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DAMPER AND HEAD SUSPENSION HAVING THE SAME**BACKGROUND OF THE INVENTION****1. Field of the Invention**

5 This invention relates to a damper adhered to a head suspension of a recording disc drive and a head suspension having the damper.

 The present application is based on Japanese Patent Application No. Hei. 11-133304 and 2000-65542, which are
10 incorporated herein by reference.

2. Description of the Related Art

 Recording disc drives for rotating a recording disc, such as a hard disc drive and a magneto-optical disc drive, have a head part for reading and recording information. As shown in
15 Fig. 3A, the head part is generally composed of a head 1 (e.g., a magnetic head or an optical head) and a head suspension 2 supporting the head 1. Numeral 3 is a block on which the head suspension is fixed.

 The head part directly receives air pressure from a
20 rotating disc and vibrations transmitted from the drive of the head 1 or the motor for rotating the disc. It tends to follow that the head suspension 2 formed of a spring-set, etc. is deformed to shift the position of the head 1, causing reading or writing errors.

25 In order to damp the vibrations of the head suspension 2, Examined Japanese Patent Publication No. Hei. 4-8868 proposes adhering a damper 4 comprising a laminate of a constraint layer

and a viscoelastic layer to a head suspension 2 as shown in Fig. 3B. According to this proposal, the viscoelastic layer sandwiched in between the vibrating head suspension 2 and the constraint layer is deformed with the vibrational deformation of the head suspension 2 to generate internal resistance (molecular friction). As a result, the vibration energy is converted to heat energy, and the vibration energy directly transmitted to the head suspension 2 is reduced greatly.

To secure such vibration damping effects, it is important for the constraint layer to have high rigidity. Usually employed constraint layers include plates of metals, such as stainless steel. The viscoelastic layer is usually made of pressure-sensitive adhesives, rubber, and the like.

Dampers the constraint layer of which is made of metal are excellent in damping effects but entertain a fear of impairing the characteristics of the head suspension 2 as a spring because of their high rigidity. Further, when dampers of prescribed size are blanked out of a laminate having the metal sheet in accordance with the shape of the head suspension 2, it is difficult to carry out precision blanking because of burr formation at or deformation of the edges of blank pieces which inherently accompanies the blanking operation of a metal sheet. Furthermore, use of metal as a constraint layer makes it difficult to obtain a light-weight damper and also involves the problem of material cost.

In order to overcome these problems, it has been proposed to use a plastic film as a constraint layer that won't impair

the spring characteristics of the head suspension 2 and can be blanked with high precision to provide burr-free cut pieces.

However, a plastic film, being an insulator, gives rise to another problem of electrification that is not experienced
5 with a metallic constraint layer. If a plastic film having no antistatic finish is used as a constraint layer, it would be charged statically when, for example, the damper is stripped off a release sheet. It is very likely that the damper having such a statically charged plastic film damages the head 1.

10 It is a conceivable solution to this problem that a conductive filler, such as carbon, metal or a metal oxide, is incorporated into the plastic film to make the film conductive or semiconductive. However, there is a possibility that the conductive filler may fall off from the cut edges on blanking
15 the plastic film. If a damper having the fallen conductive filler attached thereto is adhered to the head suspension 2, the fallen conductive filler may damage the head 1.

SUMMARY OF THE INVENTION

20 Accordingly, an object of the present invention is to provide a damper for a head suspension which does not impair the spring characteristics of a head suspension, is not statically electrified, shows excellent blanking properties, is promising for reduction of production cost and of weight, and does not give
25 cause for damage to the head.

Another object of the invention is to provide a head suspension having such a damper.

The present invention provides in its first aspect a damper which is adhered to the head suspension of a recording disc drive, which comprises a laminate of a constraint layer and a viscoelastic layer, wherein the constraint layer is a plastic
5 film of which at least one surface has been subjected to an antistatic treatment.

The present invention also provides in its second aspect a head suspension for the head of a recording disc drive which has on at least a part thereof the above-described damper.

10 The present inventors have conducted extensive studies for the above objects. In the course of their study, they ascertained that use of a plastic film as a constraint layer is very effective in providing a damper which does not impair the spring characteristics of a head suspension and exhibits
15 excellent processability in blanking and also in suppressing the production cost and reducing the weight of the damper. Hence, the inventors have noted that the demerits attributed to use of a plastic film could be eliminated by subjecting the plastic film to a specific antistatic treatment that would not give cause for
20 damage to a head. As a result of various investigations, they have found that the above-mentioned problems are settled by a damper in which at least one of the surfaces of the plastic constraint layer have been subjected to an antistatic treatment.

The present invention has been reached based on this finding.
25 The term "surfaces" as used herein as for the constraint layer denotes both the face and the back.

Since static prevention of the damper according to the

present invention is achieved not by incorporation of a
conductive filler, such as carbon, metal or a metal oxide, into
a plastic film but by an antistatic surface treatment of the
plastic constraint layer, the above-described problem due to
5 fall-off of the internal conductive filler on blanking does not
occur.

In a preferred embodiment, the antistatic surface
treatment is given to the back of the constraint layer, i.e.,
the surface to be brought into contact with the viscoelastic layer.
10 In this case, high antistatic effects are expected against
frictional electrification on stripping the damper from a
release sheet, and the antistatic layer can be protected from
external influences such as scratches or oxidation.

In another preferred embodiment, the antistatic
15 treatment is carried out by forming an antistatic layer by metal
deposition or coating with a conductive resin. The constraint
layer having the antistatic layer formed by metal deposition has
an extremely low surface resistivity. The conductive resin
coating film can be formed with relative ease and, being
20 transparent or semitransparent, brings about little change in
hue.

In still another preferred embodiment, the plastic film
is a polyimide film having an elastic modulus of 4.9×10^9 N/m²
or higher, which is relatively inexpensive and is excellent in
25 damping performance.

The head suspension having on at least a part thereof
the above-described damper enjoys the above-described effects

attributed to the damper and effectively prevents reading and writing errors of the head.

Features and advantages of the invention will be evident from the following detailed description of the preferred embodiments described in conjunction with the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

10 Fig. 1 is a cross section of an example of the damper according to the present invention;

Fig. 2 is a cross section of another example of the damper according to the present invention; and

15 Fig. 3A shows a head suspension, and Fig. 3B shows the head suspension with the damper of the invention adhered thereto.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The damper of the invention comprises a unitary laminate of a plastic film as a constraint layer and a viscoelastic layer comprising a pressure-sensitive adhesive. At least one of the surfaces of the constraint layer has been given an antistatic treatment; that is, the constraint layer has an antistatic layer on at least one surface thereof.

Preferred embodiments of the damper according to the invention will be illustrated with reference to the accompanying drawings. Fig. 1 is a cross section of a damper 4 having an antistatic layer 7 formed on the surface of a constraint layer

5 in contact with a viscoelastic layer 6. Because the viscoelastic layer 6, being adhesive, is inconvenient for storage or transportation, it is protected with a release sheet 8, which is stripped off the viscoelastic layer 6 on use so that the damper may be stuck to a head suspension of a recording disk drive. Where the antistatic layer 7 is provided on the side of the constraint layer 5 in contact with the viscoelastic layer 6 as is shown in Fig. 1, frictional electrification on stripping the damper from the release sheet can be prevented effectively, and the antistatic layer 7 is protected from external influences such as scratches or oxidation.

Fig. 2 depicts another embodiment of the damper. The damper 4' shown has the antistatic layer 7 formed on the face, i.e., the outer surface of the constraint layer 5 but is otherwise the same as in the embodiment shown in Fig. 1 in both structure and usage. The same numerals are given to the same members. The damper 4' does not hinder the spring characteristics of a head suspension, is not statically electrified, shows excellent processability in blanking, is promising for reduction of production cost and of weight, and does not give cause for damage to the head.

The damper of the present invention is not structurally limited to the embodiments shown in Figs. 1 and 2 in which the antistatic layer 7 is formed on either side of the constraint layer 5. For example, the antistatic layer 7 can be formed on both sides of the constraint layer 5, or a plurality of constraint layers 5 and a plurality of the antistatic layers 7 can alternate

to form a multilayer structure on one side of the viscoelastic layer 6.

The antistatic treatment, i.e., formation of the antistatic layer 7 can be carried out by, for example, depositing
5 a metal, such as aluminum or chromium, or coating with an electrically conductive resin, such as polyaniline or polypyrrole. Deposition of a metal is particularly preferred for producing an effect in controlling the surface resistivity.

Aluminum deposition is especially preferred for the economical
10 considerations. Coating with a conductive resin is preferred; for the antistatic layer can be formed relatively easily. Polypyrrole is especially preferred as a conductive resin for controlling the surface resistivity.

The thickness of the antistatic layer 7 is not
15 particularly limited and can be decided appropriately so that the resulting damper may fit desired criteria of surface resistivity, quantity of charges, and half-life of charges.

Usually the thickness of the antistatic layer formed by metal deposition is about 100 to 5,000 Å, and that of the antistatic
20 layer formed of a conductive resin is about 0.01 to 5 μm. The methods of measuring surface resistivity, quantity of charges and half-life and their criteria will be described in Examples hereinafter given.

While not limiting, the thickness of the plastic
25 constraint layer 5 is preferably 5 to 200 μm. With a thickness smaller than 5 μm, the function as a constraint layer tend to be insufficient. With a thickness exceeding 200 μm, the

constraint layer tends to ruin the characteristics of the head suspension as a spring.

While the plastic film as a constraint layer 5 is not particularly restricted, resins having a higher elastic modulus exhibits more excellent vibration damping properties. From this viewpoint, it is preferred to use a resin having an elastic modulus of 2.9×10^9 N/m² or more. Useful plastic films include a polyimide resin film, a biaxially stretched polyethylene terephthalate (PET) film, a biaxially stretched polypropylene film, and an aramid resin film. *Inter alia*, a polyimide film having an elastic modulus of 4.9×10^9 N/m² or more is preferred for its excellent damping properties and relative inexpensiveness.

While the material of the viscoelastic layer 6 is not particularly limited, it is preferred to use acrylic pressure-sensitive adhesives that are generally excellent in vibration damping properties and heat resistance. Because the inside temperature of a hard disc drive, for example, sometimes reaches 50 to 60°C, it is not favorable to use materials which have poor heat resistance and are apt to undergo thermal deformation or thermal deterioration, such as butylated adhesives. Silicone adhesives are known as heat-resistant pressure-sensitive adhesives, however, it is necessary to take into consideration possibility of contaminating the recording layer of hard discs, etc. which may lead to reading or writing errors or damage to the head.

The acrylic pressure-sensitive adhesives which can be

used in the invention include those obtained by the process for producing an adhesive of tape form disclosed in JP-A-5-132658, which comprises ultraviolet polymerization of a monomer mixture comprising an alkyl acrylate monomer, a carboxyl-containing monomer, a photopolymerization initiator, and a crosslinking agent. The alkyl acrylate monomer to be used usually contains 8 to 12 carbon atoms in the alkyl moiety thereof.

It should be noted that materials having a possibility of generating an organic gas as well as the above-mentioned silicone adhesives will contaminate the recording layer of hard discs, etc. In order to avoid organic gas generation, therefore, it is necessary to reduce an organic gas from the viscoelastic layer 6 having such a possibility. This can be done by, for example, passing the adhesive layer applied to the constraint layer 5 and cured through a high-temperature drying tower to evaporate the solvent and any unreacted component. Or, the damper obtained by blanking is vacuum dried to reduce the organic gas of the solvent, etc.

While not limiting, the thickness of the viscoelastic layer 6 thus formed suitably ranges from 10 to 250 μm . With a thickness smaller than 10 μm , the damping effect tends to be insufficient. If the thickness exceeds 250 μm , the characteristics of the head suspension as a spring tend to be impaired.

The structure of the viscoelastic layer 6 is not limited to the single layer structure as shown in Fig. 1 and 2 and can be a laminate composed of a plurality of viscoelastic films.

Where the viscoelastic layer 6 has insufficient adhesion to a head suspension, a separate adhesive layer may be provided on the viscoelastic layer 6.

The release sheet 8 has its surface to be brought into
5 contact with the viscoelastic layer 6 treated with a release agent.

For the same reason described above, it is preferred to use a non-silicone release agent, such as long-chain alkyl type release agents and fluorinated alkyl type release agents.

The damper of the invention is produced, for example,
10 as follows. The constraint layer 5 having on at least one side thereof the antistatic layer formed by the antistatic surface treatment and the viscoelastic layer 6 are positioned to face each other and joined by an appropriate means to obtain a laminate.

For example, the two members are press-bonded through a pair
15 of rubber rolls or in a press. The laminate can also be obtained by applying a pressure-sensitive adhesive forming the viscoelastic layer 6 directly to the constraint layer 6 followed by drying to form the viscoelastic layer 6.

Separately, a substrate, such as a PET film, is coated
20 with a diluted solution of the above-described non-silicone release agent in a conventional manner and dried in an oven, etc. to prepare the release sheet 8 having release properties. The release sheet 8 is applied to the viscoelastic layer 6 in a known manner to obtain the damper of the invention. On use, the release
25 sheet 8 is stripped off the viscoelastic layer 6.

The damper according to the present invention possesses vibration damping characteristics equally to one having a

metallic constraint layer. Additionally, it is light, competitive in price owing to the inexpensive material, and hardly suffers from burrs in fine blanking. Having an antistatic finish that does not damage the head of a recording disc drive,
5 the damper of the invention is free from the problem of electrification accompanying plastic materials.

The damper 4 or 4' of the invention, from which the release sheet 8 has been removed, is stuck to the central portion of a head suspension 2 by making use of the self adhesiveness
10 of the viscoelastic layer 6 as illustrated in Fig. 3B. There is thus obtained a head suspension having excellent properties of effectively preventing errors of the head 1 in writing and reading. The damper can be stuck to not only the central portion but other portions (such as both the lateral sides or the reverse
15 side) or all over the head suspension. If desired, the damper can be stuck by means of an adhesive separately applied onto the viscoelastic layer 6 as mentioned above. The adhesive to be used can be selected appropriately according to the material of the head suspension 2 from among various known adhesives.

20 The present invention will now be illustrated in greater detail with reference to Examples, but it should be understood that the invention is not construed as being limited thereto.

EXAMPLE 1

A 50 μm thick polyimide film (Upilex 50S, available from
25 Ube Industries, Ltd.; elastic modulus: $6.4 \times 10^9 \text{ N/m}^2$) was set in a vacuum chamber, and aluminum was heated to 1220°C under reduced pressure of 1.33 Pa or lower in the chamber to deposit

evaporated aluminum vapor onto one side of the polyimide film to form an antistatic layer having a thickness of 2000 Å. A laminate of the resulting polyimide film, the antistatic layer thereof facing inward, and a 125 μm thick viscoelastic layer made of an acrylic pressure-sensitive adhesive were passed through a pair of rubber rolls to obtain a laminated sheet. A square damper having 2-mm sides was blanked from the laminated sheet.

EXAMPLE 2

Soluble polyaniline was applied to one side of a 50 μm thick PET film (Lumilar S10, available from Toray Industries, Inc.; elastic modulus: 3.9×10^9 N/m²) and dried to form an antistatic layer having a thickness of 0.1 μm. A laminate of the resulting coated polyimide film, the antistatic layer thereof facing inward, and a 125 μm thick viscoelastic layer made of an acrylic pressure-sensitive adhesive were passed through a pair of rubber rolls to obtain a laminated sheet. A damper was blanked out of the laminated sheet in same manner as in Example 1.

EXAMPLE 3

A damper was prepared in the same manner as in Example 1, except that the polyimide film and the viscoelastic layer were joined with the antistatic layer of the former outward.

EXAMPLE 4

A damper was prepared in the same manner as in Example 2, except that the polyimide film and the viscoelastic layer were joined with the antistatic layer of the former outward.

COMPARATIVE EXAMPLE 1

A damper was prepared in the same manner as in Example 1, except that the antistatic layer was not formed on the PET film.

COMPARATIVE EXAMPLE 2

5 A damper was prepared in the same manner as in Example 1, except for using a 25 μm thick stainless steel plate (SUS304) having no antistatic finish.

The dampers obtained in Examples and Comparative Examples were examined to measure the height of the burrs.
10 Further, the surface resistivity, quantity of charges, half-life, and damping characteristics of the dampers were measured as follows. The results obtained are shown in Table 1 below.

1) Height of burrs formed by blanking

The acrylic adhesive was removed from the 2-mm square
15 sample (damper), and the thickness of the cut edge of the constraint layer was measured with a dial gauge. The difference between the thickness after blanking and that before blanking was taken as a height of burrs. A burr height of 10 μm or smaller was taken as a criterion for judging the sample to have
20 satisfactory blanking processability.

2) Surface resistivity

The surface resistivity of the constraint layer was measured with an ohmmeter High Rester (MCP-HT 250, manufactured by Mitubishi Chemical Co., Ltd.) and an ohmmeter Low Rester (MCP-T
25 250, manufactured by Mitsubishi Chemical Co., Ltd.). In Table 1, samples whose surface resistivity exceeded the upper detectable limit, $1 \times 10^{14} \Omega/\square$, were indicated as " $>1 \times 10^{14} \Omega/\square$

□". Surface resistivity of $1 \times 10^{10} \Omega/\square$ or less was taken as a criterion for judging the sample to be satisfactory.

3) Static charge and half-life

The static charge on the viscoelastic layer side of the sample (laminate) was measured with a static honest meter (S-5109, manufactured by Shishido Electro K.K.). The charge quantity at an applied voltage of 10 kV and the time required for the charge quantity to reduce by half were measured. Samples whose half-life was 60 seconds or shorter were judged satisfactory.

4) Damping characteristics

The sample (damper) was adhered to a 50 μm thick stainless steel substrate (SUS 304), and a loss coefficient was measured with an FFT analyzer (CF-5220, manufactured by Ono Sokuki K.K.). In more detail, the FFT analyzer was set to give vibrations at a frequency of 3 kHz at a measuring temperature of 25°C, and a loss coefficient was obtained by the half width method. A loss coefficient of 0.1 or greater was taken as a criterion for judging the sample to have practical damping characteristics and be satisfactory.

5) Overall Judgement

The samples were rated as follows based on the results of the above measurements.

A ... The sample fulfilled all the criteria of the attributes, exhibiting particular superiority in each attribute.

B ... The sample fulfilled all the criteria of the attributes.

C ... The sample fulfilled not all the criteria of the attributes.

TABLE 1

	Height of Burr (μm)	Surface Resis- tivity ($\Omega/\text{sq.}$)	Charge Quanti- ty (mV)	Half- life (sec)	Loss Coeffi- cient	Overall Judge- ment
Example 1	3	5×10^9	18	30	0.16	A
Example 2	5	3×10^9	19	50	0.12	B
Example 3	3	5×10^9	20	120	0.16	B
Example 4	5	3×10^9	20	200	0.12	B
Compara. Example 1	3	$>1 \times 10^{14}$	22	7000	0.16	C
Compara. Example 2	35	1×10^9	16	30	0.17	C

5 The dampers of Examples have a small height of burrs and are hardly electrified as can be seen from the results of the measurement on surface resistivity, charge quantity and half-life. They were also excellent in damping characteristics.

10 To the contrary, although the damper of Comparative Example 1, of which the constraint layer has not been subjected to an antistatic treatment, has a small height of burrs, it is easily electrified as compared with the dampers of Examples and Comparative Example 2. The damper of Comparative Example 2 using a stainless steel plate as a constraint layer is superior in
15 damping characteristics and hardly electrified as is seen from the results of measurement on surface resistivity, charge quantity and half-life but has an extremely great height of burrs, proving poor in blanking processability.

As described above, the damper of the present invention comprises a laminate of a constraint layer and a viscoelastic layer, wherein the constraint layer is a plastic film of which at least one surface has been subjected to an antistatic treatment.

5 Since the plastic film used as a constraint layer is made antistatic, the damper of the invention is not statically electrified and does not damage a head as compared with dampers using a plastic constraint layer having no antistatic finish.

10 Since the constraint layer is a plastic film, hardly does the damper form burrs on blanking. As stuck to at least part of a head suspension, the damper is capable of removing or greatly reducing the vibrations of the head suspension thereby to effectively prevent reading and writing errors of the head.

15 Where the antistatic layer is formed on the side of the constraint layer in contact with the viscoelastic layer, high antistatic effects are exerted on frictional electrification when the damper is stripped from a release sheet, and the antistatic layer is protected from external influences such as scratches or oxidation.

20 Where the antistatic layer is a layer formed by metal deposition, the damper has an extremely low surface resistivity.

Where the antistatic layer is a conductive resin coating film, the layer can be formed with relative ease and, being transparent or semitransparent, causes little change of hue.

25 Where the plastic film is a polyimide film having an elastic modulus of $4.9 \times 10^9 \text{ N/m}^2$ or more, the damper is competitive in price for damping properties.

The damper of the invention causes no hindrance to the characteristics of a head suspension as a spring, is free from the problem of static electrification, shows excellent processability in blanking, is promising for reduction of production cost and of weight, and does not give cause for damage to the head.

The head suspension of the invention having the damper of the invention adhered to at least a part thereof enjoys the above-described effects attributed to the damper and effectively prevents reading and writing errors of the head.

Although the invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form can be changed in the details of construction and in the combination and arrangement of parts without departing from the spirit and the scope of the invention as hereinafter claimed.



WHAT IS CLAIMED IS:

1. A damper to adhered to a head suspension of a recording disc drive, comprising

a constraint layer; and

5 a viscoelastic layer laminated on said constraint layer, wherein said constraint layer comprises a plastic film of which at least one surface has been subjected to an antistatic treatment.

10 2. A damper according to claim 1, wherein said antistatic treatment is given to the surface of said constraint layer in contact with said viscoelastic layer.

15 3. A damper according to claim 1, wherein said antistatic treatment is formation of an antistatic layer by metal deposition.

20 4. A damper according to claim 1, wherein said antistatic treatment is coating with a conductive resin.

5. A damper according to claim 1, wherein said plastic film comprises a polyimide film having an elastic modulus of 4.9×10^9 N/m² or greater.

25 6. A head suspension for a head of a recording disc drive, which has on at least a part thereof the damper according to any one of claims 1 to 5.