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(54) ULTRASONIC ENDOSCOPE ACOUSTIC LENS AND ULTRASONIC ENDOSCOPE

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(57) **ABSTRACT**

An ultrasonic endoscope acoustic lens includes a base material, a filler, and a friction reducing agent. The base material is composed of at least one elastomer. The filler is added to the base material. The friction reducing agent is disposed to cover at least a part of a base material surface of the base material and exposed to a lens surface.

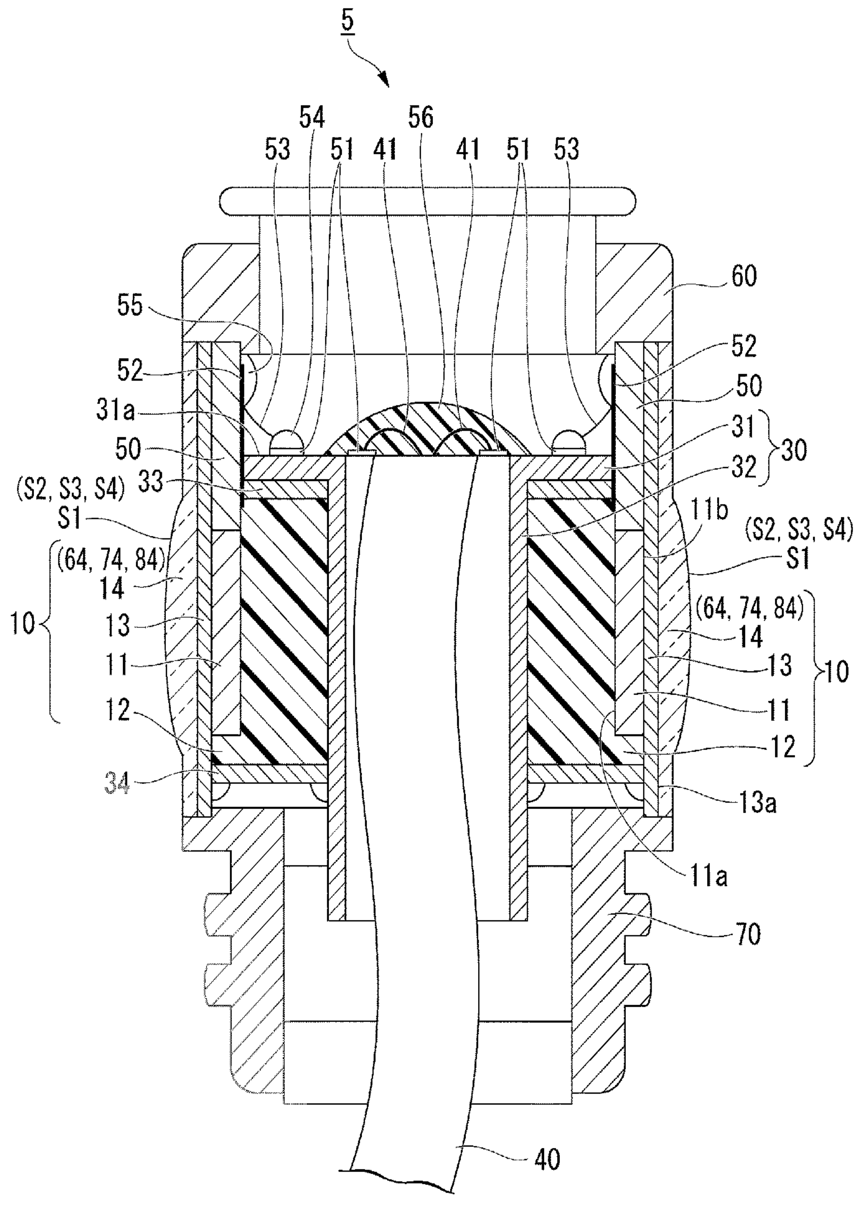


FIG. 1

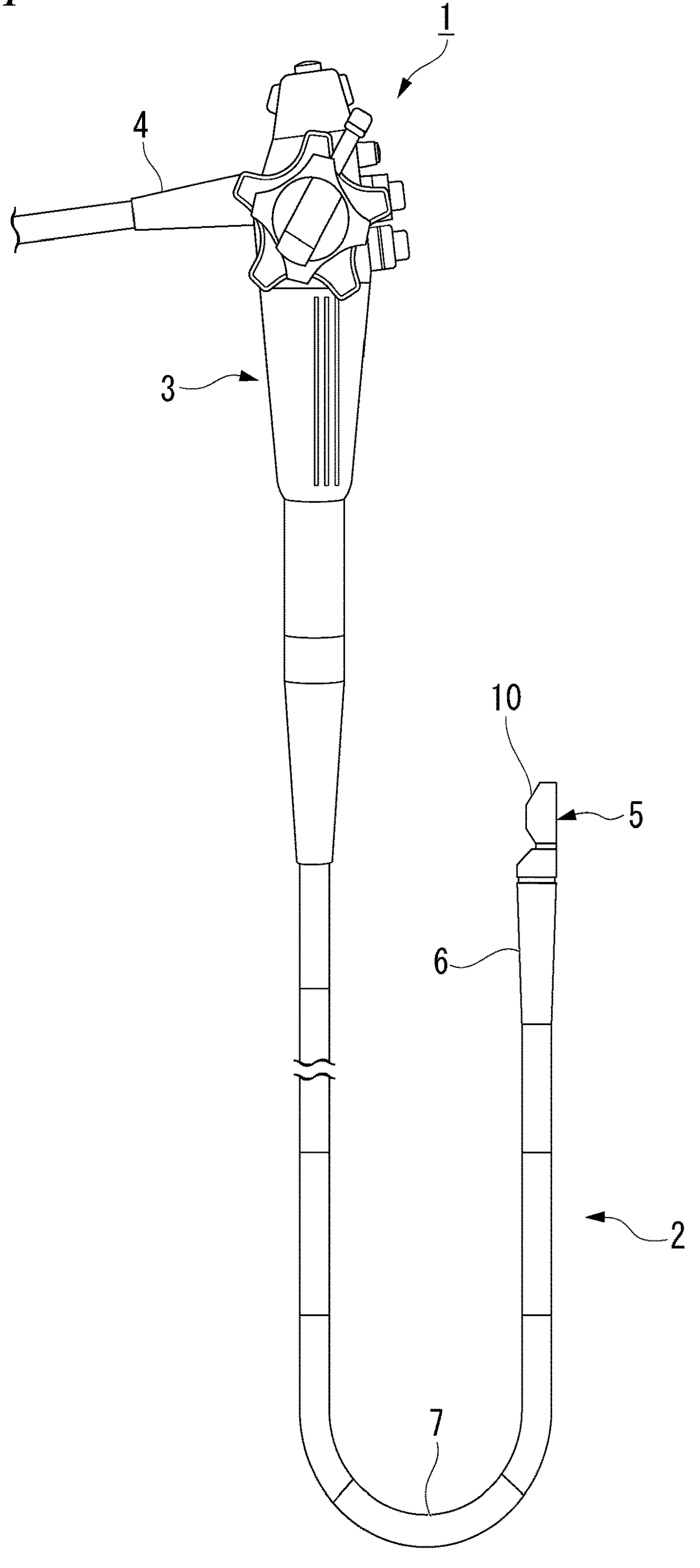
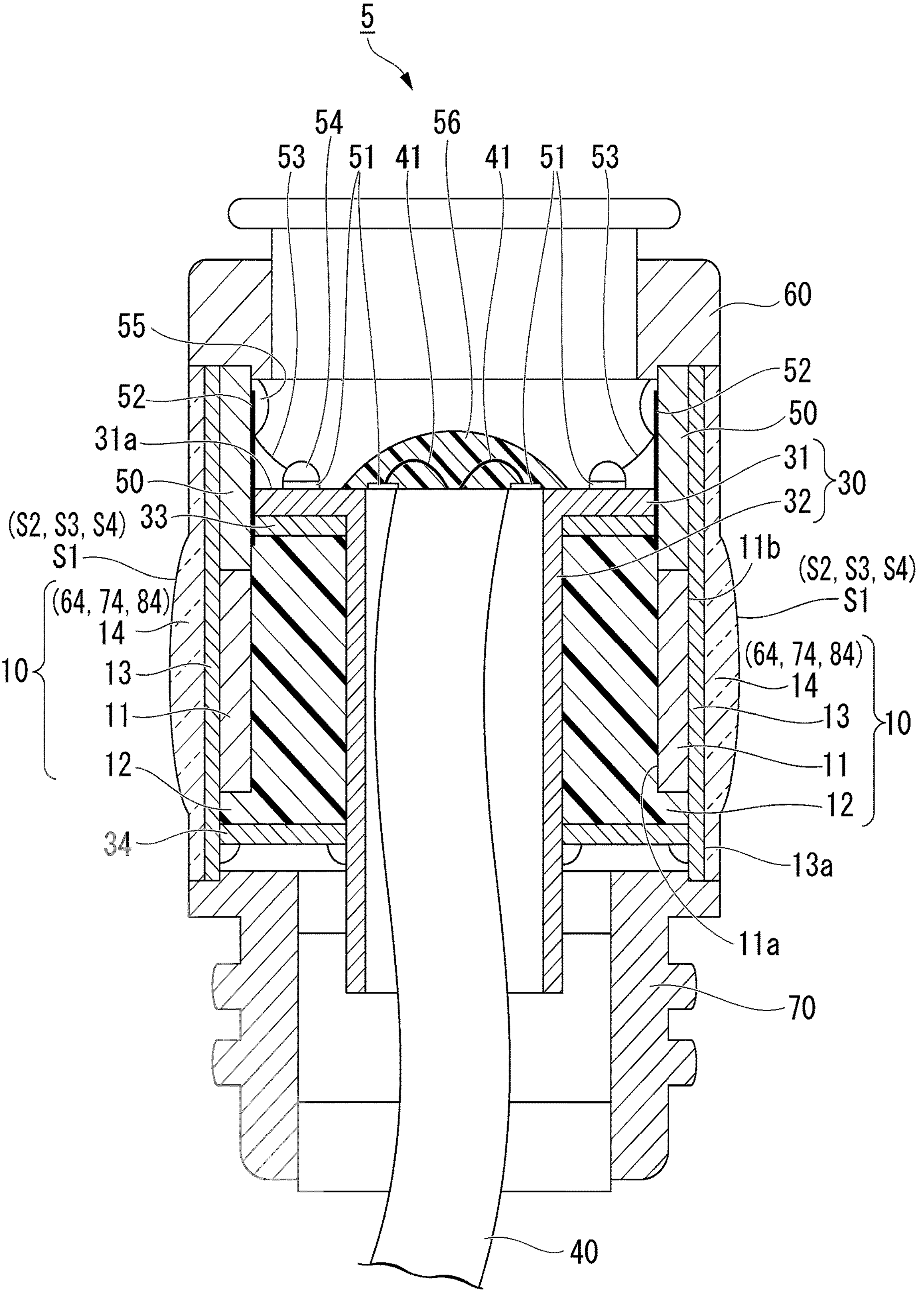


FIG. 2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51
41
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41
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53
60
55
52
52
50
31a
31
30
50
32
(S2, S3, S4)
33
11b
S1
(S2, S3, S4)
(64, 74, 84)
S1
14
(64, 74, 84)
10
13
14
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13
10
11
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12
34
13a
11a
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40

FIG. 3

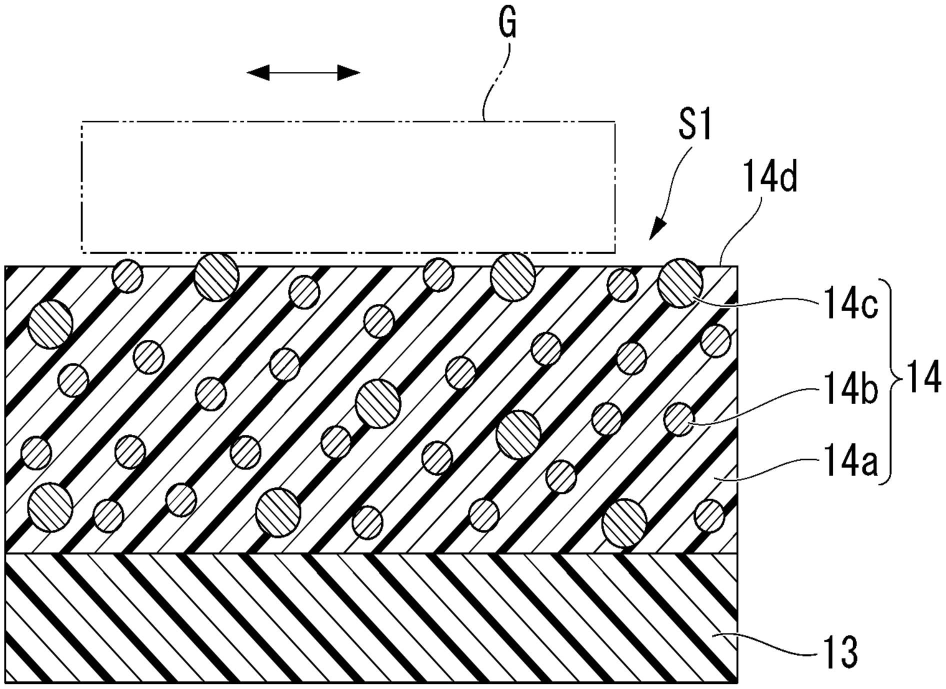


FIG. 4

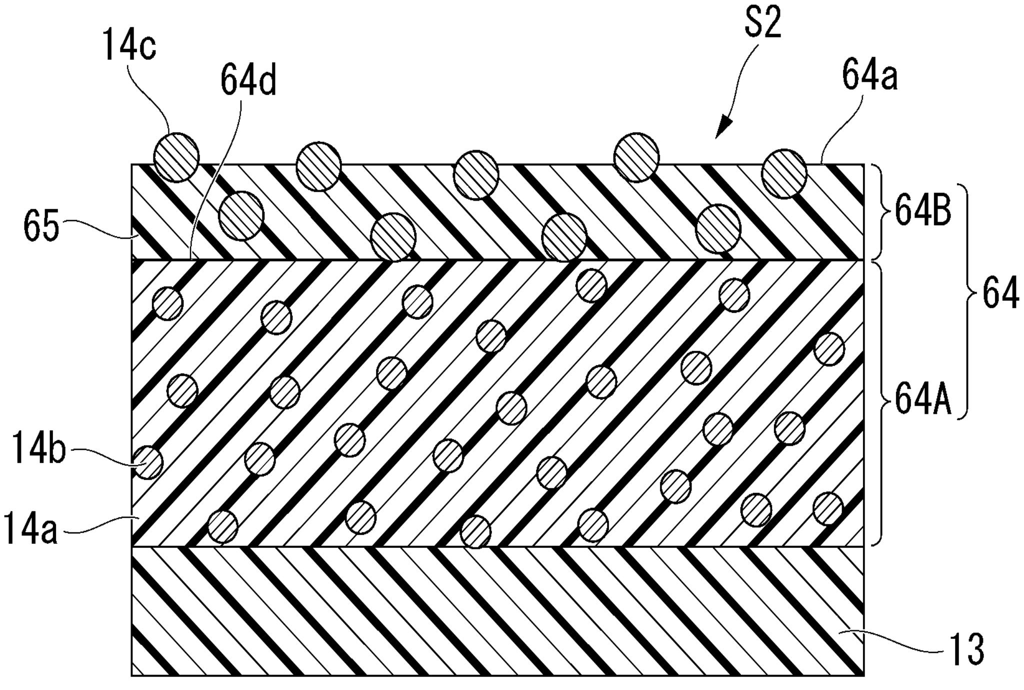


FIG. 5

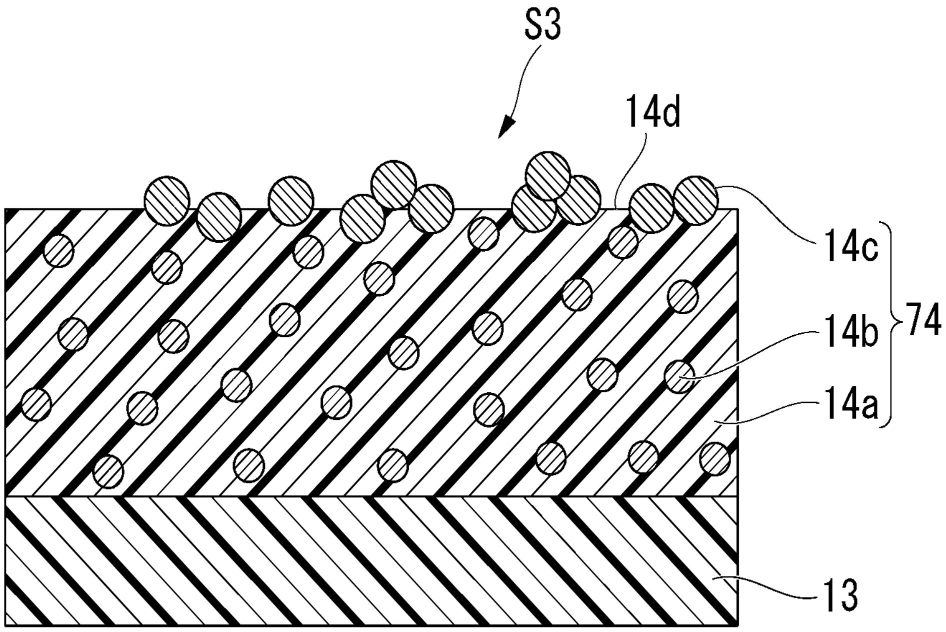
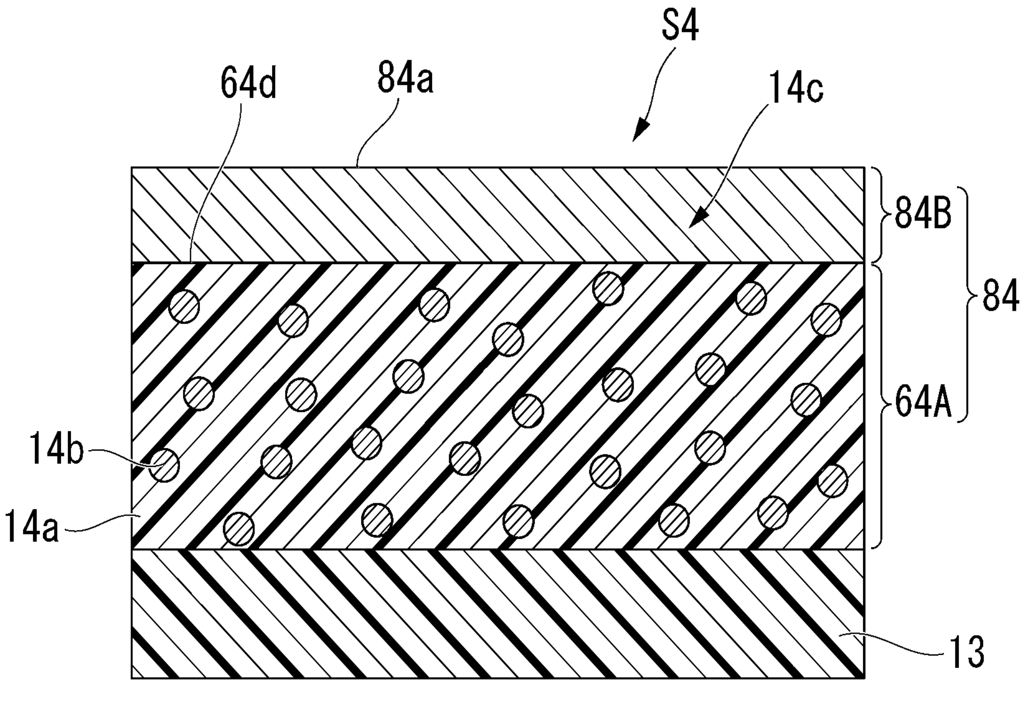


FIG. 6



ULTRASONIC ENDOSCOPE ACOUSTIC LENS AND ULTRASONIC ENDOSCOPE

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] The present invention relates to an ultrasonic endoscope acoustic lens and an ultrasonic endoscope.

[0002] The application is a continuation application based on a PCT Patent Application No. PCT/JP2018/010832, filed Mar. 19, 2018, whose priority is claimed on Japanese Patent Application No. 2017-097312, filed May 16, 2017. The content of both the PCT Application and the Japanese Application are incorporated herein by reference.

Description of Related Art

[0003] Ultrasonic endoscopes are known as medical endoscopes.

[0004] An ultrasonic endoscope is equipped with an ultrasonic transducer for acquiring an image of a subject. An acoustic lens for converging ultrasonic waves is disposed on a surface of the ultrasonic transducer.

[0005] The acoustic lens is required to have acoustic characteristics close to acoustic characteristics of biological tissue to efficiently introduce ultrasonic waves into a subject such as biological tissue. For example, when an acoustic impedance of the acoustic lens is close to an acoustic impedance of the biological tissue, surface reflection is reduced at a portion in contact with the biological tissue, and thus the ultrasonic waves are efficiently propagated to the biological tissue.

[0006] For example, an acoustic lens that contains an acoustic wave probe silicone resin in which an inorganic compound is added to polysiloxane having a vinyl group for the purpose of improving sensitivity is described in Japanese Unexamined Patent Application, First Publication No. 2016-107076. The inorganic compound contained in the acoustic lens is composed of a material selected from the group consisting of calcium carbonate, aluminum nitride, calcium oxide, vanadium oxide, silicon nitride, barium carbonate, titanium carbide, titanium nitride, copper oxide, zirconium carbide, and tungsten carbide.

SUMMARY OF THE INVENTION

[0007] An ultrasonic endoscope acoustic lens of a first aspect of the present invention includes: a base material composed of at least one elastomer; a filler added to the base material; and a friction reducing agent disposed to cover at least a part of a surface of the base material and exposed to a lens surface.

[0008] An ultrasonic endoscope of a second aspect of the present invention includes the ultrasonic endoscope acoustic lens according to the first aspect.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] FIG. **1** is a schematic front view showing a rough constitution of an ultrasonic endoscope according to a first embodiment of the present invention.

[0010] FIG. **2** is a schematic sectional view showing a constitution of main parts of the ultrasonic endoscope according to the first embodiment of the present invention.

[0011] FIG. **3** is a schematic sectional view showing an example of an ultrasonic endoscope acoustic lens according to the first embodiment of the present invention.

[0012] FIG. **4** is a schematic sectional view showing an example of an ultrasonic endoscope acoustic lens according to a second embodiment of the present invention.

[0013] FIG. **5** is a schematic sectional view showing an example of an ultrasonic endoscope acoustic lens according to a third embodiment of the present invention.

[0014] FIG. **6** is a schematic sectional view showing an example of an ultrasonic endoscope acoustic lens according to a fourth embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0015] Hereinafter, embodiments of the present invention will be described with reference to the drawings. In all the drawings, even in a case where the embodiments are different, identical or equivalent members are given the same reference signs, and common descriptions are omitted.

First Embodiment

[0016] Hereinafter, an ultrasonic endoscope acoustic lens and an ultrasonic endoscope according to a first embodiment of the present invention will be described.

[0017] FIG. **1** is a schematic front view showing a rough constitution of an ultrasonic endoscope according to a first embodiment of the present invention. FIG. **2** is a schematic sectional view showing a constitution of main parts of the ultrasonic endoscope according to the first embodiment of the present invention.

[0018] As shown in FIG. **1**, an ultrasonic endoscope **1** of the present embodiment (an ultrasonic endoscope device) includes an elongate insertion portion **2** to be inserted into a body of a subject, a manipulation portion **3** connected to a proximal end of the insertion portion **2**, and a universal cord **4** extending from the manipulation portion **3**.

[0019] The insertion portion **2** has a configuration in which a rigid distal end portion **5**, a bending portion **6**, and a flexible tube portion **7** that is thin and long and has flexibility are connected in this order from the distal end thereof. An endoscopic channel through which an endoscopic device is inserted may be provided in the flexible tube portion **7**.

[0020] As shown in FIG. **2**, the rigid distal end portion **5** includes a cylindrical member **30** and a plurality of ultrasonic transducers **10**. While not shown separately, in the case where the endoscopic channel is provided in the flexible tube portion **7**, an opening used as an exit of the endoscopic channel is formed in the rigid distal end portion **5**.

[0021] The cylindrical member **30** includes an annular flange **31** and a cylindrical portion **32** that extends from a central edge of the flange **31** in a direction of the flexible tube portion **7** (not shown) (a direction from top to bottom in FIG. **2**).

[0022] A coaxial cable **40** is inserted into the cylindrical portion **32** of the cylindrical member **30**.

[0023] Each ultrasonic transducer **10** is a device portion that emits ultrasonic waves to a subject. The plurality of ultrasonic transducers **10** are arranged along an outer circumferential surface of the cylindrical member **30** in a circumferential direction.

[0024] Each ultrasonic transducer **10** includes a piezoelectric element **11**, a backing material **12**, an acoustic matching layer **13**, an acoustic lens (an ultrasonic endoscope acoustic lens) **14**, and an electrode (not shown).

[0025] The piezoelectric element **11** generates ultrasonic vibration when a voltage is applied by the electrode (not shown). The piezoelectric element **11** in the present embodiment is formed in a flat plate shape. One plate surface **11***a* of the piezoelectric element **11** is disposed at a position at which it faces the cylindrical portion **32** in a radial direction of the cylindrical member **30**.

[0026] The backing material **12** is a member for absorbing, among ultrasonic vibrations generated by the piezoelectric element **11**, the ultrasonic vibrations advancing radially towards the inside of the rigid distal end portion **5** from the plate surface **11***a*. The backing material **12** is filled between the cylindrical portion **32** and the piezoelectric element **11**.

[0027] A resin material having a suitable vibration absorption characteristic is used as a material of the backing material **12**.

[0028] The backing material **12** is sandwiched between annular members **33** and **34** into which the cylindrical portion **32** is inserted in an axial direction of the rigid distal end portion **5**.

[0029] The annular member **33** is adjacent to the flange **31** and is provided to be in contact with a substrate **50** that extends from the piezoelectric element **11** in a direction of a distal end of the rigid distal end portion **5**.

[0030] The annular member **34** is provided to be in contact with the acoustic matching layer **13** (to be described below) at a position closer to the flexible tube portion **7** (not shown) than the piezoelectric element **11**.

[0031] The acoustic matching layer **13** is a layered part that reduces a difference in acoustic impedance between the subject and the piezoelectric element **11**. An acoustic impedance of the acoustic matching layer **13** is suitably set according to the acoustic impedance of the subject, and thus reflection of ultrasonic waves at the subject is reduced.

[0032] The acoustic matching layer **13** is provided to cover the plate surface **11***a* and a plate surface **11***b* opposite to the plate surface **11***a* in at least the piezoelectric element **11**. For this configuration, ultrasonic waves emitted from the plate surface **11***b* to the outside of the rigid distal end portion **5** in a radial direction via the acoustic matching layer **13** are efficiently introduced into the subject.

[0033] The acoustic matching layer **13** may be composed in a single layer or in multiple layers.

[0034] The acoustic lens **14** converges ultrasonic waves that are generated by the piezoelectric element **11** and are propagating to the outside of the rigid distal end portion **5** in the radial direction through the acoustic matching layer **13**, and emits the converged ultrasonic waves to the outside. The acoustic lens **14** is formed in a suitable shape for converging the ultrasonic waves. For example, a lens surface S1 of the acoustic lens **14** is a curved surface that swells outward. The acoustic lens **14** is provided to cover the acoustic matching layer **13** from the outside of the rigid distal end portion **5** in the radial direction.

[0035] A constitution of the acoustic lens **14** will be described in detail after description of the ultrasonic endoscope **1**.

[0036] In the flange **31** of the cylindrical member **30**, a plurality of electrode pads **51** are provided on a surface **31***a* in a direction opposite to the annular member **33**.

[0037] Wirings **41** extending from the coaxial cable **40** are connected to the electrode pads **51**. The electrode pads **51** and an electrode layer **52** provided on the substrate **50** are connected by wires **53**.

[0038] The electrode pads **51** and the wires **53** are joined by solder **54**. The electrode layer **52** and the wires **53** are joined by solder **55**.

[0039] To prevent the wirings **41** from being disconnected from the electrode pads **51**, for example, due to a load applied to the coaxial cable **40**, connection portions between the electrode pads **51** and the wirings **41** are covered with a potting resin **56**.

[0040] A distal end structural member **60**, which covers the connection portions between the electrode pads **51** and the wirings **41**, is provided at the distal end of the rigid distal end portion **5**. The rigid distal end portion **5** is connected to the bending portion **6** via a connecting member **70**.

[0041] Next, a detailed constitution of the acoustic lens **14** will be described.

[0042] FIG. **3** is a schematic sectional view showing an example of the ultrasonic endoscope acoustic lens according to the first embodiment of the present invention.

[0043] As shown in FIG. **3**, the acoustic lens **14** according to the present embodiment includes a base material **14***a*, a filler **14***b*, and a friction reducing agent **14***c*.

[0044] At least one elastomer having acoustic characteristics close to that of biological tissue of the subject or the like is used for the base material **14***a*. For example, a diorganopolysiloxane (elastomer) or a silicone rubber compound (elastomer) containing the diorganopolysiloxane as a main agent (which may hereinafter be referred to collectively as "silicone elastomer") may be used as the base material **14***a*. However, in the silicone elastomer, a material that is excellent in moldability, adhesiveness, etc. is more preferably. For example, in view of moldability, the silicone is more preferably a non-millable type instead of a millable type. The coefficient of friction of the silicone elastomer that is excellent in moldability, adhesiveness, etc. is likely to be high.

[0045] A configuration of the diorganopolysiloxane or the silicone rubber compound containing the diorganopolysiloxane as the main agent, which is used in the base material **14***a*, is not particularly limited. As a configuration of an organic group in the diorganopolysiloxane and the configuration of the silicone rubber compound containing the diorganopolysiloxane as the main agent, all the configurations described, for example, in Japanese Unexamined Patent Application, First Publication No. S62-11897 can be used.

[0046] An adequate amount of the filler **14***b* is added to the base material **14***a*. An inorganic filler from which acoustic characteristics required of the acoustic lens **14** are obtained is used for the filler **14***b*. Here, examples of the acoustic characteristics required of the acoustic lens **14** include, for example, an acoustic impedance, an attenuation factor of ultrasonic waves, and so on.

[0047] It is more preferable that a material of the filler **14***b* have a high density. In this case, even if an added amount of the filler **14***b* to the base material **14***a* is small, the acoustic lens **14** can obtain the required acoustic impedance, and thus the attenuation factor of the ultrasonic waves can be reduced.

[0048] It is more preferable that the material of the filler **14***b* have high mechanical strength. In this case, mechanical strength of the acoustic lens **14** is improved. Since a high-density material generally has high mechanical strength, when the density of the filler **14***b* is high, the mechanical strength of the acoustic lens **14** is easily increased.

[0049] Examples of the inorganic filler preferred as the filler **14***b* include silica, alumina, boehmite, cerium oxide, boron nitride, aluminum nitride, magnesium oxide, aluminum hydroxide, zinc oxide, tungsten trioxide, zirconia, diamond, silicon nitride, silicon carbide, sapphire, and so on. Since any of the inorganic fillers given above by way of example has high mechanical strength, shear strength thereof is also high.

[0050] The filler **14***b* is not limited to one type. A plurality of types of inorganic fillers may be used as the filler **14***b*.

[0051] Since FIG. **3** is a schematic view, the filler **14***b* is represented in a spherical shape. However, the shape of the filler **14***b* is not limited to the spherical shape. For example, the shape of the filler **14***b* may be a granular shape, a polyhedral shape, a plate shape, a rod shape, a fabric shape, an indefinite shape, or the like in addition to the spherical shape.

[0052] The amount of the filler **14***b* in the acoustic lens **14** can be an adequate content by which the acoustic characteristics and the mechanical strength required for the acoustic lens **14** are obtained.

[0053] For example, the amount of the filler **14***b* in the acoustic lens **14** may be 1 part by mass or more and 100 parts by mass or less with respect to 100 parts by mass of the base material **14***a*.

[0054] When there is less than 1 part by mass of the filler **14***b*, since the added amount of the filler **14***b* is too small, it may be difficult to adequately adjust the acoustic impedance of the acoustic lens **14**, or the mechanical strength of the acoustic lens **14** may not be able to be improved much.

[0055] When the filler **14***b* exceeds 100 parts by mass, the moldability of the acoustic lens **14** is deteriorated, and thus a shape of a molding die may not be accurately transferred. In this case, lens performance of the acoustic lens **14** may be reduced. Furthermore, when the added amount of the filler **14***b* is increased, the attenuation factor of ultrasonic waves may be increased.

[0056] The friction reducing agent **14***c* is exposed to at least a part of the lens surface S1 of the acoustic lens **14** when disposed. In the present embodiment, the friction reducing agent **14***c* is dispersed and added to the base material **14***a*, and thereby a part of the friction reducing agent **14***c* is exposed from a base material surface **14***d* on the lens surface S1.

[0057] When viewed from the outside, the friction reducing agent **14***c* exposed from the base material surface **14***d* is disposed in a state in which the friction reducing agent **14***c* covers the base material surface **14***d*. The friction reducing agent **14***c* exposed from the base material surface **14***d* constitutes the lens surface S1 along with the filler **14***b* exposed from the base material surface **14***d* and the base material surface **14***d*.

[0058] A material of the friction reducing agent **14***c* is not particularly limited as long as the material is a solid that can improve a slip characteristic of the lens surface S1 compared to a slip characteristic of the base material surface **14***d*.

[0059] For example, a solid lubricant that is easily subjected to shear fracture or slip deformation by an external force and thereby can improve a slip characteristic may be used as the friction reducing agent **14***c*.

[0060] For example, a solid lubricant formed of a laminated structure particle in which layered molecular structures are bonded by an intermolecular force may be used as the friction reducing agent **14***c*.

[0061] For example, a solid lubricant formed of a material having a small coefficient of friction of a surface like a fluororesin or the like may be used as the friction reducing agent **14***c*.

[0062] However, the friction reducing agent **14***c* is not limited to the solid lubricant as described above. For example, an inorganic material or an organic material that is not necessarily referred to as a solid lubricant may be used as the friction reducing agent **14***c* as long as the solid lubricant has a smaller coefficient of friction than the base material surface **14***d*.

[0063] Since FIG. **3** is a schematic view, the friction reducing agent **14***c* is represented in a spherical shape. However, the shape of the friction reducing agent **14***c* is not limited to the spherical shape. For example, the shape of the friction reducing agent **14***c* may be a granular shape, a polyhedral shape, a plate shape, a rod shape, a fabric shape, an indefinite shape, or the like in addition to the spherical shape.

[0064] Materials suitable for the friction reducing agent **14***c* include molybdenum disulfide, tungsten disulfide, graphite, graphite fluoride, boron nitride, mica, talc, calcium fluoride, silicon dioxide, fullerenes, carbon nanotubes, lead monoxide, gold, silver, tin, lead, copper, polytetrafluoroethylene (PTFB) (a fluororesin), perfluoroalkoxyfluororesin (PFA) (a fluororesin), a polyamide resin, a polyacetal resin, and so on.

[0065] The friction reducing agent **14***c* contained in the acoustic lens **14** is not limited to one type. For example, one or more materials selected from the group consisting of the materials listed as examples above may be used as the friction reducing agent **14***c*.

[0066] An exposed shape, an exposed area, and a distribution density of an exposed part of the friction reducing agent **14***c* on the base material surface **14***d* are not particularly limited as long as the coefficient of friction of the lens surface **S1** can be reduced compared to the coefficient of friction of the base material surface **14***d*.

[0067] For example, the friction reducing agent **14***c* may be exposed in an adequate shape such as a granular shape, an insular shape, a layered shape, or the like on the base material surface **14***d*. As an example, a case where the friction reducing agent **14***c* is exposed in the granular shape in a range of a particle size or less is depicted in FIG. **3**.

[0068] It is more preferable that the coefficient of friction on the lens surface **S1** have a coefficient of dynamic friction smaller than 0.3.

[0069] It is more preferable that the particle size of the friction reducing agent **14***c* be smaller than or equal to 10 μm. When the particle size of the friction reducing agent **14***c* exceeds 10 μm, the attenuation factor of ultrasonic waves may become too large in the acoustic lens **14**. When the attenuation factor of ultrasonic waves becomes too large in the acoustic lens **14**, it becomes difficult for the ultrasonic waves to reach a deep part of the subject, and thus it becomes difficult to observe the deep part of the subject.

[0070] To further reduce the attenuation factor of ultrasonic waves, it is more preferable that the particle size of the friction reducing agent **14***c* be smaller than or equal to 6 μm.

[0071] In the present embodiment, since the friction reducing agent **14***c* is also dispersed to the inside of the base material **14***a*, the amount of the friction reducing agent **14***c* may also influence the acoustic characteristics of the acoustic lens **14**. For this reason, the amount of the friction reducing agent **14***c* is set along with the amount of the filler **14***b* such that the acoustic characteristics required of the acoustic lens **14** are obtained.

[0072] For example, the amount of the friction reducing agent **14***c* in the acoustic lens **14** may be 3 parts by mass or more and 15 parts by mass or less with respect to 100 parts by mass of the base material **14***a*. In this case, an amount of the friction reducing agent **14***c* exposed to the lens surface **S1** becomes appropriate, and thus a friction reducing effect caused by the friction reducing agent **14***c* becomes more excellent.

[0073] When the friction reducing agent **14***c* is less than 3 parts by mass, the amount of the friction reducing agent **14***c* exposed to the lens surface **S1** becomes too small, and thus the coefficient of friction of the lens surface **S1** may be hardly reduced.

[0074] When the friction reducing agent **14***c* exceeds 15 parts by mass, propagation of ultrasonic waves is obstructed by the friction reducing agent **14***c*, and thus it becomes easy for the attenuation factor of ultrasonic waves to increase. For this reason, a resolution of an ultrasonic image of the ultrasonic endoscope **1** may be reduced.

[0075] Each ultrasonic transducer **10** having the acoustic lens **14** according to the present embodiment is, for example, manufactured as follows.

[0076] The piezoelectric element **11** having the electrodes (not shown) provided on the respective plate surfaces **11***a* and **11***b* is joined with the acoustic matching layer **13** that is previously molded. Afterward, the substrate **50** is attached on the piezoelectric element **11** so as to extend in a surface direction. In addition, the annular members **33** and **34** are disposed at prescribed positions.

[0077] Afterward, a resin composition for forming the backing material **12** is poured into a space between the piezoelectric elements **11** and the cylindrical member **30**, which space is surrounded by the annular members **33** and **34**. When the resin composition is cured, the backing material **12** is formed.

[0078] Afterward, the acoustic lens **14** is disposed on a surface **13***a* of the acoustic matching layer **13** in a direction opposite to the piezoelectric element **11**.

[0079] The acoustic lens **14** is manufactured as follows. For example, the base material **14***a*, the filler **14***b*, and the friction reducing agent **14***c* are mixed and thus a mixture thereof is formed. The mixture is molded in the shape of the acoustic lens **14**, for example, by press working or the like and is vulcanized.

[0080] The acoustic lenses **14** manufactured in this way are bonded to the acoustic matching layer **13** each other by an adhesive whose acoustic impedance is adjusted to a value between the acoustic impedance of the acoustic matching layer **13** and the acoustic lens **14**.

[0081] In this way, the ultrasonic transducer **10** is manufactured.

[0082] However, the method of forming the acoustic lens **14** is not limited to the aforementioned method. For example, the acoustic lens **14** may be formed as follows.

[0083] First, a molding die for the acoustic lens **14** is disposed around the acoustic matching layer **13**. A resin composition for forming the acoustic lens **14** is poured into the molding die. Before this resin composition is cured, heat curing is performed in a state in which this resin composition is in contact with the acoustic matching layer **13** mounted on the piezoelectric element **11**. Thus, the acoustic lens **14** is joined to the acoustic matching layer **13**. When the acoustic lens **14** is cured, the molding die is removed.

[0084] Next, an operation of the acoustic lens **14** will be described.

[0085] Since the acoustic lens **14** contains the filler **14***b* in the base material **14***a*, the amount of the filler **14***b* is appropriately set, and thereby acoustic characteristics preferred as the acoustic lens of the ultrasonic endoscope is obtained.

[0086] An acoustic impedance is obtained by a density of a medium×the speed of sound in the medium. The acoustic impedance needs to be set to an appropriate value depending on a subject. For example, the filler **14***b* is different in density from the base material **14***a*, and thus the acoustic impedance is adjusted by changing the amount of the filler **14***b* with respect to the base material **14***a*. In a case where the density of the filler **14***b* is higher than that of the base material **14***a*, the acoustic impedance can be increased compared to the case of the base material **14***a* alone by increasing the amount of the filler **14***b*.

[0087] In a case where a high-density material is used as the friction reducing agent **14***c*, an added amount of the filler **14***b* is appropriately adjusted such that the acoustic lens **14** obtains necessary acoustic characteristics by combining the friction reducing agent **14***c* and the filler **14***b*.

[0088] As shown in FIG. **3**, a part of the friction reducing agent **14***c* is exposed from the base material surface **14***d* in the acoustic lens **14**. When a contact member G comes into contact with the lens surface **S1**, the friction reducing agent **14***c* comes into contact with a part of the contact member G. For this reason, a contact area between the base material **14***a* having worse slip characteristics than the friction reducing agent **14***c* and the contact member G is reduced. A frictional force between the contact member G and the acoustic lens **14** is reduced at a contact portion between the contact member G and the friction reducing agent **14***c* due to a friction reducing effect of the friction reducing agent **14***c*.

[0089] The friction reducing effect of the friction reducing agent **14***c* varies according to the material of the friction reducing agent **14***c*.

[0090] For example, in a case where the friction reducing agent **14***c* is formed of a material, such as molybdenum disulfide, which has a crystalline structure that is easy to undergo shear deformation. The friction reducing agent **14***c* that is in contact with the contact member G is subjected to shear deformation, and thus the contact member G becomes easy to slide.

[0091] For example, in a case where the friction reducing agent **14***c* is formed of a material, such as graphite, in which layered molecular structures are bonded each other by a weak intermolecular force, the layered molecular structures of the friction reducing agent **14***c* that is in contact with the contact member G slip with each other by the external force from the contact member G, and thus the contact member G becomes easy to slide.

[0092] For example, in a case where the friction reducing agent **14***c* is formed of a material, such as a fluororesin, in which the coefficient of friction of the surface is small, a frictional force itself applied to the contact member G from the friction reducing agent **14***c* becomes small, and thus the contact member G becomes easy to slide.

[0093] In this way, the friction reducing agent **14***c* is exposed to the base material surface **14***d* in the acoustic lens **14**, and thus an actual coefficient of friction of the lens surface S**1** is reduced. Thus, the contact member G becomes easy to slide on the lens surface S**1**.

[0094] As a result, since the contact member G is hardly caught on the base material surface **14***d* or the filler **14***b* protruding from the base material surface **14***d*, the base material **14***a* can be prevented from being broken by an external force from the contact member G.

[0095] For example, before and after use of the ultrasonic endoscope **1**, the lens surface S**1** of the acoustic lens **14** is cleaned with a cleaning member such as gauze. In this case, the cleaning member is the contact member G. Since the actual coefficient of friction of the lens surface S**1** is reduced in the acoustic lens **14**, the cleaning member is hardly caught on the lens surface S**1**. As a result, the acoustic lens **14** is prevented from being broken during cleaning work. In this way, durability of the acoustic lens **14** is improved, and thus a life span of the ultrasonic endoscope **1** is also prolonged.

[0096] For example, in a case where the endoscopic channel is provided in the ultrasonic endoscope **1**, the endoscopic device is taken in and out from the opening that becomes the exit of the endoscopic channel in the rigid distal end portion **5**. In this case, when the endoscopic device moves into the body of a patient, a metal part or a resin part of the endoscopic device may also come into contact with the lens surface S**1** of the acoustic lens **14** as the contact member G. However, since the actual coefficient of friction of the lens surface S**1** is low in the acoustic lens **14**, the metal portion or the resin portion of the endoscopic device is also hardly caught on the lens surface S**1**. As a result, the acoustic lens **14** is prevented from being broken by contact with the endoscopic device. Since the durability of the acoustic lens **14** is improved in this way, the life span of the ultrasonic endoscope **1** is also prolonged.

[0097] As described above, according to the acoustic lens **14** and the ultrasonic endoscope **1** according to the present embodiment, durability against physical contact can be improved.

Second Embodiment

[0098] Next, an ultrasonic endoscope acoustic lens according to a second embodiment will be described.

[0099] FIG. **4** is a schematic sectional view showing an example of an ultrasonic endoscope acoustic lens according to a second embodiment of the present invention.

[0100] An acoustic lens (an ultrasonic endoscope acoustic lens) **64** of the present embodiment of which main parts are shown in FIG. **4** can be used in place of the acoustic lens **14** in the ultrasonic endoscope **1** of the first embodiment (see FIG. **2**). The acoustic lens **64** has the same shape as the acoustic lens **14** of the first embodiment. The acoustic lens **64** is different in internal structure from the acoustic lens **14**.

[0101] Hereinafter, a description will be made focusing on a difference from the first embodiment.

[0102] The acoustic lens **64** includes a lens main body **64**A and a surface layer **64**B.

[0103] A filler **14***b* is dispersed to a base material **14***a*, and thus the lens main body **64**A is formed. A shape (a layer thickness) of the lens main body **64**A is formed in a shape (a layer thickness) that is obtained by subtracting a thickness of the surface layer **64**B (to be described below) from the lens surface S**1** of the acoustic lens **14** in the first embodiment.

[0104] The surface layer **64**B covers a surface **64***d* in the lens main body **64**A on the whole, and is formed in a layered shape. A surface **64***a* of the surface layer **64**B constitutes a lens surface S**2** that is a surface of the acoustic lens **64**.

[0105] The surface layer **64**B includes a binder resin **65**, and a friction reducing agent **14***c* that is the same as that of the first embodiment.

[0106] The binder resin **65** holds the friction reducing agent **14***c*. A material of the binder resin **65** is not particularly limited if it is a resin material that can hold the friction reducing agent **14***c* and can fix the base material **14***a* by coming into close contact with the base material **14***a*. For example, examples of the binder resin **65** include a solvent-soluble fluororesin, an acrylic resin, an epoxy resin, a phenol resin, polyamide imide, polyimide, a silicone resin, a polyether ether ketone (PEEK) resin, PFA, and so on.

[0107] A material whose coefficient of friction is lower than that of the base material **14***a* is more preferably used as the material of the binder resin **65**. In this case, the binder resin **65** also functions as the friction reducing agent. For example, one capable of holding the friction reducing agent **14***c* among the resin materials included in the examples of the friction reducing agent **14***c* in the first embodiment may be used as the material of the binder resin **65**.

[0108] An added amount of the friction reducing agent **14***c* in the surface layer **64**B is an adequate added amount by which a coefficient of friction on the lens surface S**2** becomes lower than the coefficient of friction of the base material **14***a*. For example, in a slip characteristic of the lens surface S**2**, a coefficient of dynamic friction is more preferably less than 0.3.

[0109] For example, in a case where the same friction reducing agent **14***c* as in the first embodiment is used as the friction reducing agent **14***c* of the present embodiment, a blended amount of the friction reducing agent **14***c* in the present embodiment may be set such that an exposed area of the friction reducing agent **14***c* from the binder resin **65** on the lens surface S**2** becomes similar to that from the base material **14***a* in the first embodiment. The blended amount of the friction reducing agent **14***c* in the present embodiment may be set such that a distribution density of the friction reducing agent **14***c* exposed from the binder resin **65** on the lens surface S**2** becomes similar to that of the friction reducing agent **14***c* exposed from the base material **14***a* in the first embodiment.

[0110] For example, the amount of the friction reducing agent **14***c* in the acoustic lens **64** may be 3 parts by mass or more and 15 parts by mass or less with respect to 100 parts by mass of the binder resin **65**. In this case, an amount of the friction reducing agent **14***c* exposed to the lens surface S**2** becomes appropriate, and thus a friction reducing effect caused by the friction reducing agent **14***c* becomes more excellent.

[0111] The layer thickness of the surface layer **64**B is not particularly limited if the surface layer **64**B is capable of holding the friction reducing agent **14***c* exposed to the lens surface S**2**. For example, the layer thickness of the surface layer **64**B may be 100% or more and 300% or less of a maximum particle size of the friction reducing agent **14***c*.

[0112] The acoustic lens **64** having this constitution is manufactured as follows. For example, the base material **14***a* and the filler **14***b* are mixed and thus a mixture thereof is formed. The mixture is molded in the shape of the acoustic lens **64**, for example, by press working or the like and is vulcanized. Afterward, a coating liquid in which the binder resin **65**, a solvent, and the friction reducing agent **14***c* are mixed is coated on a surface of the lens main body **64**A.

[0113] Afterward, adequate drying treatment of volatilizing the solvent of the coating liquid is performed. Thus, the surface layer **64**B is formed on the surface **64***d* of the lens main body **64**A, and the acoustic lens **64** is manufactured.

[0114] The acoustic lens **64** manufactured in this way is joined to the acoustic matching layer **13** in the same way as in the first embodiment. Thus, the ultrasonic transducer **10** of the present embodiment is manufactured.

[0115] Next, an operation of the acoustic lens **64** will be described.

[0116] The acoustic lens **64** contains the filler **14***b* in the base material **14***a* in the lens main body **64**A. For this reason, the amount of the filler **14***b* is appropriately set, and thereby acoustic characteristics preferred as the acoustic lens of the ultrasonic endoscope are obtained in the same way as in the first embodiment.

[0117] Since the friction reducing agent **14***c* is not contained in the lens main body **64**A in the present embodiment, the acoustic characteristics of the acoustic lens **64** are substantially determined by the base material **14***a* and the filler **14***b*.

[0118] The friction reducing agent **14***c* is dispersed only around the surface layer **64**B of the acoustic lens **64** in the present embodiment. For this reason, an added amount of the friction reducing agent **14***c* which the lens surface S**2** requires to have the same frictional characteristics as in the first embodiment is remarkably reduced. Therefore, to curb an influence on the acoustic characteristics of the acoustic lens **64** of the friction reducing agent **14***c*, a need to reduce the added amount of the friction reducing agent **14***c* or accurately adjust the added amount of the friction reducing agent **14***c* is remarkably reduced.

[0119] For example, in the case of the first embodiment, when the friction reducing agent **14***c* is distributed unevenly in the base material **14***a*, a variation in the acoustic characteristics of the acoustic lens **14** is easy to occur. For this reason, there is a need to select a material having a good distribution characteristic in the base material **14***a* as the friction reducing agent **14***c*.

[0120] However, in the present embodiment, corresponding to the material of the friction reducing agent **14***c*, the binder resin **65** by which the distribution characteristic is improved is selected, and thereby a variation of the friction reducing agent **14***c* can be easily curbed. To begin with, in the present embodiment, the added amount itself of the friction reducing agent **14***c* does not contribute much to the acoustic characteristics of the acoustic lens **64**. For this reason, even if there is a variation in the distribution of the friction reducing agent **14***c*, an influence on the acoustic characteristics of the acoustic lens **64** is small. With regard to the slip characteristics, if a coefficient of friction lower than a constant coefficient of friction is obtained, slip characteristics resistant to breakage are obtained. For this reason, an allowable range is wide with regard to a distribution variation in a direction in which the distribution of the friction reducing agent **14***c* becomes dense.

[0121] According to the present embodiment, a selection range of the material of the friction reducing agent **14***c* becomes wide.

[0122] According to the acoustic lens **64**, in the same way as in the first embodiment, an actual coefficient of friction of the lens surface S**2** can be reduced depending on an exposed amount of the friction reducing agent **14***c* on the lens surface S**2**. For this reason, according to the present embodiment, a contact member G (not shown) becomes easy to slide on the lens surface S**2**.

[0123] As a result, the contact member G is hardly caught on the lens surface S**2**, and thus the surface layer **64**B and the lens main body **64**A can be prevented from being broken by an external force from the contact member G. In this way, durability of the acoustic lens **64** is improved.

[0124] In particularly, in the present embodiment, the material having a lower coefficient of friction than the base material **14***a* is selected as the material of the binder resin **65**, and thus the actual coefficient of friction of the lens surface S**2** can be further reduced.

[0125] As in the present embodiment, in a case where the entire lens surface S**2** is covered by the surface layer **64**B, the durability of the acoustic lens **64** is further improved in that the surface layer **64**B has a protective function of preventing direct contact between the contact member G and the base material **14***a*.

[0126] In the present embodiment, the entire lens main body **64**A is covered by the surface layer **64**B, and thus the filler **14***b* in the lens main body **64**A is not exposed to the lens surface S**2**. For this reason, the slip characteristics are prevented from being deteriorated by the exposure of the filler **14***b*.

[0127] As described above, according to the acoustic lens **64** of the present embodiment, durability against physical contact can be improved.

Third Embodiment

[0128] Next, an ultrasonic endoscope acoustic lens of a third embodiment will be described.

[0129] FIG. **5** is a schematic sectional view showing an example of an ultrasonic endoscope acoustic lens according to a third embodiment of the present invention.

[0130] An acoustic lens (an ultrasonic endoscope acoustic lens) **74** of the present embodiment of which main parts are shown in FIG. **5** can be used in place of the acoustic lens **14** in the ultrasonic endoscope **1** of the first embodiment (see FIG. **2**). The acoustic lens **74** has the same shape as the acoustic lens **14** of the first embodiment. The acoustic lens **74** is different in internal structure from the acoustic lens **14**.

[0131] Hereinafter, a description will be made focusing on a difference from the first embodiment.

[0132] Like the first embodiment, the acoustic lens **74** includes a base material **14***a*, a filler **14***b*, and a friction reducing agent **14***c*. However, in the present embodiment, the friction reducing agent **14***c* is disposed only around a base material surface **14***d*. For this reason, like the lens surface S**1** in the first embodiment, a lens surface S**3** of the acoustic lens **74** has the filler **14***b* and the friction reducing agent **14***c* exposed from the base material surface **14***d*. However, in the present embodiment, since the friction reducing agent **14***c* is distributed only around the base material surface **14***d*, an added amount of the friction reducing agent **14***c* is remarkably small compared to the first embodiment.

[0133] Like the first embodiment, the friction reducing agent **14***c* in the present embodiment is disposed to cover a part of the base material surface **14***d*. The friction reducing agent **14***c* in the present embodiment may be exposed in an adequate shape such as a granular shape, an insular shape, or the like. An example in which the friction reducing agent **14***c* is exposed in an insular shape that is larger than a particle size of an individual particle is depicted as an example in FIG. **5**.

[0134] Like the first embodiment, an exposed shape, an exposed area (an exposed amount), and a distribution density of an exposed part of the friction reducing agent **14***c* on the lens surface S**3** are appropriately set such that a coefficient of friction of the lens surface S**3** becomes lower than that of the base material **14***a*. For example, it is more preferable that the coefficient of friction on the lens surface S**3** be smaller than 0.3 as a coefficient of dynamic friction.

[0135] The acoustic lens **74** having this constitution is manufactured as follows. For example, the base material **14***a* and the filler **14***b* are mixed and thus a mixture thereof is formed. The mixture is molded in the shape of the acoustic lens **74**, for example, by press working or the like and is vulcanized. Afterward, the friction reducing agent **14***c* is deposited on a surface of the molding. The method of depositing the friction reducing agent **14***c* is not particularly limited if fixing strength by which the friction reducing agent **14***c* is hardly peeled off by contact with a contact member G (not shown) is obtained. For example, the method of depositing the friction reducing agent **14***c* includes a sputtering method, electroless plating, a rubbing method, a tumbling method, an impingement method, an ion plating method, a thermal chemical vapor deposition (CVD), a plasma CVD, or the like. For example, a physical vapor deposition (PVD) or CVD in addition to those provided as exemplary examples above may be used as the method of depositing the friction reducing agent **14***c*.

[0136] For example, in a case where the friction reducing agent **14***c* has a strong adsorption force against the base material **14***a*, a powder of the friction reducing agent **14***c* may be only dusted on the base material surface **14***d*.

[0137] In this way, when the deposition of the friction reducing agent **14***c* on a surface of the base material surface **14***d* is completed, the acoustic lens **74** is manufactured.

[0138] The acoustic lens **74** manufactured in this way is joined to an acoustic matching layer **13** in the same way as in the first embodiment. Thus, an ultrasonic transducer **10** of the present embodiment is manufactured.

[0139] Next, an operation of the acoustic lens **74** will be described.

[0140] Like the second embodiment, the friction reducing agent **14***c* of the acoustic lens **74** is disposed on the lens surface S**3** and only therearound. In this respect, the acoustic lens **74** has the same operation as the acoustic lens **64** of the second embodiment.

[0141] However, in the present embodiment, the friction reducing agent **14***c* is directly deposited around the base material surface **14***d* without a binder resin **65**. For this reason, the friction reducing agent **14***c* is fixed by a fixing force between the friction reducing agent **14***c* and the base material **14***a*.

[0142] In this way, the acoustic lens **74** does not have a layered structure such as the base material **14***a* and the binder resin **65** in the second embodiment. For this reason, a variation or the like in a focusing characteristic of ultrasonic waves caused by a layer thickness variation or the like of the binder resin **65** may not occur. Further, since stress caused by a difference in thermal expansion coefficient or the like between the base material **14***a* and the binder resin **65** does not occur, durability against sterilization treatment or the like is improved.

[0143] As described above, according to the acoustic lens **74** of the present embodiment, durability against physical contact can be improved.

Fourth Embodiment

[0144] Next, an ultrasonic endoscope acoustic lens of a fourth embodiment will be described.

[0145] FIG. **6** is a schematic sectional view showing an example of an ultrasonic endoscope acoustic lens according to a fourth embodiment of the present invention.

[0146] An acoustic lens (an ultrasonic endoscope acoustic lens) **84** of the present embodiment of which main parts are shown in FIG. **6** can be used in place of the acoustic lens **14** in the ultrasonic endoscope **1** of the first embodiment (see FIG. **2**). The acoustic lens **84** has the same shape as the acoustic lens **14** of the first embodiment.

[0147] The acoustic lens **84** includes a surface layer **84**B in place of the surface layer **64**B in the second embodiment.

[0148] Hereinafter, description will be made focusing on a difference from the second embodiment.

[0149] Like the surface layer **64**B in the second embodiment, the surface layer **84**B is formed in a layered shape that covers a surface **64***d* in a lens main body **64**A on the whole. A surface **84***a* of the surface layer **84**B constitutes a lens surface S4 that is a surface of the acoustic lens **84**.

[0150] A friction reducing agent **14***c* that is similar to that of the first embodiment is deposited in a layered shape, and the surface layer **84**B is formed. However, since the friction reducing agent **14***c* is densely deposited, a granular shape is not shown in FIG. **6**. Since FIG. **6** is a schematic view, it is represented that a layer thickness of the surface layer **84**B is constant. However, the layer thickness of the surface layer **84**B may be set to an adequate value that is greater than or equal to a particle size of the friction reducing agent **14***c* if an influence on acoustic characteristics of the acoustic lens **84** is an allowable range. The layer thickness of the surface layer **84**B may be changed according to a place if an influence on the acoustic characteristics of the acoustic lens **84** is an allowable range. The surface **84***a* in the surface layer **84**B may have a fine uneven shape if a necessary coefficient of friction is obtained.

[0151] In the acoustic lens **84** having this constitution, in the same way as in the second embodiment, after the lens main body **64**A is formed, the friction reducing agent **14***c* is deposited on the surface **64***d* in the lens main body **64**A in a layered shape by covering the entire surface **64***d*. The same method of depositing the friction reducing agent **14***c* as in the third embodiment may be used as the method of depositing the friction reducing agent **14***c*.

[0152] In this way, when the formation of the surface layer **84**B is completed on the surface **64***d*, the acoustic lens **84** is manufactured.

[0153] The acoustic lens **84** manufactured in this way is joined to an acoustic matching layer **13** in the same way as in the first embodiment. Thus, an ultrasonic transducer **10** of the present embodiment is manufactured.

[0154] Next, an operation of the acoustic lens **84** will be described.

[0155] Like the second embodiment, the friction reducing agent **14***c* of the acoustic lens **84** is disposed only on the lens surface S**4** and therearound. In this respect, the acoustic lens **84** has the same operation as the acoustic lens **64** of the second embodiment.

[0156] Further, in the present embodiment, as in the third embodiment, the friction reducing agent **14***c* is directly deposited over the entire lens surface S**4**. In other words, the friction reducing agent **14***c* is directly deposited on the surface **64***d* of the lens main body **64**A without a binder resin **65**. In this respect, the acoustic lens **84** also has the same effect as in the third embodiment. Like the present embodiment, in a case where the entire lens surface S4 is covered by the friction reducing agent **14***c*, durability of the acoustic lens **84** is further improved in that the surface layer **84**B has a protective function of preventing direct contact between a contact member G and a base material **14***a*.

[0157] As described above, according to the acoustic lens **84** of the present embodiment, durability against physical contact can be improved.

[0158] In the description of each embodiment, the case where the ultrasonic endoscope acoustic lens is used in the ultrasonic endoscope has been described by way of example. However, the ultrasonic endoscope acoustic lens may be used in various medical instruments for measuring ultrasonic waves or instruments other than the medical instruments.

EXAMPLES

[0159] Hereinafter, Examples 1 to 4 of the ultrasonic endoscope acoustic lens of each embodiment will be described along with Comparative Example.

[0160] Constitutions and evaluation results of the ultrasonic endoscope acoustic lenses of Examples 1 to 4 and Comparative Example are shown in Table 1 below. However, the reference signs of member names are omitted in Table 1.

TABLE 1

	Base material		Filler		Friction reducing agent			Evaluation results		
									Acoustic	
	Material	Parts by mass	Material	Parts by mass	Material	Parts by mass	Distributed state	Coefficient of friction	IMP (Pa · s/m^3)	Comprehensive
Example 1	Polysiloxane	100	Silica	30	MoS_2	5	Dispersed in base material	0.28	1.38	A
Example 2	Polysiloxane	100	Silica	30	PTFE particle	5	Distributed on surface of lens main body in layered shape	0.29	1.3	A
Example 3	Polysiloxane	100	Silica	30	PTFE particle	5	Distributed on surface of lens main body in layered shape	0.27	1.33	A
Example 4	Polysiloxane	100	Silica	30	Graphite	5	Dispersed in base material	0.28	1.39	A
Comparative Example	Polysiloxane	100	Silica	30	—	—	—	0.36	1.35	B

Example 1

[0161] Example 1 is an example that relates to the acoustic lens **14** of the first embodiment. However, evaluation was performed by a sheet-like test sample (equally applied to each of Examples and Comparative Example below).

[0162] As shown in Table 1, a silicone rubber compound containing dimethylpolysiloxane, which is a silicone rubber compound (written as "polysiloxane" in Table 1) using a diorganopolysiloxane as a main agent, in a main skeleton was used as the base material **14***a* of Example 1.

[0163] Silica having an average particle size of 3 μm was used as the filler **14***b*. Here, the average particle size was measured by a laser diffraction method (equally applied to the following average particle size). The filler **14***b* was added at a fraction of 30 parts by mass based on 100 parts by mass of the cured base material **14***a*.

[0164] Molybdenum disulfide (MoS_2) having an average particle size of 5 μm was used as the friction reducing agent **14***c*. The friction reducing agent **14***c* was added at a fraction of 5 parts by mass based on 100 parts by mass of the cured base material **14***a*.

[0165] The base material **14***a*, the filler **14***b*, and the friction reducing agent **14***c* were mixed at a blending ratio as described above, and were injection-molded using a molding die, and thereby a test sample of Example 1 was manufactured. The cured test sample was a sheet having an external shape of 100 mm×50 mm×0.5 mm.

Example 2

[0166] Example 2 is an example that relates to the acoustic lens **64** of the second embodiment.

[0167] Materials and added amounts of the base material **14***a* and the filler **14***b* of Example 2 were the same as those of Example 1.

[0168] A solvent-soluble fluororesin containing fluoroethylene vinyl ether (FEVE) as a main agent was used as the binder resin **65** of the surface layer **64**B. A PTFE powder having an average particle size of 5 μm (however, a maximum particle size was 10 μm or less) was used as the friction reducing agent **14***c* of the surface layer **64**B. The friction reducing agent **14***c* was added at a fraction of 5 parts by mass when the dried binder resin **65** was set to 100 parts by mass.

[0169] In this example, the binder resin **65** is also a fluororesin, and functions as the friction reducing agent. For this reason, this example becomes an example of a case where a plurality of types of friction reducing agents are contained in the acoustic lens **64**.

[0170] In a test sample of Example 2, the base material **14***a* and the filler **14***b* were mixed at a blending ratio as described above, and were injection-molded using a molding die, and thereby a sheet body corresponding to the lens main body **64**A was manufactured.

[0171] The friction reducing agent **14**_c_ was dispersed in the binder resin **65** dissolved in a solution, and thereby a coating liquid was produced. The coating liquid was uniformly spray-coated on a surface of the sheet body. The sheet body coated with the coating liquid was dried by heating at a temperature of 120° C. Thus, a solvent of the coating liquid was volatilized, and solid components of the friction reducing agent **14**_c_ and the binder resin **65** were deposited on the surface of the sheet body in a layered shape, so that the surface layer **64**B was formed. A layer thickness of the surface layer **64**B was less than or equal to 10 μm. A shape of the cured sheet body was set to 100 mm×50 mm×0.5 mm.

Example 3

[0172] Example 3 is an example that relates to the acoustic lens **74** of the third embodiment.

[0173] Materials and added amounts of the base material **14**_a_ and the filler **14**_b_ of Example 3 were the same as those of Example 1.

[0174] A PTFE powder having an average particle size of 5 μm (however, a maximum particle size was 10 μm or less) was used as the friction reducing agent **14**_c_. The friction reducing agent **14**_c_ was used by 5 parts by mass based on 100 parts by mass of the cured base material **14**_a_.

[0175] After the same sheet body as in Example 2 was manufactured at a blending ratio as described above, the friction reducing agent **14**_c_ was deposited on a surface of the sheet body by a sputtering method, and thereby a test sample of Example 3 was manufactured. In the test sample of Example 3, the surface of the sheet body was coated within a range of about 5% with the friction reducing agent **14**_c_ distributed in an insular shape in a top view.

Example 4

[0176] Example 4 is an example that relates to the acoustic lens **14** of the first embodiment.

[0177] In Example 4, in place of MoS_2 of Example 1, graphite was used as the friction reducing agent **14**_c_. The graphite was added at a fraction of 5 parts by mass based on 100 parts by mass the cured base material **14**_a_.

Comparative Example

[0178] Silica having an average particle size of 3 μm was added as a filler using a polysiloxane equal to that of Example 1 as a base material, and thereby a test sample of Comparative Example was manufactured. The silica was added at a fraction of 30 parts by mass based on 100 parts by mass of the cured base material. The test sample of Comparative Example became a sheet body having the same external shape as in Example 1.

[0179] No friction reducing agent was added to the test sample of Comparative Example.

[0180] [Evaluation Method]

[0181] As shown in Table 1, as evaluation of the test samples, coefficient of friction evaluation, acoustic characteristic evaluation, and comprehensive evaluation were performed.

[0182] In the coefficient of friction evaluation, a coefficient of dynamic friction of each test sample was measured according to JIS K7129:1999. However, mass of slip piece was 100 g, and a speed of the slip piece was 500 mm/min SUS304 was used as a material of a counterpart member of each test sample.

[0183] It was determined that the coefficient of dynamic friction was good in the case of 0.3 or less, and poor in the case of 0.3 or more.

[0184] In the acoustic characteristic evaluation, an acoustic impedance was measured. The acoustic impedance was an amount that related to an image resolution.

[0185] A method according to a water immersion multiple reflection method without using a contrast measurement piece in the method for measurement of ultrasonic attenuation coefficient of solids (JIS Z 2354) was used as a method for measuring an acoustic impedance (described in Table 1 as "acoustic IMP"). In this case, the ultrasonic transducer for measurement was driven at a frequency of 5 MHz.

[0186] It was determined that the acoustic impedance was good in the case of 1.2 $Pa\cdot s/m^3$ or more and 1.4 $Pa\cdot s/m^3$, and poor in the case of being less than 1.2 or exceeding 1.4.

[0187] In the comprehensive evaluation, it was determined that each test sample was "good" ("A" in Table 1) when the coefficient of dynamic friction and the acoustic impedance were good, and "no good" ("B" in Table 1) when at least one of the coefficient of dynamic friction and the acoustic impedance was poor.

[0188] [Evaluation Results]

[0189] As shown in Table 1, since the coefficient of dynamic frictions of Examples 1 to 4 were 0.28, 0.29, 0.27, and 0.28, all of Examples 1 to 4 were determined to be good. In Examples 1 to 4, it was considered that the coefficient of dynamic friction was reduced due to an effect of the friction reducing agent.

[0190] In contrast, in Comparative Example, it was determined that the test sample was no good because the coefficient of dynamic friction was 0.36.

[0191] It was understood that, in Comparative Example, the silica was exposed from the base material, but even if the silica was exposed, an effect of reducing the coefficient of dynamic friction was not obtained. For this reason, the silica did not function as the friction reducing agent.

[0192] Since the acoustic impedances of Examples 1 to 4 and Comparative Example were 1.38 $Pa\cdot s/m^3$, 1.30 $Pa\cdot s/m^3$, 1.33 $Pa\cdot s/m^3$, 1.39 $Pa\cdot s/m^3$, and 1.35 $Pa\cdot s/m^3$, all of Examples 1 to 4 and Comparative Example were determined to be good. This was considered to be because the same amount of silica was used as the filler in common with Examples and Comparative Example, and the acoustic characteristics were decided by the added amount of the silica.

[0193] As the comprehensive evaluation, it was determined that Examples 1 to 4 were good, and Comparative Example was no good.

[0194] While preferred embodiments of the invention have been described and illustrated above, it should be understood that these are exemplary of the invention and are not to be considered as limiting. Additions, omissions, substitutions, and other modifications can be made without departing from the scope of the present invention. Accordingly, the invention is not to be considered as being limited by the foregoing description, and is only limited by the scope of the appended claims.

What is claimed is:

1. An ultrasonic endoscope acoustic lens comprising:

a base material composed of at least one elastomer;

a filler added to the base material; and

a friction reducing agent disposed to cover at least a part of a surface of the base material and exposed to a lens surface.

2. The ultrasonic endoscope acoustic lens according to claim **1**,

wherein the friction reducing agent contains one or more materials selected from a group consisting of a fluororesin, molybdenum disulfide, graphite, boron nitride, a polyamide resin, a polyacetal resin, and tungsten disulfide.

3. The ultrasonic endoscope acoustic lens according to claim **1**,

wherein a particle size of the friction reducing agent is less than or equal to 10 μm.

4. The ultrasonic endoscope acoustic lens according to claim **1**,

wherein an amount of the friction reducing agent is 3 parts by mass or more and 15 parts by mass or less based on 100 parts by mass of the base material.

5. The ultrasonic endoscope acoustic lens according to claim **1**,

wherein a coefficient of dynamic friction on the lens surface is smaller than 0.3.

6. The ultrasonic endoscope acoustic lens according to claim **1**,

wherein the base material is composed of a diorganopolysiloxane or a silicone rubber compound containing the diorganopolysiloxane as a main agent.

7. The ultrasonic endoscope acoustic lens according to claim **1**,

wherein the friction reducing agent is disposed on the surface of the base material in a layered shape.

8. The ultrasonic endoscope acoustic lens according to claim **1**,

wherein the friction reducing agent is fixed to the surface of the base material.

9. An ultrasonic endoscope comprising the ultrasonic endoscope acoustic lens according to claim **1**.

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专利名称(译)	超声波内窥镜声透镜和超声波内窥镜		
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申请(专利权)人(译)	OLYMPUS CORPORATION		
当前申请(专利权)人(译)	OLYMPUS CORPORATION		
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摘要(译)

超声内窥镜声透镜包括基材，填料和减摩剂。 基材由至少一种弹性体组成。 将填料添加到基础材料中。 减摩剂被布置为覆盖基础材料的基础材料表面的至少一部分并且暴露于透镜表面。