickness of the load beam **30**. The thickness of the metal base **41** is 15 to 20 μm, for example. The metal base **41** overlaps with the surface **33**A of the load beam **30**.
(31) As shown in FIG. **3** and FIG. **5**, the flexure **40** includes a body portion F**1**, terminal portions F**2**A and F**2**B, and a connection portion F**3** connecting the body portion F**1** with the terminal portion F**2**A. The body portion F**1** includes a distal end portion **40***a* and a tail portion **40***b* extending toward the rear of the baseplate **20** (right side in FIG. **3** and FIG. **4**).
(32) The slider **11**, which constitutes the magnetic head, is provided at the distal end portion **40***a* of the body portion F**1**. In the example shown in FIG. **3**, the slider **11** to be mounted is represented by a dashed line. Each of the terminal portions F**2**A and F**2**B is electrically connected to the actuator. The terminal portion F**2**A overlaps with the aperture **35**, and the terminal portion F**2**B overlaps with the aperture **37**. The connection portion F**3** extends from the body portion F**1** toward the aperture **35** and connects the body portion F**1** with the terminal portion F**2**A.
(33) The suspension **10** further comprises piezoelectric elements **61**A and **61**B and piezoelectric elements **63**A and **63**B. In the present embodiment, the piezoelectric elements **61**A, **61**B, **63**A, and **63**B are examples of actuators. Each of the piezoelectric elements **61**A, **61**B, **63**A, and **63**B is formed of a piezoelectric material such as zirconate titanate (PTZ).
(34) When voltage is applied to the piezoelectric elements **61**A, **61**B, **63**A, and **63**B, piezoelectric body expands and contracts in response to the applied voltage, the distal end side of the suspension **10** can be moved a minute amount in the sway direction S.
(35) The piezoelectric elements **61**A and **61**B are located on both sides of the slider **11** in the second direction Y. The piezoelectric elements **61**A and **61**B may be arranged on a side opposite to the side on which the slider **11** of the flexure **40** is mounted, for example.
(36) The piezoelectric elements **63**A and **63**B are provided on the actuator mounting portions **15**A and **15**B, respectively. More specifically, the piezoelectric elements **63**A and **63**B are accommodated in the apertures **23** and **25**, respectively. The piezoelectric elements **63**A and **63**B are fixed to the surface **33**B of the load beam **30** by an adhesive member **81**. In FIG. **4**, the adhesive member **81** is represented by dots. For example, the adhesive member **81** is an electrically insulating resin adhesive such as epoxy.
(37) The piezoelectric element **63**A is electrically connected to the terminal portion F**2**A, and the piezoelectric element **63**B is electrically connected to the terminal portion F**2**B. The piezoelectric elements **63**A and **63**B include an electrode **65** located on one side of the third direction Z (surface facing the surface **33**B) and an electrode **67** located on the surface of the other side in the third direction Z.
(38) The electrodes **65** and **67** are formed into flat electrode surfaces by sputtering or plating, for example. The electrodes **65** of the piezoelectric elements **63**A and **63**B are exposed from the apertures **35** and **37**, respectively.

(39) The electrodes **65** are electrically connected to the wiring portion **50** of the flexure **40** through the terminal portions F**2**A and F**2**B. The electrode **67** is electrically connected to the baseplate **20**, which is the ground side, by an adhesive member **82**. In FIG. **4**, the adhesive member **82** is represented by dots. The adhesive member **82** can be formed of, for example, a conductive adhesive such as a silver paste.
(40) Next, an example of a structure that can be applied to the connection portion F**3** of the flexure **40** will be described.
(41) FIG. **6** is a schematic cross-sectional view of the flexure **40** along VI-VI line shown in FIG. **5**. FIG. **7** is a schematic cross-sectional view of the flexure **40** along VII-VII line shown in FIG. **5**. In FIG. **6**, the flexure **40** is viewed along the second direction Y, and in FIG. **7**, the flexure **40** is viewed along the first direction X.
(42) The flexure **40** includes the metal base **41** and the wiring portion **50**, as described above. The metal base **41** includes a surface **43**A facing the surface **33**A of the load beam **30** and a surface **43**B on a side opposite to the surface **43**A, as shown in FIG. **7**. While the body portion F**1** includes the metal base **41**, the connection portion F**3** does not include the metal base **41**.
(43) The wiring portion **50** includes a base insulating layer **51**, a conductor layer **53**, and a cover insulating layer **55**. The base insulating layer **51** and the cover insulating layer **55** can be formed of an electrically insulating resin material such as polyimide, for example.
(44) The conductor layer **53** can be formed of a metal material with high electrical conductivity such as copper. The conductor layer **53** is formed by coating, an additive method (for example, semi-additive method or full additive method) using plating, or the like, for example.
(45) The conductor layer **53** is formed in the body portion F**1** from a connection terminal (not shown) located on the tail portion **40***b* to the distal end portion **40***a*. The conductor layer **53** includes a plurality of conductive lines, for example.
(46) The plurality of conductive lines include conductive lines for reading and conductive lines for writing, for example. Each of these conductive lines for reading and conductive lines for writing is connected to the slider **11**. Conductive lines for supplying power to the piezoelectric elements **63**A and **63**B, which are part of the plurality of conductive lines, branch from the body portion F**1** and extend to the terminal portions F**2**A and F**2**B.
(47) The base insulating layer **51** is formed over the body portion F**1**, the connection portion F**3**, and the terminal portion F**2**A, as shown in FIG. **7**. The base insulating layer **51** includes a surface **52**A (first surface) facing the surface **43**B of the metal base **41**, and a surface **52**B (second surface) on a side opposite to the surface **52**A.
(48) The base insulating layer **51** includes a base portion **511** (second base portion) provided on the body portion F**1**, a base portion **512** (first base portion) provided on the connection portion F**3**, and a base portion **513** (third base portion) provided on the terminal portion F**2**A. The base portion **511**, the base portion **512**, and the base portion **513** are integrally formed.
(49) The base portion **512** has a uniform thickness in the first direction X in the example shown in FIG. **6**. The base portion **512** has a uniform thickness in the second direction Y in the example shown in FIG. **7**.
(50) A thickness T**12** (shown in FIG. **7**) of the base portion **512** is smaller than a thickness T**11** (shown in FIG. **7**) of the base portion **511** and a thickness T**13** (shown in FIG. **7**) of the base portion **513**. In other words, the base portions **511** and **513** have the thicknesses T**11** and T**13** greater than that of the base portion **512**.
(51) The thickness T**11** of the base portion **511** is equivalent to the thickness T**13** of the base portion **513**, for example. The thickness T**11** of the base portion **511** may be different from the thickness T**13** of the base portion **513**.
(52) The thicknesses T**11** and T**13** of the base portion **511** and the base portion **513** are 7 μm to 12 μm, for example. The thicknesses T**11** and T**13** of the base portion **511** and the base portion **513** are 10 μm in one example.

(53) The thickness T**12** of the base portion **512** is 3 μm to 7 μm, for example. The thickness T**12** of the base portion **512** is 5 μm in one example. The thickness T**12** of the base portion **512** is the half of the thicknesses T**11** and T**13** of the base portion **511** and the base portion **513** in one example.
(54) The base portion **512** of the base insulating layer **51** is formed, in one example, through an exposure process using a gradation mask. For example, in a case of positive-type photosensitive polyimide, by adjusting the amount of exposure in the area corresponding to the base portion **512**, the area can be removed by development, and the thickness T**12** of the base portion **512** can be made smaller than the other portions.
(55) In this case, the surface **52**B located on the base portion **512** is located lower than the surface **52**B located on the base portion **511** and the base portion **513** (load beam **30** side).
(56) As shown in FIG. **7**, since the metal base **41** is not provided on the connection portion F**3**, an air layer is formed between the surface **52**A located on the base portion **512** and the surface **33**A of the load beam **30**.
(57) The conductor layer **53** is provided on the surface **52**B and overlaps with the base portions **511**, **512**, and **513**. The conductor layer **53** has a uniform thickness in the example shown in FIG. **7**. For example, the thickness of the conductor layer **53** is 5 μm to 12 μm and is 6 μm in one example.
(58) The cover insulating layer **55** covers the base insulating layer **51** and the conductor layer **53**. In other words, the conductor layer **53** is located between the base insulating layer **51** and the cover insulating layer **55**. A part of the cover insulating layer **55** covers the base insulating layer **51** in the example shown in FIG. **6**. In other words, the part of the cover insulating layer **55** is in contact with the surface **52**B.
(59) The cover insulating layer **55** includes a cover portion **551** (second cover portion) provided on the body portion F**1**, a cover portion **552** (first cover portion) provided on the connection portion F**3**, and a cover portion **553** (third cover portion) provided on the terminal portion F**2**A. In the connection portion F**3**, the base portion **512**, the conductor layer **53**, and the cover portion **552** are stacked in this order.
(60) A thickness T**52** (shown in FIG. **7**) of the cover portion **552** is greater than a thickness T**51** (shown in FIG. **7**) of the cover portion **551** and a thickness T**53** (shown in FIG. **7**) of the cover portion **553**. In other words, the cover portions **551** and **553** have the thicknesses T**51** and T**53** smaller than that of the cover portion **552**. The thickness of the cover portion **552** corresponds to the thickness of a portion of the cover portion **552** that overlaps with the conductor layer **53**.
(61) The thickness T**51** of the cover portion **551** is the same as the thickness T**53** of the cover portion **553**, for example. The thickness T**51** of the cover portion **551** may be different from the thickness T**53** of the cover portion **553**.
(62) The cover portion **552** is formed of a plurality of layers, for example. Thus, the thickness T**52** of the cover portion **552** is greater than the thickness T**12** of the base portion **512**. The cover insulating layer **55** includes a first layer **71** and a second layer **73** overlapping with the first layer **71**. Each of the first layer **71** and the second layer **73** is formed of a polyimide.
(63) The first layer **71** is formed over the body portion F**1**, the connection portion F**3**, and the terminal portion F**2**A. The first layer **71** has a surface **72**A facing the conductor layer **53** and a surface **72**B on a side opposite to the surface **72**A.
(64) The second layer **73** is formed on the connection portion F**3**. The second layer **73** has a surface **74**A facing the surface **72**B and a surface **74**B on a side opposite to the surface **74**A. In the example shown in FIG. **7**, the surface **74**B is located lower than the surface **72**B of the first layer **71** located on the cover portion **551** and the cover portion **553**.
(65) The thickness T**52** of the cover portion **552** corresponds to the sum of a thickness T**71** (shown in FIG. **7**) of the first layer **71** and a thickness T**73** (shown in FIG. **7**) of the second layer **73**. The thickness T**73** of the second layer **73** is greater than the thickness T**71** of the first layer **71**, for example.
(66) The thickness T**71** of the first layer **71** is from 3 μm to 7 μm, for example. The thickness T**71**

of the first layer **71** is 4 μm, in one example. The thickness T**73** of the second layer **73** is from 4 μm to 8 μm, for example. The thickness T**73** of the second layer **73** is 5 μm in one example.
(67) The thickness T**73** of the second layer **73** may be smaller than the thickness T**71** of the first layer **71** or equivalent to the thickness T**71** of the first layer **71**. The thickness T**73** of the second layer **73** is smaller than the thickness T**12** of the base portion **512**.
(68) When the base insulating layer **51** is focused, the thickness of the base insulating layer **51** in the connection portion F**3** is smaller than the thickness of the cover insulating layer **55** in the connection portion F**3**. More specifically, the thickness T**12** of the base portion **512** is smaller than the thickness T**52** of the cover portion **552**. When the conductor layer **53** is focused, the thickness T**12** of the base portion **512** is smaller than the thickness of the conductor layer **53**, and the thickness T**52** of the cover portion **552** is greater than the thickness of the conductor layer **53**.
(69) The base portion **512** constitutes a thin portion functioning as an adjustment portion for adjusting the deformation amount of the connection portion F**3**. The cover portion **552** constitutes a thick portion functioning as an adjustment portion for adjusting the deformation amount of the connection portion F**3**.
(70) The flexure **40** further includes a metal base **45** (second metal base) in the terminal portion F**2**A. The metal base **45** is arranged on the surface **52**A located on the base portion **513**. The metal base **45** has a circular shape, for example, when viewed in the third direction Z. The metal base **45** has a surface **47**A facing the surface **52**A located on the base portion **513** and a surface **47**B located on a side opposite to the surface **47**A, as shown in FIG. **7**. The metal base **45** is provided on the terminal portion F**2**B as well, though not shown.
(71) When the piezoelectric element **63**A is focused, the metal base **45** is provided between the base portion **513** and the electrode **65** of the piezoelectric element **63**A. In other words, the electrode **65** faces the surface **52**A with the metal base **45** interposed therebetween as shown in FIG. **7**. Similarly to the metal base **41**, the metal base **45** can be formed of a metal material such as stainless steel.
(72) A through hole H**1** penetrating the metal base **45** and the base portion **513** in the third direction z is formed in the terminal portion F**2**A. Since the through hole H**1** is not formed in the conductor layer **53**, the conductor layer **53** is exposed in the through hole H**1**. In other words, the through hole H**1** connects the electrode **65** with the conductor layer **53**.
(73) The suspension **10** further comprises the adhesive member **83**. The adhesive member **83** electrically connects the electrode **65** with the conductor layer **53** located on the terminal portion F**2**A. For example, the adhesive member **83** is formed of a conductive adhesive such as a silver paste.
(74) The adhesive member **83** is located not only between the metal base **45** and the electrode **65**, but also in the through hole H**1**. As a result, the electrode **65** and the conductor layer **53** of the terminal part F**2**A are electrically connected to each other, and power can be supplied from the flexure **40** to the piezoelectric element **63**A. The adhesive member **83** is also used to connect the terminal portion F**2**B with the piezoelectric element **63**B.
(75) Next, a flexure **400** of the comparative example will be described.
(76) FIG. **8** and FIG. **9** are schematic cross-sectional views showing the connection portion of the flexure **400** of the comparative example. The connection portion F**3** of the flexure **400** is viewed along the second direction Y in FIG. **8**, and the connection portion F**3** of the flexure **400** and the vicinity thereof are viewed along the first direction X in FIG. **9**.
(77) The flexure **400** includes the metal base **41** and the wiring portion **50**. The wiring portion **50** may include the base insulating layer **51**, the conductor layer **53**, and the cover insulating layer **55**.
(78) In the comparative example, the base insulating layer **51** has a uniform thickness T**510** (shown in FIG. **9**) over the body portion F**1**, the connection portion F**3**, and the terminal portion F**2**A. In other words, the thickness T**510** of the base insulating layer in the connection portion F**3** is greater than the thickness T**12** (shown in FIG. **7**) of the base portion **512** in the present example.

(79) In the comparative example, the cover insulating layer **55** has a uniform thickness T**550** (shown in FIG. **9**) over the body portion F**1**, the connection portion F**3**, and the terminal portion F**2**A. The cover insulating layer **55** does not include a layer corresponding to the second layer **73** of the cover insulating layer **55** in the present embodiment.
(80) In other words, the thickness T**550** of the cover insulating layer **55** in the connection portion F**3** is smaller than the thickness **52** (shown in FIG. **7**) of the cover portion **552** in the present embodiment. In the comparative example, the thickness T**510** of the base insulating layer **51** in the connection portion F**3** is greater than the thickness T**550** of the cover insulating layer **55** in the connection portion F**3**.
(81) In the process of curing the conductive adhesive by ultraviolet rays (UV) or heat, the humidity changes around the terminal portion F**2**A to be connected. Since the base insulating layer **51** and the cover insulating layer **55** are formed of polyimide, the base insulating layer **51** and the cover insulating layer **55** may be subjected to hygroscopic expansion and deform due to changes in ambient humidity.
(82) Since the metal base **41** is not provided on the connection portion F**3**, the base insulating layer **51** and the cover insulating layer **55** are easily deformed in the connection portion F**3**. In the flexure **400** in the comparative example, the thickness T**510** of the base insulating layer **51** is greater than the thickness T**550** of the cover insulating layer **55** in the connection portion F**3**.
(83) Therefore, when the base insulating layer **51** and the cover insulating layer **55** are subjected to hygroscopic expansion, the connection portion F**3** tends to deform in the direction in which the terminal portion F**2**A becomes farther from the piezoelectric element **63**A (upward in FIG. **9**). This deformation of the connection portion F**3** enlarges the gap between the terminal portion F**2**A and the electrode **65** of the piezoelectric element **63**A.
(84) Such an enlarged gap can be a factor for the decrease in reliability in the electrical connection between the terminal portion F**2**A and the electrode **65**. This can occur before, after, and during the curing of the conductive adhesive.
(85) In the flexure **40** configured as described above, the thickness of the base insulating layer **51** in the connection portion F**3** is smaller than the thickness of the cover insulating layer **55** in the connection portion F**3**. More specifically, the thickness T**12** of the base portion **512** is smaller than the thickness T**52** of the cover portion **552**.
(86) As a result, even when the base insulating layer **51** and the cover insulating layer **55** are subjected to hygroscopic expansion due to changes in ambient humidity, the connection portion F**3** hardly deforms in the direction in which the terminal portion F**2**A becomes farther from the electrode **65** of the piezoelectric element **63**A. In other words, the flexure **40** of the present embodiment can adjust the amount of deformation (warpage amount) of the connection portion F**3**.
(87) By making the terminal portion F**2**A hardly deformable in the direction in which the connection portion F**2**A becomes farther from the electrode **65** of the piezoelectric element **63**A, the conductor layer **53** of the terminal portion F**2**A and the electrode **65** can be stably connected to each other via the adhesive member **83**. As a result, the present embodiment can provide the flexure **40** and the suspension **10** that can increase reliability.
(88) In the present embodiment, the connection portion F**3** of the flexure **40** is easily deformable in the direction in which the terminal portion F**2**A becomes closer to the electrode **65** of the piezoelectric element **63**A. In other words, the occurrence of stress in the connection portion F**3** in the direction in which the terminal portion F**2**A becomes farther from the electrode **65** of the piezoelectric element **63**A can be reduced. Since the terminal portion F**2**A becomes closer to the electrode **65** of the piezoelectric element **63**A, the reliability of the flexure **40** and the suspension **10** can be increased.
(89) In the present embodiment, the gap between the terminal portion F**2**A and the electrode **65** can be adjusted. More specifically, a desired gap can be formed between the metal base **45** and the electrode **65** of the piezoelectric element **63**A. Thus, it is possible to properly provide the

conductive adhesive for this gap. In other words, the conductive adhesive hardly expands excessively to the surround of the metal base **45** and pull hardly occurs.
(90) In the present embodiment, the thicknesses T**11** and T**13** of the base portion **511** and base portion **513** are greater than the thickness T**12** of the base portion **512**. Since the base portion **511** and the base portion **513** are the portions overlapping with the metal base **41** and the metal base **45**, insulation resistance can be maintained in these portions.
(91) In the present embodiment, the thickness T**51** of the cover portion **551** is smaller than the thickness T**52** of the cover portion **552**. For example, the rigidity of the flexure **40** at a gimbal portion **9** (shown in FIG. **3**) located on the body portion F**1** is desirably small.
(92) When the thickness of the cover insulating layer **55** is increased in the entire flexure **40**, the rigidity of the flexure **40** in the vicinity of the gimbal portion **90** is increased. As a result, the control of the gimbal portion **90** using the actuator may be difficult.
(93) In the present embodiment, since the thickness T**51** of the cover portion **551** is smaller than the thickness T**52** of the cover portion **552**, the effect on the control of the gimbal portion **90** can be suppressed and thus the reliability of the suspension **10** can be increased. In other words, the present embodiment can adjust the amount of deformation of the connection portion F**3** while suppressing the effect on the characteristics of the suspension **10**. Along with the above advantages, various other advantages can be achieved by the present embodiment.
(94) In the present embodiment, as another example, the thickness T**12** of the base portion **512** may be smaller than the thickness T**11** of the base portion **511** and the thickness T**13** of the base portion **513**, and the cover insulating layer **55** may have a uniform thickness over the body portion F**1**, the connection portion F**3**, and the terminal portion F**2**A.
(95) In the present embodiment, as yet another example, the thickness T**52** of the cover portion **552** may be greater than the thickness T**51** of the cover portion **551** and the thickness T**53** of the cover portion **553**, and the base insulating layer **51** may have a uniform thickness over the body portion F**1**, the connection portion F**3**, and the terminal portion F**2**A.
(96) In the connection portion F**3**, the area in which the thicknesses of the base insulating layer **51** is decreased and the area in which the thickness of the cover insulating layer **55** is increased can be adjusted according to the type of the suspension **10**. For example, the shapes, widths, and lengths in these areas can be adjusted according to the type of the suspension **10**.
(97) In the present embodiment, an example in which the thickness T**52** of the cover portion **552** is increased by forming the cover insulating layer **55** in two layers is disclosed, but the thickness T**52** of the cover portion **552** can be increased by forming the cover insulating layer **55** in one layer, or the thickness T**52** of the cover portion **552** can be increased by forming the cover insulating layer **55** in three or more layers.
(98) Next, another embodiment will be described. In the following another embodiment, constituent elements identical to those of the first embodiment described above will be designated by the same reference numbers, and detailed descriptions therefor will be omitted or simplified in some cases.
Second Embodiment
(99) FIG. **10** shows a schematic cross-sectional view of a flexure **40**A of the present embodiment. In FIG. **10**, a connection portion F**3** of the flexure **40**A is viewed along the second direction Y.
(100) As shown in FIG. **10**, a base portion **512** includes a first portion P**1** overlapping with a conductor layer **53** and second portions P**2**A and P**2**B located on both sides of the first portion P**1** in the first direction X. The second portions P**2**A and P**2**B do not overlap with the conductor layer **53**. The second portion P**2**A, the first portion P**1**, and the second portion P**2**B are aligned in the first direction X. A thickness T**120** of the first portion P**1** is smaller than a thickness T**130** of the second portions P**2**A and P**2**B.
(101) A first layer **71** of a cover insulating layer **55** overlaps with an entire base insulating layer **51**. A second layer **73** of the cover insulating layer **55** overlaps with the conductor layer **53** with the

first layer **71** interposed therebetween. The thickness T**120** of the first portion P**1** is smaller than a thickness T**52** of a cover portion **552**, as shown in FIG. **10**.
(102) Next, the analysis result of the deformation in a case where the base insulating layer **51** and the cover insulating layer **55** are subjected to hygroscopic expansion will be described.
(103) FIG. **11** and FIG. **12** show the analysis result. FIG. **11** shows the analysis result of the flexure **40**A of the present embodiment, and FIG. **12** shows the analysis result of the flexure **400** of the comparative example (shown in FIG. **8** and FIG. **9**).
(104) The conditions in the analysis are as follows.
(105) In the flexure **40**A, the thickness T**120** of the first portion P**1** is 5 μm, a thickness T**71** of the first layer **71** of the cover insulating layer is 4 μm, and a thickness T**73** of the second layer **73** is 5 μm. In the flexure **400** of the comparative example, a thickness T**510** of the base insulating layer **51** is 10 μm, and a thickness T**550** of the cover insulating layer is 4 μm. The conductor layer **53** is 6 μm in each of the flexures **40**A and **400**.
(106) In FIG. **11** and FIG. **12**, the traverse axis shows the position (mm) from a body portion F**1**, and the vertical axis shows the position (mm) in the third direction Z. As the value on the vertical axis becomes greater, the terminal portion becomes farther from an electrode **65** of a piezoelectric element **63**A, and as the value on the vertical axis becomes smaller, the terminal portion becomes closer to the electrode **65** of the piezoelectric element **63**A.
(107) In FIG. **11** and FIG. **12**, a state before hygroscopic expansion is represented by dashed lines, and a state after hygroscopic expansion is represented by solid lines. The analysis result in a case where the base insulating layer **51** and the cover insulating layer **55** absorb 80% of moisture will be described.
(108) In the flexure **40**A, a value in the third direction Z becomes smaller as the flexure **40**A becomes farther from the body portion F**1**, as shown in FIG. **11**. In other words, it is confirmed that the connection portion F**3** deforms such that a terminal portion F**2**A becomes closer to an electrode **65** of the piezoelectric element **63**A after hygroscopic expansion.
(109) On the other hand, in the flexure **400**, as shown in FIG. **12**, it is confirmed that a value in the third direction Z increases as the flexure **400** becomes farther from the body portion F**1**. In other words, it is confirmed that the connection portion F**3** deforms such that the terminal portion F**2**A becomes farther from the electrode **65** of the piezoelectric element **63**A after hygroscopic expansion.
(110) Thus, in the analysis result, it is confirmed that in the flexure **40**A of the present embodiment, the connection portion F**3** deforms such that the terminal portion F**2**A becomes closer to the electrode **65** of the piezoelectric element **63**A after hygroscopic expansion.
(111) Although the analysis result of the flexure **40**A in the present embodiment is described, a result showing the same advantageous effect as the present embodiment can be obtained by even the flexure **40** of the first embodiment. In other words, in the present embodiment as well, an advantageous effect similar to that of the first embodiment can be obtained.
Third Embodiment
(112) FIG. **13** shows a schematic cross-sectional view showing a connection portion of a flexure **40**B of the present embodiment. In the present embodiment, a base portion **512** of a base insulating layer **51** is formed by polyimide etching. In this case, a surface **52**A located on the base portion **512** is located above a surface **52**A located on a base portion **511** and a base portion **513**.
(113) A surface **74**B of a second layer **73** of a cover portion **552** is located above a surface **72**B of a first layer **71** located on a cover portion **551** and a cover portion **553** in the example shown in FIG. **13**.
(114) In the present embodiment as well, the same advantageous effect as the first embodiment can be obtained. The base insulating layer **51** may be formed by combining polyimide etching and the gradation mask described in the first embodiment. The base insulating layer **51** may be formed by methods other than those described in each of the above-described embodiments.

(115) When carrying out the inventions disclosed in the above embodiments, the specific forms of each of the elements constituting the disk drive suspension, in addition to the specific forms regarding the shapes of the baseplate, the load beam, the flexure, and the like can be modified variously.
(116) Various aspects of the invention can also be extracted from any appropriate combination of constituent elements disclosed in the above-described embodiments. For example, some constituent elements may be deleted from the entire constituent elements in each of the embodiments. Furthermore, the constituent elements described in different embodiments may be combined arbitrarily.
(117) The base portion **512** of the base insulating layer **51** may include a plurality of portions having thicknesses smaller than the cover portion **552** of a cover insulating layer **55** in the second direction Y. Similarly, the cover portion **552** of the cover insulating layer **55** may include a plurality of portions having thickness greater than that of the base portion **512** of the base insulating layer **51** in the second direction Y.
(118) Additional advantages and modifications will readily occur to those skilled in the art. Therefore, the invention in its broader aspects is not limited to the specific details and representative embodiments shown and described herein. Accordingly, various modifications may be made without departing from the spirit or scope of the general inventive concept as defined by the appended claims and their equivalents.

Claims

1. A flexure including a first metal base and a wiring portion overlapping with the first metal base, the flexure comprising: a body portion including the first metal base; a terminal portion electrically connected to an actuator; and a connection portion connecting the body portion with the terminal portion and not including the first metal base, wherein the wiring portion includes: a base insulating layer including a first surface formed over the body portion, the connection portion, and the terminal portion and facing the first metal base and a second surface on a side opposite to the first surface; a conductor layer provided on the second surface; and a cover insulating layer covering the conductor layer, wherein the cover insulating layer includes a first cover portion provided on the connection portion, and the base insulating layer includes a first base portion provided on the connection portion and having a thickness smaller than a thickness of the first cover portion.
2. The flexure of claim 1, wherein the base insulating layer includes a second base portion provided on the body portion and having a thickness greater than the thickness of the first base portion.
3. The flexure of claim 2, wherein the base insulating layer includes a third base portion provided on the terminal portion and having a thickness greater than the thickness of the first base portion.
4. The flexure of claim 1, wherein the cover insulating layer includes a first layer formed on the body portion, the connection portion, and the terminal portion and a second layer formed on the connection portion and overlapping with the first layer.
5. The flexure of claim 1, wherein the cover insulating layer includes a second cover portion provided on the body portion and having a thickness smaller than the thickness of the first cover portion.
6. The flexure of claim 5, wherein the cover insulating layer includes a third cover portion provided on the terminal portion and having a thickness smaller than the thickness of the first cover portion.
7. A disk drive suspension, comprising: a load beam; the flexure of claim 1 overlapping with the load beam; and an actuator electrically connected to the terminal portion.
8. The disk drive suspension of claim 7, further comprising: an adhesive member, wherein the actuator includes an electrode facing the first surface, and the adhesive member electrically connects the electrode with the conductor layer located on the terminal portion.

9. The disk drive suspension of claim 8, wherein the flexure further includes a second metal base located between the base insulating layer located on the terminal portion and the electrode, and a through hole connecting the electrode with the conductor layer is formed in the base insulating layer located on the second metal base and the terminal portion.
10. The disk drive suspension of claim 7, wherein the base insulating layer includes a second base portion provided on the body portion and having a thickness greater than the thickness of the first base portion, and a surface of the second surface located on the first base portion is located closer to the load beam than a surface located on the second base portion.
11. The disk drive suspension of claim 7, wherein the base insulating layer includes a second base portion provided on the body portion and having a thickness greater than the thickness of the first base portion, and a surface of the first surface located on the first base portion is farther from the load beam than a surface located on the second base portion.