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(54) THIN-FILM READ ELEMENT

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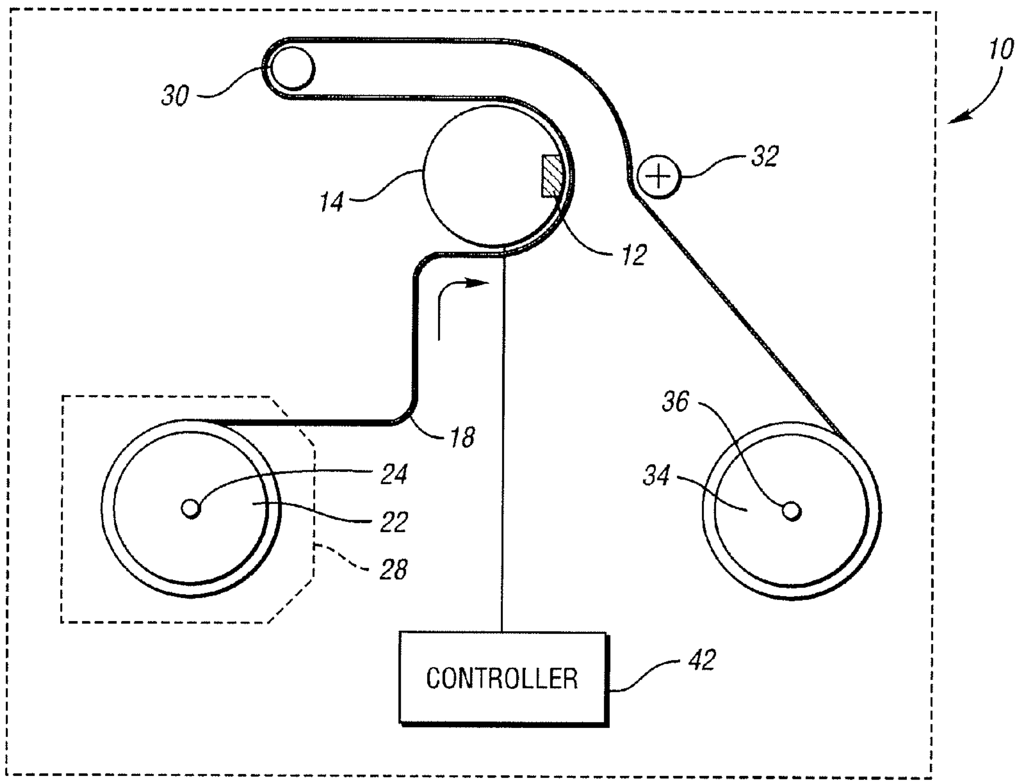
(57) ABSTRACT

The present invention relates to a thin-film read element for use in reading magnetic signals from a device. The read element includes a first thin-film read sensor and a second thin-film read sensor that are each configured to convert the magnetic signals of the device to electrical signals.



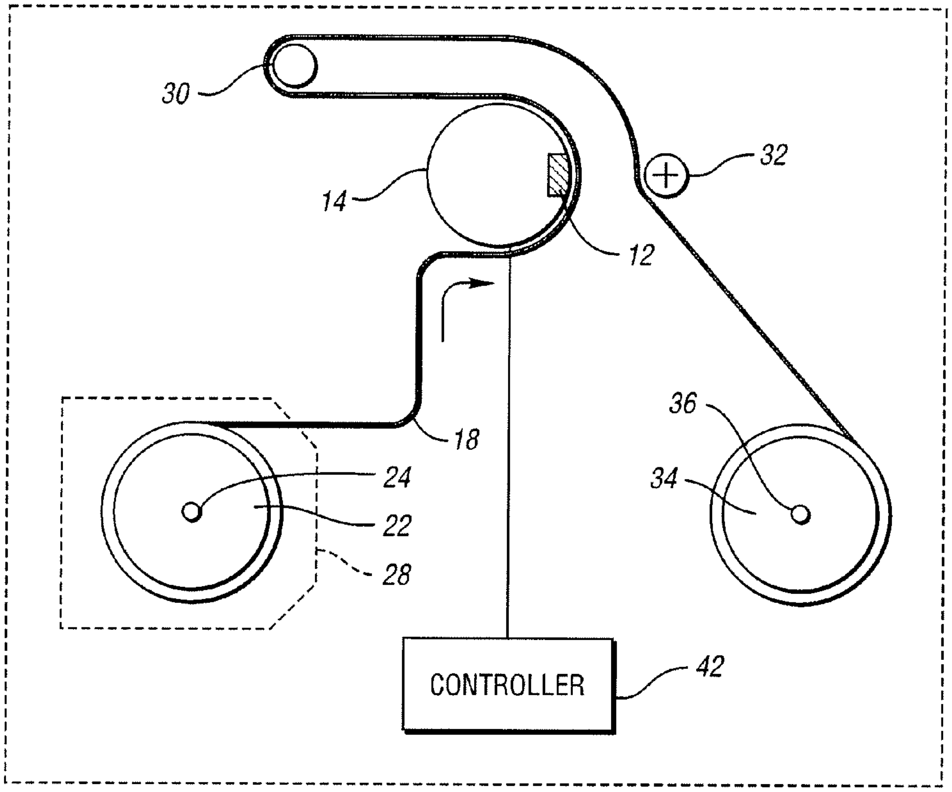

10
30
32
14
12
18
36
34
24
22
28
CONTROLLER
42

Fig. 1

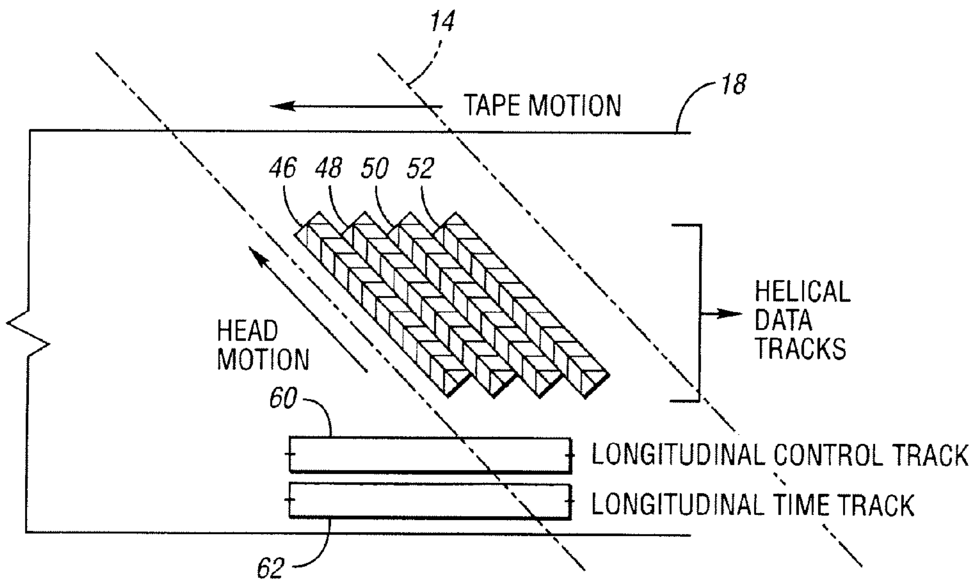

14
TAPE MOTION
18
46 48 50 52
HELICAL
DATA
TRACKS
HEAD
MOTION
60
LONGITUDINAL CONTROL TRACK
LONGITUDINAL TIME TRACK
62

Fig. 2

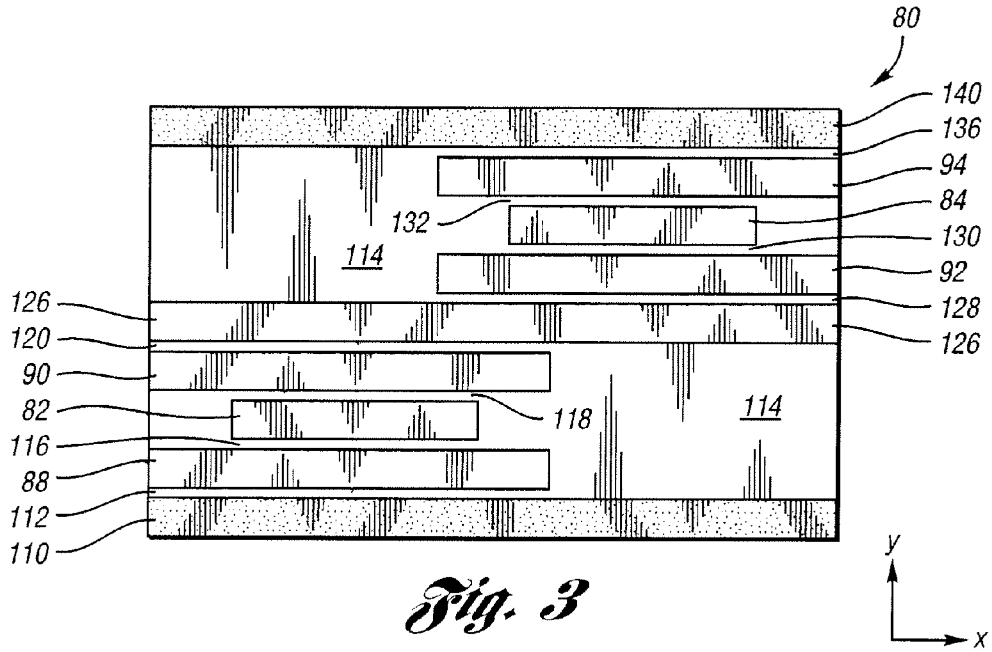

80
140
136
94
84
130
92
128
126
132
114
126
120
90
82
116
88
112
110
118
114
y
x

Fig. 3

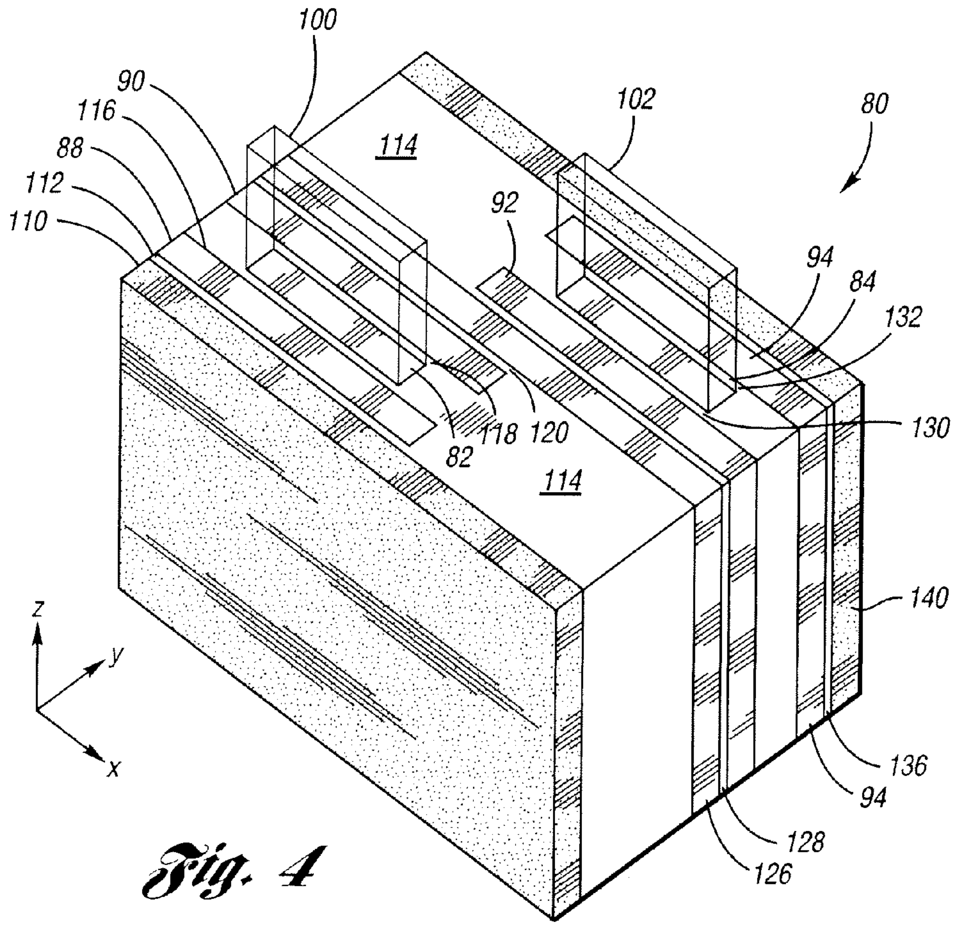

100
90
116
88
112
110
114
102
80
92
94
84
132
130
82
118
120
114
140
z
y
x
136
94
128
126

Fig. 4

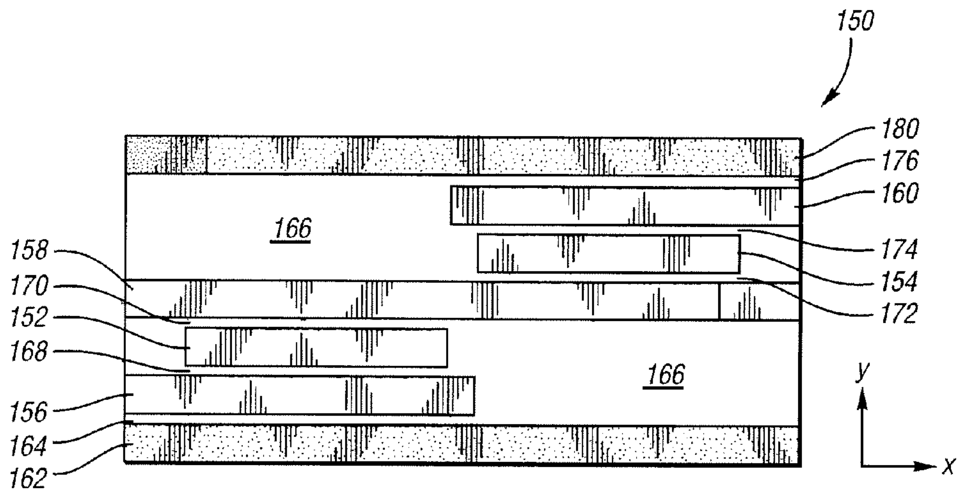

150
180
176
160
174
154
172
166
158
170
152
168
156
164
162
166
y
x

Fig. 5

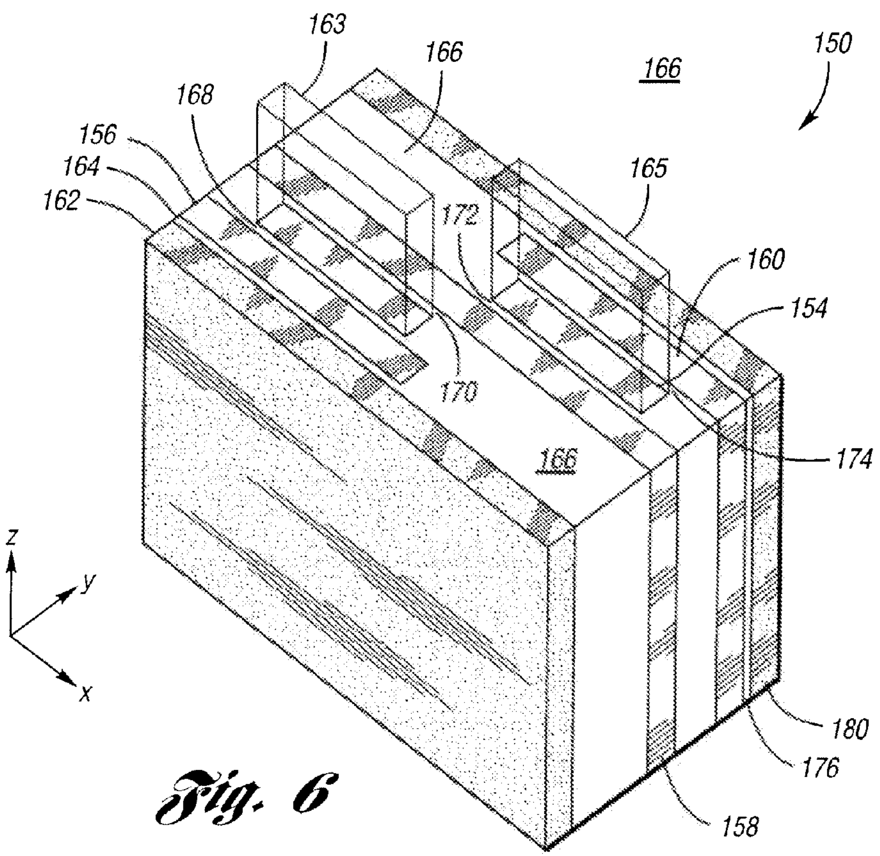

163
166
166
150
168
156
164
162
165
172
160
154
170
174
166
z
y
x
180
176
158

Fig. 6

THIN-FILM READ ELEMENT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a division of U.S. application Ser. No. 10/935,048 filed Sep. 7, 2004.

BACKGROUND OF THE INVENTION

[0002] 1. Field of the Invention

[0003] The present invention relates to thin-film read elements used to read magnetic information by converting magnetic signals to electrical signals.

[0004] 2. Background Art

[0005] In tape and disc recording systems, multiple read elements on multiple chips can be used to improve track locating and following. This necessitates precise control of the placement of the read elements in both X and Y coordinates relative to a written track. The larger the Y offset becomes, the more difficult it is to achieve the necessary X offset. This problem is made worse by the use of multiple chips because the positioning of the multiple chips is limited to the mechanical precision of the devices used to position the chips.

SUMMARY OF THE INVENTION

[0006] One aspect of the present invention relates to a thin-film read element for use in reading magnetic signals from a device. The read element includes a first thin-film read sensor and a second thin-film read sensor that are each configured to convert the magnetic signals of the device to electrical signals. The read sensors are preferably formed on a single chip structure to enhance alignment between the first read sensor and the second read sensor.

[0007] In one aspect of the present invention, the read element can include a shared shield between the first and second read sensor that defines at least a portion of a first window for the first read sensor and at least a portion of a second window of the second read sensor, whereby the read sensors receive the magnetic signals through the windows.

[0008] In one aspect of the present invention, the read element can include a first and second shield on opposite sides of the first read sensor and a third and fourth shield on opposite sides of the second read sensor. The first and second shields defining a portion of a first window of the first read sensor and the third and fourth shield defining a portion of a second window of the second read sensor, whereby the read sensors receive the magnetic signals through the windows. Preferably, a planarization layer is formed between the second shield and the third shield. The planarization layer providing a level surface for maximizing alignment positioning of the second read sensor relative to the first read sensor.

[0009] One aspect of the present invention relates to a method for manufacturing a thin-film read element for use in reading magnetic signals from a device. The method includes forming a first layer of ceramic material; forming a first portion of an insulating layer on the first layer; positioning a first shield on the first portion of the insulating layer; forming a second portion of the insulating layer on the first shield; positioning a first thin-film read sensor on the second portion of the insulating layer, the first read sensor converting the magnetic signals to electrical signals; forming a third portion of the insulating layer on the first thin-film read sensor; positioning a shared-shield on the third portion of the insulating layer; forming a fourth portion of the insulating layer on the shared-shield; positioning a second read sensor on the fourth portion of the insulating layer, the second read sensor converting the magnetic signals to electrical signals; forming a fifth portion of the insulating layer on the second read sensor; positioning a second shield on the fifth portion of the insulating layer; forming a sixth portion of the insulating layer on the second shield; and forming a second layer of ceramic material on the sixth portion of the insulating layer.

[0010] It is an advantage of the present invention that an accumulation of tolerances during read element fabrication is reduced by eliminating an alumina spacer layer between the multiple read sensors.

[0011] It is an advantage of the present invention that the total number of process steps in read element fabrication is reduced by limiting a number of planarization steps between read sensor placements.

[0012] It is an advantage of the present invention that separation between read elements is reduced.

[0013] It is an advantage of the present invention that the number of shield deposition and process steps are reduced.

[0014] It is an advantage of the present invention that a number of chemical mechanical polished (CMP) steps are reduced.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. **1** illustrates a diagram of a helical scan tape drive having a read element on a tape head in accordance with one aspect of the present invention;

[0016] FIG. **2** illustrates a diagram of a data recording format of the tape in accordance with one aspect of the present invention;

[0017] FIG. **3** illustrates a top-view diagram of a separate-shield read element in accordance with one aspect of the present invention;

[0018] FIG. **4** illustrates a perspective view diagram of the separate-shield read element in accordance with one aspect of the present invention;

[0019] FIG. **5** illustrates a top-view diagram of a shared-shield read element in accordance with one aspect of the present invention;

[0020] FIG. **6** illustrates a perspective view diagram of the shared-shield read element in accordance with one aspect of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

[0021] FIG. **1** illustrates a diagram of a helical scan tape drive **10** having a read element **12** on a tape head **14** in accordance with one aspect of the present invention. The read element **12** includes features for reading data bits from a magnetic tape **18**. The tape **18** is wound on a reel **22** that rotates around a spindle **24** within a magnetic tape cartridge

28. The tape **18** proceeds around the tape head **14**, around a guide **30**, over a capstan **32**, and is wound on a reel **34** that rotates around spindle **36**. A controller **42** controls operation of the drive **10**, including positioning of the tape head **14** and movement of the tape **18**.

[0022] FIG. **1** illustrates one exemplary application of the read element **12** as it generally applies to tape drives and tape drive systems. As will be apparent from the description provided below, the read element **12** of present invention is suitable for use in other environments and in other applications beyond tape drives. In particular, the present invention contemplates that the read element **12** may be included in a disc drive for reading data from a magnetic disc.

[0023] FIG. **2** is a diagram of a helical data recording format of the tape **18** in accordance with one aspect of the present invention. The tape head **14** is shown in phantom to illustrate its position relative to the tape **18** as it selectively rotates at an azimuth angle relative to the tape to control the exposure of the read element to the tape **18** as the tape **18** is feed past the tape head **14**. The azimuth angle of the tape head **14** preferably matches an azimuth angle of pairs of data tracks **46-52**, such as with an azimuth angle of +–20°.

[0024] The magnetic tape **18** also preferably includes a longitudinal servo control track **60** and longitudinal time code track **62**. Servo control track **60** is recorded as the helical tracks are written onto the magnetic tape. One use of the servo control track is to synchronize the rotation of the tape head **14** with the position of the helical tracks **46-52** on the magnetic tape **18** during playback. The time code track **62** contains location information that uniquely identifies groups of helical tracks.

[0025] FIGS. **3** and **4** illustrate a diagram of a separate-shield read element **80** in accordance with one aspect of the present invention. The read element **80** includes a first read sensor **82** and a second read sensor **84**. The read sensors **82-84** are preferably thin-filmed elements, such as a Magnetoresistive transducer of 1-10 microns (μ) that uses Anisotropic Magnetoresistance (AMR), Giant Magnetoresistance (GMR), or Tunneling Magnetoresistance (TMR) to convert magnetic information on the tape or disc to electrical signals. Of course, the present invention is not limited to these materials and contemplates the use of other materials that produce or provide the same or similar functions for reading data from a tape or disc.

[0026] A first shield **88**, a second shield **90**, a third shield **92**, and a fourth shield **94** are positioned relative to the first read sensor **82** and the second read sensor **84** to define a first window **100** for the first read sensor **82** and a second window **102** for the second read sensor **84** through which the read sensors **82-84** receive magnetic signals from the tape **18** for reading the data bits stored thereon. The shields **88-94** are layers of magnetic material having high magnetic permeability so that undesired magnetic fluxes, such as from adjacent data elements, mainly flow to the shields **88-94** and not to the read sensors **82-84**. This is advantageous to enhancing the precision of the window **100-102** for each read sensor whereby the precisely defined window permits the data bits on the tape or disc to be positioned closely to each other to maximize data density.

[0027] The read element **80** preferably comprises a number layers built upon each other to form a single chip structure that includes both the first read sensor **80** and the second read sensor **82**. To build such a unitary structure, a first layer **110**, or substrate layer, is initially created by pouring a ceramic or other material into a mold or other shape defining element. A first portion **112** of an insulating layer **114** is applied thereto, such as by vacuum deposition, for example by sputtering, of aluminum oxide or other insulating material, to electrically isolate the first layer **110**. The first shield **88** is then applied and covered by a second application of the insulating material to form a second portion **116** of the insulating layer for covering the first shield **88**. The first read sensor **82** is then applied and covered by a third application of the insulating material to form a third portion **118** of the insulating layer for covering the first read sensor **82**. Preferably, the third application of the insulating material encapsulates electrical leads or wires that connect to the first read sensor. A fourth application of the insulating material is applied to the second shield **90** to form a fourth portion **120** of the insulating layer **114**. A planarization layer **126** is applied to the fourth portion of the insulating layer **114**. The planarization layer **126** is an aluminum oxide used to provide a flat, level surface upon which additional layers of the read element **80** are formed. The use of the planarization layer **126** in this manner is advantageous to enhance the precision at which the first and second read sensors **80-82** are positioned with respect to each other. A fifth portion **128** of the insulating layer **114** is applied to the planarization layer **126** to electrically isolate the planarization layer **126** and the third shield **92** is applied thereto and covered by a sixth application of the insulating material to form a sixth portion **130** of the insulating layer **114** for covering the third shield **92**. The second read sensor **82** is then applied and covered by a seventh application of the insulating material to form a seventh portion **132** of the insulating layer for covering the second read sensor **82**. An eight application of the insulating material is applied to the fourth shield **94** to form an eighth portion **136** of the second insulating layer upon which is applied a second layer **140**, or closure. The construction of the read element **80** in this manner permits each layer to built upon a preceding layer on a singular chip structure, thereby maximizing the precision at which the first read sensor **80** is positioned relative to the second read sensor **82**.

[0028] The second read sensor **82** is offset in an X and Y direction relative to the first read sensor **80** so that the first window and the second window cover different areas of the tape **18**. By covering the different areas, the tape head **14** can be positioned by the controller **42** so that either one of the first read sensor **80** or the second read sensor **82** is aligned with the data tracks **46-52** on the tape **18**. Should the tape alignment change, the controller **42** can move the tape head **14** depending on which of the first read sensor **80** or the second read sensor **82** is closer to being properly aligned with the moved tape **18**, thereby reducing an amount of travel of the tape head **14**.

[0029] FIGS. **5** and **6** illustrate a diagram of a shared-shield read element in accordance with one aspect of the present invention. The read element **150** includes a first read sensor **152** and a second read sensor **154**. The read sensors **152-154** are preferably thin-filmed elements, such as a Magnetoresistive transducer of 1-10 microns (μ) that uses Anisotropic Magnetoresistance (AMR), Giant Magnetoresistance (GMR), or Tunneling Magnetoresistance (TMR) to convert magnetic information on the tape or disc to electrical signals. Of course, the present invention is not limited to these materials and contemplates the use of other material that produce or provide the same or similar functions for reading data from a tape or disc.

[0030] A first shield **156**, a shared-shield **158**, and a second shield **160** are positioned relative to the first read sensor **152** and the second read sensor **154** to define a first window **163** for the first read sensor **152** and a second window **165** for the second read sensor **154** through which the read sensors **152-154** receive magnetic signals from the tape **18** for reading the data bits stored thereon. The shields **156-160** are layers of magnetic material having high magnetic permeability so that undesired magnetic fluxes, such as from adjacent data elements, mainly flow to the shields **156-160** and not to the read sensors **152-154**. This is advantageous to enhancing the precision of the window **164-166** for each read sensor **152-154** whereby the precisely defined window permits the data bits on the tape or disc to be positioned closely to each other to maximize data density.

[0031] The read element **150** preferably comprises a number layers built upon each other to form a single chip structure that includes both the first read sensor **152** and the second read sensor **154**. To built such a unitary structure, a first layer **162**, or substrate layer, is initially created by pouring a ceramic or other material into a mold or other shape defining element. A first portion **164** of an insulating layer **166** is applied thereto, such as by vacuum deposition, for example by sputtering, of aluminum oxide or other insulating material, to electrically isolate the first layer, commonly referred to as an alumina spacer. The first shield **156** is then applied and covered by a second application of the insulating material to form a second portion **168** of the insulating layer **166** for covering the first shield **156**. The first read sensor **152** is then applied and covered by a third application of the insulating material to form a third portion **170** of the insulating layer **166** for covering the first read sensor **152**. Preferably, the third application of the insulating material encapsulates electrical leads or wires that connect to the first read sensor **152**. A fourth application of the insulating material is applied to the shared-shield **158** to form a fourth portion **172** of the insulating layer **166**. The second read sensor **154** is then applied and covered by a fifth application of the insulating material to form a fifth portion **174** of the insulating layer **166**. The second shield **160** is then applied and covered with a sixth application of the insulating material to form a sixth portion **176** of the insulating layer **166**. A second layer **180**, or closure, of ceramic material is positioned on the portion **176** to define a length of the read element **150**. The construction of the read element in this manner permits each layer to built upon a preceding layer on a singular chip structure, thereby maximizing the precision at which the first read sensor is positioned relative to the second read sensor.

[0032] The second read sensor **154** is offset in an X and Y direction relative to the first read sensor **152** so that the first window **163** and the second window cover **165** different areas of the tape **18**. By covering the different areas, the tape head **14** can be positioned by the controller so that either one of the first read sensor **152** or the second read sensor **154** is aligned with the data tracks **46-52** on the tape **18**. Should the tape alignment change, the controller **42** can move the tape head **14** depending on which of the first read sensor **152** or the second read sensor **154** is closer to being properly aligned with the moved tape, thereby reducing an amount of travel of the tape head.

[0033] The shared-shield **158** eliminates the second shield **90**, the planarization layer **126**, and the third shield **92** of the separate shield element **80** shown in FIGS. **3** and **4**. This reduces a length of the read element in the Y direction, reduces an accumulating of tolerances during head fabrication by eliminating a need for additional layers between the first and second read sensors **152-154**, reduces a total number of process steps in head fabrication by eliminating a planarization step, reduces a number of shield deposition and process steps, and reduces a number of chemical mechanized polished (CMP) steps.

[0034] While embodiments of the invention have been illustrated and described, it is not intended that these embodiments illustrate and describe all possible forms of the invention. Rather, the words used in the specification are words of description rather than limitation, and it is understood that various changes may be made without departing from the spirit and scope of the invention.

What is claimed is:

1. A thin-film read element for use in reading magnetic signals from a device, the read element comprising:

a first thin-film read sensor and a second thin-film read sensor, each read sensor converting the magnetic signals to electrical signals;

a shared shield between the first and second read sensor, the shared shield defining at least a portion of a first window for the first read sensor and at least a portion of a second window of the second read sensor, the read sensors receiving the magnetic signals through the windows.

2. The read element of claim 1 wherein the second read sensor is offset from the first read sensor.

3. The read element of claim 2 wherein the second read sensor is offset in a X direction relative to the first read sensor.

4. The read element of claim 2 wherein the second read sensor is offset in a Y direction relative to the first read sensor.

5. The read element of claim 2 wherein the second read sensor is offset in a X and Y direction relative to the first read sensor.

6. The read element of claim 1 wherein the read sensors are formed on a single chip structure.

7. The read element of claim 6 wherein the single chip structure includes a first shield proximate the first read sensor and a second shield proximate the second read sensor, the first and second shield cooperating with the shared-shield to further define at least a portion of the first and second windows.

8. The read element of claim 7 wherein the single chip structure includes an insulator deposited between each of the shields and the read sensors for electrical isolation.

9. The read element of claim 8 wherein the single chip structure includes a first ceramic layer and a second ceramic layer at opposite ends of the chip structure to define a length of the structure.

10. A thin-film read element for use in reading magnetic signals from a device, the read element comprising:

a first thin-film read sensor and a second thin-film read sensor, each read sensor converting the magnetic signal to electrical signals; and

wherein the read sensors are formed on a single chip structure.

11. The read element of claim 10 wherein the single chip structure includes a first shield proximate the first read sensor and a second shield proximate the second read sensor and a shared-shield between the first read sensor and the second read sensor, the first and second shield cooperating with the shared-shield to define at least a portion of a first window for the first read sensor and at least a portion of a second window of the second read sensor, the read sensors receiving the magnetic signals through the windows.

12. The read element of claim 11 wherein the single chip structure includes an insulator deposited between each of the shields and the read sensors for electrical isolation.

13. The read element of claim 12 wherein the single chip structure includes a first ceramic layer and a second ceramic layer at opposite ends of the chip structure to define a length of the structure.

14. A method for manufacturing a thin-film read element for use in reading magnetic signals from a device, the read element comprising:

forming a first layer of ceramic material;

forming a first portion of an insulating layer on the first layer;

positioning a first shield on the first portion of the insulating layer;

forming a second portion of the insulating layer on the first shield;

positioning a first thin-film read sensor on the second portion of the insulating layer, the first read sensor converting the magnetic signals to electrical signals;

forming a third portion of the insulating layer on the first thin-film read sensor;

positioning a shared-shield on the third portion of the insulating layer;

forming a fourth portion of the insulating layer on the shared-shield;

positioning a second read sensor on the fourth portion of the insulating layer, the second read sensor converting the magnetic signals to electrical signals;

forming a fifth portion of the insulating layer on the second read sensor;

positioning a second shield on the fifth portion of the insulating layer;

forming a sixth portion of the insulating layer on the second shield; and

forming a second layer of ceramic material on the sixth portion of the insulating layer.

* * * * *