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Optical element drive mechanism

Abstract

An optical element drive mechanism is provided. The optical element drive mechanism includes an immovable part, a movable part, a drive assembly, and a strengthening assembly. The movable part is connected to an optical element. The movable part is movable relative to the immovable part. The drive assembly drives the movable part to move relative to the immovable part. The strengthening assembly strengthens the driving force of the drive assembly. The strengthening assembly is close to the drive assembly.

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Background/Summary

CROSS REFERENCE TO RELATED APPLICATIONS (1) This application claims the benefit of U.S. Provisional Application No. 63/127,746, filed Dec. 18, 2020, and U.S. Provisional Application No. 63/143,344, filed Jan. 29, 2021, the entirety of which is incorporated by reference herein.

BACKGROUND OF THE INVENTION

Field of the Invention

(1) The present invention relates to a drive mechanism, and, in particular, to an optical element drive mechanism.

Description of the Related Art

(2) As technology has developed, many electronic devices (such as tablet computers and smartphones) may be used for capturing images and recording video. The optical element and the optical element drive mechanism in the electronic device allow the user to use the electronic device to capture images and record video. When the electronic device is being used, shock or vibration may occur, and this may cause the images or video to come out blurry. Therefore, the demand for higher quality images and video is increasing.

BRIEF SUMMARY OF THE INVENTION

(3) An optical element drive mechanism is provided. The optical element drive mechanism includes an immovable part, a movable part, a drive assembly, and a strengthening assembly. The movable part is connected to an optical element. The movable part is movable relative to the immovable part. The drive assembly drives the movable part to move relative to the immovable part. The strengthening assembly strengthens the driving force of the drive assembly. The strengthening assembly is close to the drive assembly.

(4) In some embodiments, the immovable part includes a case and a bottom. The case includes a top wall with a plate structure and a side wall with a plate structure. the top wall is perpendicular to

a main axis. The bottom is immovably connected to the case. An accommodation space is formed between the case and the bottom to accommodate the movable part. The case further includes a first protrusion protruding from the top wall toward the accommodation space. The thickness of the first protrusion is greater than the thickness of the top wall. The drive assembly is disposed on the first protrusion. In some embodiments, the strengthening assembly includes a side plate with a plate structure and parallel with the side wall of the case, and the side plate is located between the drive assembly and the side wall. The thickness of the side wall is identical to the thickness of the side plate. The side wall and the side plate include a metal material. The magnetic permeability of the side wall is less than the magnetic permeability of the side plate. The drive assembly includes a magnetic element disposed on the side wall.

(5) In some embodiments, the strengthening assembly further includes a top plate with a plate structure and parallel with the top wall of the case, and the top plate is located between the drive assembly and the top wall. The thickness of the top wall is identical to the thickness of the top plate. The thickness of the top plate is identical to the thickness of the side plate. The thickness of the top plate is between 0.15 mm to 0.60 mm. The top wall and the top plate include a metal material. The magnetic permeability of the top wall is less than the magnetic permeability of the top plate. The top plate is spaced apart from the magnetic element by a gap. The minimum distance between the top plate and the magnetic element is different from the minimum distance between the side plate and the magnetic element. The top plate is spaced apart from the top wall by a gap. The minimum distance between the top plate and the top wall is different from the minimum distance between the side plate and the side wall.

(6) In some embodiments, the minimum distance between the top plate and the magnetic element is greater than the minimum distance between the side plate and the magnetic element, and the minimum distance between the top plate and the top wall is greater than the minimum distance between the side plate and the side wall. In some embodiments, the case further includes a second protrusion protruding from the top wall toward the accommodation space. The drive assembly is disposed on the second protrusion. The first protrusion and the second protrusion are arranged along a first axis. In the first axis, the minimum distance between the first protrusion and the second protrusion is greater than the maximum size of the top plate. When viewed along the main axis, the top plate is spaced apart from the first protrusion by a gap. When viewed along the main axis, the top plate is spaced apart from the second protrusion by a gap.

(7) In some embodiments, the immovable part further includes an embedded assembly, and at least part of the embedded assembly is embedded and not revealed from the bottom. The bottom includes a non-metal material. The embedded assembly includes a metal material, and the embedded assembly and the side wall include different materials. The embedded assembly is electrically connected to the case. The embedded assembly is immovably connected to the side wall via soldering or welding. The embedded assembly includes a connection portion connected to the side wall. The embedded assembly further includes a protruding pin connected to an external circuit. The side wall includes a protruding portion protruding from the side wall.

(8) In some embodiments, the optical element drive mechanism further includes a circuit assembly and a sensing assembly. The circuit assembly is electrically connected to the drive assembly, and the sensing assembly senses movement of the movable part relative to the immovable part. The circuit assembly has a plate structure and is perpendicular to the main axis. The circuit assembly and the bottom are separate elements. The circuit assembly includes a first pin and a second pin electrically connected to the external circuit. The minimum distance between the protruding pin and the first pin is different from the minimum distance between the first pin and the second pin. The minimum distance between the protruding pin and the first pin is greater than the minimum distance between the first pin and the second pin. The sensing assembly includes a sensing element disposed on the circuit assembly. The bottom includes an opening structure receiving the circuit assembly, and the opening structure is a closed structure.

(9) In some embodiments, the optical element drive mechanism further includes a first elastic element and a second elastic element. The movable part is movably connected to the immovable part via the first elastic element and the second elastic element. The first elastic element has a plate structure and is perpendicular to the main axis. The first elastic element is connected to the bottom. The first elastic element has a metal material. The magnetic permeability of the first elastic element is less than the magnetic permeability of the side plate. The second elastic element has a plate structure and is perpendicular to the main axis. The second elastic element is connected to the bottom. The first elastic element is parallel with the second elastic element. The first elastic element is electrically connected to an external module. The first elastic element includes an electrical contact electrically connected to the external module. When viewed along the main axis, the electrical contact is revealed from the top wall. The second elastic element is electrically connected to the drive assembly. The embedded assembly further includes a first circuit and a second circuit. At least part of the first circuit and the second circuit is embedded and not revealed from the bottom. The first elastic element is electrically connected to the circuit assembly via the first circuit. The second elastic element is electrically connected to the circuit assembly via the second circuit.

(10) In some embodiments, the side wall includes a non-metal material. The strengthening assembly includes a metal material. The strengthening assembly is disposed in the side wall. The strengthening assembly includes a plurality of strengthening elements. The strengthening elements are embedded in the side wall. The strengthening elements have particle structures. The maximum size of each of the strengthening elements is less than 0.05 mm. The ratio of the total volume of the strengthening elements to the volume of the side wall is between 5% and 40%. The side wall is dark-colored. The thickness of the top wall is different from the thickness of the side wall. The thickness of the top wall is less than the thickness of the side wall. The thickness of the top wall is between 0.10 mm and 0.55 mm. The thickness of the side wall is between 0.15 mm and 0.60 mm.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

- (1) The present invention can be more fully understood by reading the subsequent detailed description and examples with references made to the accompanying drawings, wherein:
- (2) FIG. 1 is a schematic view of the electronic device, the optical element, and the optical element drive mechanism.
- (3) FIG. 2 is a schematic view of the optical element and the optical element drive mechanism.
- (4) FIG. 3 is an exploded view of the optical element drive mechanism.
- (5) FIG. 4 is a perspective view of the elastic assembly and the embedded assembly.
- (6) FIG. 5 is a perspective view of the optical element drive mechanism.
- (7) FIG. 6 is a bottom view of the optical element drive mechanism.
- (8) FIG. 7 is a perspective view of the case.
- (9) FIG. 8 is a bottom view of the case.
- (10) FIG. 9 is a perspective view of the case, the strengthening assembly, and the magnetic element.
- (11) FIG. 10 is a bottom view of the case, the strengthening assembly, and the magnetic element.
- (12) FIG. 11 is a cross-section view taken along the line A-A' in FIG. 9.
- (13) FIG. 12 and FIG. 13 are perspective views of the case and the strengthening assembly according to some other embodiments from different perspectives.

DETAILED DESCRIPTION OF THE INVENTION

- (14) The following disclosure provides many different embodiments, or examples, for implementing different features of the subject matter provided. Specific examples of components

and arrangements are described below to simplify this disclosure. These are, of course, merely examples and are not intended to be limiting. For example, the formation of a first feature “on” and/or “above” a second feature in the description that follows may include embodiments in which the first and second features are formed in direct contact, and may also include embodiments in which additional features may be formed between the first and second features, so that the first and second features may not be in direct contact. The spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in figures. The apparatus may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein may likewise be interpreted accordingly. In addition, in different examples of this disclosure, symbols or alphabets may be used repeatedly.

(15) Ordinal terms such as “first”, “second”, etc., used in the description and in claims do not by themselves connote any priority, precedence, or order of one element over another, but are used merely as labels to distinguish one element from another element having the same name. Unless the context requires otherwise, throughout the specification and claims that follow, the word “include”, “have” and variations thereof, such as “includes”, “including”, “having” are to be construed in an open, inclusive sense, that is, as “including, but not limited to.”

(16) Please refer to FIG. 1 and FIG. 2. FIG. 1 is a schematic view of an electronic device **1**, an optical element **10**, and an optical element drive mechanism **100**. FIG. 2 is a schematic view of the optical element **10** and the optical element drive mechanism **100**. The electronic device **1** may be a tablet computer, a smart phone, etc. The optical element **10** may be a lens. The optical element **10** may be made of plastic or glass. The optical element **10** may be circular or it may have another shape. The optical element **10** and the optical element drive mechanism **100** may be disposed in the electronic device **1**, so that a user may capture images and record video. The optical element drive mechanism **100** may hold the optical element **10** and drive the optical element **10** to move, so as to adjust the position of the optical element **10** to capture clear images. The optical element drive mechanism **100** is typically placed in the top region of the electronic device **1** to increase the display area of the electronic device **1**, but it is not limited thereto.

(17) The optical element **10** has an optical axis O. The optical axis O is an imaginary axis passing through the center of the optical element **10**. The optical element drive mechanism **100** has a main axis MA (denoted in FIG. 3). The main axis MA is an imaginary axis passing through the center of the optical element drive mechanism **100**. When the optical element **10** and the optical element drive mechanism **100** are aligned, the optical axis O substantially overlaps the main axis MA. Therefore, in the followings and in the drawings, the optical axis O of the optical element **10** and/or the main axis MA of the optical element drive mechanism **100** may be used to illustrate or describe the related features of the optical element drive mechanism **100**. It should be noted that, since the optical element **10** is movably placed in the optical element drive mechanism **100**, the optical axis O of the optical element **10** may be not exactly overlap the main axis MA of the optical element drive mechanism **100** because of the movement, shake, rotation, tilt, and the like, of the optical element drive mechanism **100**.

(18) When viewed along the optical axis O, the optical element drive mechanism **100** is polygonal, such as quadrilateral. For ease of illustration, the four sides of the optical element drive mechanism **100** are referred to as a first side **1001**, a second side **1002**, a third side **1003**, and a fourth side **1004**. The first side **1001** is opposite the third side **1003**, and the second side **1002** is opposite the fourth side **1004**. The first side **1001** is substantially parallel with the third side **1003**, and the second side **1002** is substantially parallel with the fourth side **1004**. The first side **1001**, the second side **1002**, the third side **1003**, and the fourth side **1004** are substantially perpendicular to the optical axis O. When viewed along the optical axis O, the second side **1002** and the fourth side **1004** are parallel with a first axis A1, and the second side **1002** and the fourth side **1004** extend along the first axis A1. When viewed along the optical axis O, the first side **1001** and the third side **1003** are parallel with a second axis A2, and the first side **1001** and the third side **1003** extend

along the second axis A2. The first axis A1 and the second axis A2 are substantially perpendicular to the optical axis O.

(19) Next, please refer to FIG. 2 and FIG. 3. FIG. 3 is an exploded view of the optical element drive mechanism **100** with some elements omitted. The optical element drive mechanism **100** includes an immovable part I, a movable part M, an elastic assembly E, a drive assembly D, a circuit assembly C, a sensing assembly S, an embedded assembly EM, and a strengthening assembly STR. The movable part M may be connected to the optical element **10**. The movable part M is movable relative to the immovable part I. The elastic assembly E connects the immovable part I and the movable part M. The drive assembly D may drive the movable part M to move relative to the immovable part I. The circuit assembly C may transmit the current. The sensing assembly S may sense the movement of the movable part M relative to the immovable part I. The strengthening assembly STR may strengthen the driving force of the drive assembly D.

(20) In this embodiment, the immovable part I includes a case **110** and a bottom **120**. The movable part M includes a holder **130**. The elastic assembly E includes two first elastic elements **140** and two second elastic elements **150**. The drive assembly D includes two coils **160** and two magnetic elements **170**. The circuit assembly C includes a circuit element **180**. The sensing assembly S includes a reference element **190** and a sensing element **200**. The embedded assembly EM includes a plurality of embedded elements **210**. The strengthening assembly STR includes two strengthening elements **220**. It should be noted that elements may be added or removed as needed. Also, for a clear illustration, some elements may be omitted from the drawings.

(21) The case **110** may be immovably connected to the bottom **120**, and thus an accommodation space is formed between the case **110** and the bottom **120**. The accommodation space may accommodate the movable part M, the elastic assembly E, the circuit assembly C, the sensing assembly S, and the strengthening assembly STR, and the like. The case **110** includes a top wall **111** with a plate structure and a plurality of side walls **112** each with a plate structure. The top wall **111** is substantially perpendicular to the main axis MA. Each of the side walls **112** extends along the main axis MA from the edge of the top wall **111**. In some embodiments, the case **110** and/or the bottom **120** include a metal material or a magnetic material. In some embodiments, the case **110** and/or the bottom **120** include a non-metal material such as a plastic material. The material may be determined as needed.

(22) The bottom **120** includes an opening structure **121**, a plurality of connection portions **122**, a plurality of columns **123**, and a support portion **124**. The opening structure **121** is located on the first side **1001**. The opening structure **121** may accommodate the circuit assembly C. The opening structure **121** is a closed structure. The connection portions **122** may be located on different surfaces of the bottom **120** in the main axis MA. The columns **123** are located at different corners of the bottom **120**. The columns **123** may be in contact with the side wall **112** of the case **110** to increase the contact area between the case **110** and the bottom **120**, thereby strengthening the connection between the case **110** and the bottom **120** to prevent the case **110** from falling off. The circuit assembly C may in direct contact with the support portion **124** to be supported and fixed by the support portion **124**.

(23) The holder **130** may be connected to the optical element **10**. In some embodiments, the holder **130** includes a plastic material. The holder **130** includes a plurality of stopper-portions **131**, a plurality of connection portions **132**, a plurality of electrical connection portions **133**, and a recess **134**. The stopper-portions **131** and the connection portions **132** are disposed on the top surface of the holder **130**. The stopper-portions **131** and the connection portions **132** may be protrusions. The electrical connection portions **133** are located on the second side **1002** and the fourth side **1004**. The recess **134** is formed on the side of the holder **130** and located on the first side **1001**.

(24) When the drive assembly D drives the holder **130** to move along the optical axis O toward the top wall **111** of the case **110** and to reach the limit, the stopper-portions **131** may be in contact with the top wall **111** of the case **110** first so as to prevent the rest of the portions of the holder **130** from

colliding with the case **110**. Similar stopper-portions may also be placed on the bottom surface of the bottom surface of the holder **130**. Therefore, the stability of the overall optical element drive mechanism **100** is enhanced.

(25) The first elastic element **140** has a plate structure and is perpendicular to the main axis MA. The second elastic element **150** has a plate structure and is perpendicular to the main axis MA. The first elastic element **140** is parallel with the second elastic element **150**. In detail, the first elastic element **140** is disposed between the top wall **111** of the case **110** and the holder **130**. The second elastic element **150** is disposed between the holder **130** and the bottom **120**. The first elastic element **140** and the second elastic element **150** are made of an elastic material or a ductile material, e.g., metal. In this technical field, the first elastic element **140** and the second elastic element **150** may be known as “spring”, “leaf spring”, “plate spring”, etc.

(26) The first elastic element **140** connects the bottom **120** and the holder **130**. In other words, the movable part M is movably connected to the immovable part I via the first elastic element **140** and the second elastic element **150**. For example, the first elastic element **140** may be disposed on the connection portions **122** of the bottom **120** and the connection portions **132** of the holder **130**. When the movable part M moves relative to the immovable part I, the range of motion of the holder **130** may be restricted by the first elastic element **140** and the second elastic element **150**. Therefore, the holder **130** and the optical element **10** therein do not get damaged because of collision of the holder **130** with the case **110** or the bottom **120** when the optical element drive mechanism **100** moves or is impacted.

(27) Furthermore, the first elastic element **140** may be used for electrical connection to an external module (not shown). For example, the external module that the first elastic element **140** is electrically connected to may be an aperture, another optical element drive mechanism, etc. The first elastic element **140** includes an electrical contact **141** (denoted in FIG. 2) for electrical connection to the external module. When viewed along the main axis MA, the electrical contact **141** is revealed from the top wall **111** of the case **110**. Also, the second elastic element **150** may be used for electrical connection to the drive assembly D.

(28) The two coils **160** are disposed on the second side **1002** and the fourth side **1004**, respectively. The coils **160** are polygonal and surround the electrical connection portions **133** of the holder **130**. The two magnetic elements **170** are disposed on the second side **1002** and the fourth side **1004**, respectively, and the magnetic elements **170** correspond to the coils **160**. The magnetic elements **170** are disposed on the inner side of the side walls **112** of the case **110**. When the current is supplied to the drive assembly D, the magnetic force that is parallel with the optical axis O is generated between the coils **160** and the magnetic elements **170**. The magnetic force may drive the holder **130** and the optical element **10** therein to move relative to the immovable part I along the optical axis O to make an object to be in focus, thereby achieving auto focus (AF).

(29) The circuit assembly C is electrically connected to the drive assembly D. The circuit element **180** is disposed on the first side **1001**. The circuit element **180** has a plate structure and is parallel with the main axis MA. The circuit element **180** and the bottom **120** are separate elements. The circuit element **180** may be a circuit board such as a flexible printed circuit (FPC), a rigid-flexible board, etc. The circuit element **180** includes a plurality of pins used for electrical connection to an external circuit (not shown) outside the optical element drive mechanism **100**, and the pins include a first pin **181** and a second pin **182**. The first pin **181** is adjacent to the second pin **182**.

(30) The reference element **190** is disposed on the recess **134**. The sensing element **200** corresponds to the reference element **190**, and the sensing element **200** is disposed on the circuit element **180**. The reference element **190** may be a magnetic element. The sensing element **200** may be a Hall sensing element, a giant magnetoresistive (GMR) sensing element, a tunneling magnetoresistive (TMR) sensing element, etc. The sensing element **200** may sense the reference element **190** to find out the position of the movable part M. In particular, the sensing element **200** may sense the change of the lines of magnetic field (including but not limited to the density of the

lines of magnetic field and the direction of the lines of magnetic field) of the reference element **190** to find out the position of the holder **130**.

(31) Next, in addition to FIG. **2** and FIG. **3**, please also refer to FIG. **4** to FIG. **6** to know the embedded assembly EM. FIG. **4** is a perspective view of the elastic assembly E and the embedded assembly EM. FIG. **5** is a perspective view of the optical element drive mechanism **100**. FIG. **6** is a bottom view of the optical element drive mechanism **100**. In some embodiments, the embedded assembly EM includes a metal material, and the embedded assembly EM and the side walls **112** of the case **110** include different materials. In some embodiments, the embedded assembly EM may be circuits. The embedded assembly EM may be formed in the bottom **120** by methods such as insert molding. That is, the embedded assembly EM and the bottom **120** may be formed integrally as one piece, and at least part of the embedded assembly EM is embedded and not revealed from the bottom **120**. The magnetic attraction force may be generated between the embedded assembly EM and the drive assembly D. Also, the external force exerted on the bottom **120** may be distributed by the embedded assembly EM. Therefore, in addition to the electrical connection, the embedded assembly EM may also increase the strength of the bottom **120** and the overall strength of the optical element drive mechanism **100**.

(32) The embedded assembly EM may include a first embedded portion **211**, a second embedded portion **212**, and a third embedded portion **213** that are electrically connected to different elements. For example, the first embedded portion **211** is electrically connected to the case **110**, the second embedded portion **212** is electrically connected to an external circuit (not shown), and the third embedded portion **213** is electrically connected to the circuit assembly C. To avoid shortcut, the first embedded portion **211**, the second embedded portion **212**, and the third embedded portion **213** are independent. The first embedded portion **211**, the second embedded portion **212**, and the third embedded portion **213** may have different shapes.

(33) The first embedded portion **211** may include a plurality of connection portions **2111** connected to the side walls **112** of the case **110**. The connection portions **2111** are disposed on the second side **1002**, the third side **1003**, and the fourth side **1004**. To strengthen the connection between the side walls **112** and the connection portions **2111**, the side walls **112** may include a plurality of protruding portions **1121** protruding from the side walls **112** (denoted in FIG. **7**). The protruding portions **1121** may immovably connected to the side walls **112** of the case **110** via soldering, welding, etc.

(34) The second embedded portion **212** may include a protruding pin **2121**. The protruding pin **2121** may be a ground pin. The protruding pin **2121** protrudes from the bottom surface of the bottom **120**. In some embodiments, the protruding pin **2121** is located on the corner of the bottom **120**. The protruding pin **2121** and the first pin **181** and the second pin **182** of the circuit element **180** may be connected to the same or different external circuits. The minimum distance between the protruding pin **2121** and the first pin **181** is different from the minimum distance between the first pin **181** and the second pin **182**. In some embodiments, the minimum distance between the protruding pin **2121** and the first pin **181** is greater than the minimum distance between the first pin **181** and the second pin **182**. In the present disclosure, the protruding pin **2121** is disposed on the bottom **120**, not the case **110** to simplify the manufacturing process and save the cost. For example, the electroplating process of the case **110** may be omitted or simplified.

(35) The third embedded portion **213** includes a first circuit **2131** and a second circuit **2132**. At least part of the first circuit **2131** and the second circuit **2132** are embedded and not revealed from the bottom **120**. The first elastic element **140** may be electrically connected to the circuit assembly C via the first circuit **2131**. The second elastic element **150** may be electrically connected to the circuit assembly C via the second circuit **2132**.

(36) Next, in addition to FIG. **2** and FIG. **3**, please also refer to FIG. **7** to FIG. **11** to know the strengthening assembly STR. FIG. **7** is a perspective view of the case **110**. FIG. **8** is a bottom view of the case **110**. FIG. **9** is a perspective view of the case **110**, the strengthening assembly STR, and

the magnetic elements **170**. FIG. **10** is a bottom view of the case **110**, the strengthening assembly STR, and the magnetic elements **170**. FIG. **11** is a cross-section view taken along the line A-A' in FIG. **9**. In FIG. **9** and FIG. **10**, the magnetic elements **170** are shown as dashed lines.

(37) The case **110** may further include two first protrusions **113** and two second protrusions **114**. The first protrusions **113** and the second protrusions **114** may have substantially the same structure. The first protrusions **113** are disposed on the first side **1001**. The second protrusions **114** are disposed on the third side **1003**. The first protrusions **113** and the second protrusions **114** are arranged along the first axis A1. The first protrusions **113** protrude toward the accommodation space formed between the case **110** and the bottom **120** from the top wall **111** of the case **110**. Therefore, the thickness of each of the first protrusions **113** is greater than the thickness of the top wall **111**. Similarly, the second protrusions **114** protrude toward the accommodation space formed between the case **110** and the bottom **120** from the top wall **111** of the case **110**. Therefore, the thickness of each of the second protrusions **114** is greater than the thickness of the top wall **111**. The magnetic elements **170** are disposed on the first protrusions **113** and the second protrusions **114**.

(38) The strengthening elements **220** are disposed between the case **110** and the magnetic elements **170**. Each strengthening element **220** includes a top plate **221** and a side plate **222**. The top plate **221** includes a plate structure that is perpendicular to the optical axis O, and the top plate **221** is located between the top wall **111** of the case **110** and the top surfaces of the magnetic elements **170**. The side plate **222** includes a plate structure that is parallel with the optical axis O, and the side plate **222** is located between the side walls **112** of the case **110** and the side surfaces of the magnetic elements **170**. The side plate **222** is substantially parallel with the side walls **112**.

(39) In some embodiments, in the first axis A1, the minimum distance D1 between the first protrusions **113** and the second protrusions **114** is greater than the maximum size D2 of the top plate **221**. In some embodiments, when viewed along the main axis MA, the top plate **221** is not in direct contact with the first protrusions **113**, so that the top plate **221** is spaced apart from the first protrusions **113** by a gap G1. In some embodiments, when viewed along the main axis MA, the top plate **221** is not in direct contact with the second protrusions **114**, so that the top plate **221** is spaced apart from the second protrusions **114** by a gap G2.

(40) In some embodiments, the minimum distance between the top plate **221** and the magnetic elements **170** is different from the minimum distance between the side plate **222** and the magnetic elements **170**. In some embodiments, the minimum distance between the top plate **221** and the magnetic elements **170** is greater than the minimum distance between the side plate **222** and the magnetic elements **170**. For example, in some embodiments, the top plate **221** is not in direct contact with the magnetic elements **170**, so that the top plate **221** is spaced apart from the magnetic elements **170** by a gap G3 (only denoted in FIG. **11**), and the side plate **222** is in direct contact with the magnetic elements **170**.

(41) In some embodiments, the minimum distance between the top plate **221** and the top wall **111** is different from the minimum distance between the side plate **222** and the side walls **112**. In some embodiments, the minimum distance between the top plate **221** and the top wall **111** is greater than the minimum distance between the side plate **222** and the side walls **112**. For example, in some embodiments, the top plate **221** is not in direct contact with the top wall **111**, so that the top plate **221** is spaced apart from the top wall **111** by a gap G4 (only denoted in FIG. **11**), and the side plate **222** is in direct contact with the side walls **112**. The side plate **222** may be fixed to the side walls **112** by adhesion, welding, etc.

(42) In some embodiments, the thickness of the top plate **221** is identical to the thickness of the side plate **222**. Therefore, after the strengthening elements **220** with uniform thickness are formed, the strengthening elements **220** may be folded to distinguish the top plate **221** and the side plate **222**. In some embodiments, the thickness of the top plate **221** is identical to the thickness of the top wall **111**. In some embodiments, the thickness of the side plate **22** is identical to the thickness of the

side walls **112**. In some embodiments, the thicknesses of the top wall **111**, the side walls **112**, the top plate **221**, and the side plate **222** are all between 0.15 mm to 0.60 mm.

(43) In some embodiments, the top wall **111**, the side walls **112**, the top plate **221**, and the side plate **222** include metal materials. In some embodiments, the magnetic permeability of the case **110** is less than the magnetic permeability of the strengthening elements **220**. In some embodiments, the magnetic permeability of the top wall **111** is less than the magnetic permeability of the top plate **221**. In some embodiments, the magnetic permeability of the side walls **112** is less than the magnetic permeability of the side plate **222**. In some embodiments, the magnetic permeability of the first elastic element **140** is less than the magnetic permeability of the side plate **222**.

(44) The magnetic attraction force may be generated between the strengthening elements **220** and the drive assembly D, which facilitates the connection and fixation of the drive assembly D, and thus the driving force of the drive assembly D is strengthened. Also, since the magnetic permeability of the strengthening elements **220** is greater than those of the case **110** and the first elastic element **140**, the strengthening elements **220** may reduce the magnetic interference outside the optical element drive mechanism **100**. The strengthening elements **220** may also concentrate the driving force generated by the drive assembly D, thereby further strengthening the driving force of the drive assembly D. In addition, each strengthening element **220** with a plate structure may cover at least part of each magnetic element **170** to protect the magnetic element **170**.

(45) In the followings, identical or similar elements are denoted by identical or similar elements. Next, please refer to FIG. **12** and FIG. **13**. FIG. **12** and FIG. **13** are perspective views of a case **110V** and a strengthening assembly STRV according to some other embodiments from different perspectives. In FIG. **12** and FIG. **13**, the features of the strengthening assembly STRV are different from the features of the strengthening assembly STR. In detail, the strengthening assembly STRV is not a plate structure, and the strengthening assembly STRV is disposed in the case **110V**.

(46) In some embodiments, the main material of the case **110V** is a metal material or a magnetic material. In some embodiments, the main material of the case **110V** is a plastic material. To strengthen the magnetic force between the case **110V** and the magnetic elements **170** (especially when the main material of the case **110V** is a plastic material), the strengthening assembly STRV may include a metal material. The strengthening assembly STRV includes a plurality of strengthening elements **220V**. The strengthening elements **220V** may have particle structures, such as metal particles, e.g. iron particles.

(47) The strengthening elements **220V** may be embedded in the case **110V**, including the top wall **111V** and/or the side walls **112V**. In some embodiments, the maximum size (e.g. the diameter) of each strengthening element **220V** is less than 0.10 mm, for example, less than 0.05 mm, but is not limited thereto. In some embodiments, the ratio of total volume of the strengthening elements **220V** to the volume of the case **110V** is between 1% and 50%. For example, the ratio of total volume of the strengthening elements **220V** in the side walls **112V** to the volume of the side walls **112V** is between 5% and 40%, such as 20%, but is not limited thereto. Since the magnetic attraction force may be generated between the strengthening elements **220V** and the drive assembly D, which facilitates the connection and fixation of the drive assembly D, and thus the driving force of the drive assembly D is strengthened.

(48) In some embodiments, the top wall **111V** and the side walls **112V** may have different thicknesses. In other words, the thickness of the top wall **111V** may be different from the thickness of the side walls **112V**. In some embodiments, the thickness of the top wall **111V** is less than the thickness of the side walls **112V**. In some embodiments, the thickness of the top wall **111V** may be between 0.10 mm and 0.55 mm, and the thickness of the side walls **112V** may be between 0.15 mm and 0.60 mm. Since the top wall **111V** is thinner than the side walls **112V**, the range of motion of the optical element **10** along the optical axis O toward the top wall **111V** is increased, and the focusing effects are enhanced, thereby enhancing the image quality and the image clearness.

(49) Since the strengthening elements **220V** may be dark-colored, the surface of the case **110V** may

also be dark-colored, such as black, dark blue, dark purple, etc. Therefore, when the light enters the case **110V**, the possibilities of generating reflected lights and stray lights are reduced, and thus the user experience is enhanced. It should be noted that, for some traditional techniques, if the case is designed to be dark-colored, then some other process for changing the color of the case is needed. Therefore, due to the strengthening elements **220V**, the manufacturing process is simplified and the cost is reduced.

(50) As described above, an optical element drive mechanism including the embedded assembly and the strengthening assembly is provided. At least part of the embedded assembly is embedded in the bottom. The embedded assembly may be electrically connected to other elements, distribute the external force, and generate magnetic attraction force with the drive assembly. Therefore, in addition to the electrical connection, the embedded assembly may also increase the strength of the bottom and the overall strength of the optical element drive mechanism. Also, the magnetic attraction force may be generated between the strengthening assembly and the drive assembly, which facilitates the connection and fixation of the drive assembly D, and thus the driving force of the drive assembly is strengthened. In addition, since the magnetic permeability of the strengthening assembly is relatively large, the strengthening assembly may reduce the magnetic interference outside the optical element drive mechanism **100** and may also concentrate the driving force generated by the drive assembly, thereby further strengthening the driving force of the drive assembly. Furthermore, the strengthening elements with plate structures may protect magnetic elements, and the strengthening elements with particle structures may make the case dark-colored to reduce the possibilities of generating reflected lights and stray lights. It should be noted that, the aforementioned embedded assembly, the strengthening elements with plate structures, and the strengthening elements with particle structures may be used separately or together.

(51) The foregoing outlines features of several embodiments so that those skilled in the art may better understand the aspects of this disclosure. Those skilled in the art should appreciate that they may readily use this disclosure as a basis for designing or modifying other processes and structures for carrying out the same purposes and/or achieving the same advantages of the embodiments introduced herein. Those skilled in the art should also realize that such equivalent constructions do not depart from the spirit and scope of this disclosure, and that they may make various changes, substitutions, and alterations herein without departing from the spirit and scope of this disclosure. In addition, the scope of this disclosure is not limited to the specific embodiments described in the specification, and each claim constitutes a separate embodiment, and the combination of various claims and embodiments are within the scope of the disclosure.

Claims

1. An optical element drive mechanism, comprising: an immovable part; a movable part connected to an optical element, wherein the movable part is movable relative to the immovable part; a drive assembly driving the movable part to move relative to the immovable part; and a strengthening assembly strengthening a driving force of the drive assembly, wherein the strengthening assembly is in contact with the drive assembly, wherein the immovable part comprises: a case; a bottom immovably connected to the case, wherein an accommodation space is formed between the case and the bottom to accommodate the movable part; and an embedded assembly connected to the case, wherein at least part of the embedded assembly is embedded and not revealed from the bottom, wherein the case comprises: a top wall with a plate structure and perpendicular to a main axis; a side wall with a plate structure; and a first protrusion protruding from the top wall toward the accommodation space, wherein a thickness of the first protrusion is greater than a thickness of the top wall, and the drive assembly is disposed on the first protrusion, wherein the bottom comprises a non-metal material, and the embedded assembly comprises a metal material, wherein the embedded assembly and the side wall comprise different materials, and the embedded assembly

is immovably connected to the side wall via soldering or welding, wherein the embedded assembly comprises a connection portion connected to the side wall, and wherein the side wall comprises a protruding portion protruding from the side wall.

2. The optical element drive mechanism as claimed in claim 1, wherein the strengthening assembly comprises a side plate with a plate structure and parallel with the side wall of the case, and the side plate is located between the drive assembly and the side wall, wherein: a thickness of the side wall is identical to a thickness of the side plate; the side wall and the side plate comprise a metal material; a magnetic permeability of the side wall is less than a magnetic permeability of the side plate.

3. The optical element drive mechanism as claimed in claim 2, wherein: the strengthening assembly comprises a top plate with a plate structure and parallel with the top wall of the case; a thickness of the top plate is identical to the thickness of the side plate; the thickness of the top plate is between 0.15 mm to 0.60 mm; the top wall and the top plate comprise a metal material; and a magnetic permeability of the top wall is less than a magnetic permeability of the top plate.

4. The optical element drive mechanism as claimed in claim 3, wherein the top plate is spaced apart from the top wall by a gap, and a minimum distance between the top plate and the top wall is different from a minimum distance between the side plate and the side wall.

5. The optical element drive mechanism as claimed in claim 4, wherein the minimum distance between the top plate and the top wall is greater than the minimum distance between the side plate and the side wall.

6. The optical element drive mechanism as claimed in claim 3, wherein: the drive assembly comprises a magnetic element disposed on the side wall; the top plate is spaced apart from the magnetic element by a gap; a minimum distance between the top plate and the magnetic element is different from a minimum distance between the side plate and the magnetic element.

7. The optical element drive mechanism as claimed in claim 6, wherein the minimum distance between the top plate and the magnetic element is greater than the minimum distance between the side plate and the magnetic element.

8. The optical element drive mechanism as claimed in claim 2, further comprising a first elastic element and a second elastic element, wherein the movable part is movably connected to the immovable part via the first elastic element and the second elastic element, wherein: the first elastic element has a plate structure and is perpendicular to the main axis; the first elastic element is connected to the bottom; the first elastic element has a metal material; a magnetic permeability of the first elastic element is less than the magnetic permeability of the side plate; the second elastic element has a plate structure and is perpendicular to the main axis; the second elastic element is connected to the bottom; the first elastic element is parallel with the second elastic element; the first elastic element is electrically connected to an external module; the first elastic element comprises an electrical contact electrically connected to the external module; when viewed along the main axis, the electrical contact is revealed from the top wall; the second elastic element is electrically connected to the drive assembly.

9. The optical element drive mechanism as claimed in claim 8, further comprising a circuit assembly electrically connected to the drive assembly, wherein: the embedded assembly further comprises a first circuit and a second circuit; at least part of the first circuit and the second circuit is embedded and not revealed from the bottom; the first elastic element is electrically connected to the circuit assembly via the first circuit; the second elastic element is electrically connected to the circuit assembly via the second circuit.

10. The optical element drive mechanism as claimed in claim 1, wherein the embedded assembly further comprises a protruding pin connected to an external circuit.

11. The optical element drive mechanism as claimed in claim 10, further comprising a circuit assembly and a sensing assembly, wherein the circuit assembly is electrically connected to the drive assembly, and the sensing assembly senses movement of the movable part relative to the

immovable part, wherein: the circuit assembly has a plate structure and is perpendicular to the main axis; the circuit assembly and the bottom are separate elements; the circuit assembly comprises a first pin and a second pin electrically connected to the external circuit; a minimum distance between the protruding pin and the first pin is different from a minimum distance between the first pin and the second pin; the sensing assembly comprises a sensing element disposed on the circuit assembly; the bottom comprises an opening structure receiving the circuit assembly, and the opening structure is a closed structure.

12. The optical element drive mechanism as claimed in claim 11, wherein the minimum distance between the protruding pin and the first pin is greater than the minimum distance between the first pin and the second pin.

13. The optical element drive mechanism as claimed in claim 1, wherein the side wall is dark-colored.

14. The optical element drive mechanism as claimed in claim 1, wherein the thickness of the top wall is different from a thickness of the side wall.

15. The optical element drive mechanism as claimed in claim 14, wherein the thickness of the top wall is less than the thickness of the side wall.

16. The optical element drive mechanism as claimed in claim 14, wherein the thickness of the top wall is between 0.10 mm and 0.55 mm, and the thickness of the side wall is between 0.15 mm and 0.60 mm.

17. The optical element drive mechanism as claimed in claim 1, wherein the side wall comprises a non-metal material, the strengthening assembly comprises a metal material, and the strengthening assembly is disposed in the side wall.

18. The optical element drive mechanism as claimed in claim 17, wherein the strengthening assembly comprises a plurality of particle-structured strengthening elements embedded in the side wall.

19. The optical element drive mechanism as claimed in claim 18, wherein a maximum size of each of the particle-structured strengthening elements is less than 0.05 mm, and a ratio of a total volume of the particle-structured strengthening elements to a volume of the side wall is between 5% and 40%.

20. The optical element drive mechanism as claimed in claim 1, wherein the case further comprises a second protrusion protruding from the top wall toward the accommodation space, and the drive assembly is disposed on the second protrusion, wherein the strengthening assembly comprises a top plate with a plate structure and parallel with the top wall of the case, and the top plate is located between the drive assembly and the top wall, wherein the first protrusion and the second protrusion are arranged along a first axis, and in the first axis, a minimum distance between the first protrusion and the second protrusion is greater than a maximum size of the top plate, wherein when viewed along the main axis, the top plate is spaced apart from the first protrusion by a gap, and wherein when viewed along the main axis, the top plate is spaced apart from the second protrusion by a gap.
