United States Patent

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[54] SEMICONDUCTIVE MAGNETIC TRANSDUCER

11 Claims, 9 Drawing Figs.

[52] **U.S. Cl.** **317/235,** 307/309, 307/303
[51] **Int. Cl.** **H01l 11/00**
[50] **Field of Search** 317/235, 23, 235/27; 307/309, 275; 179/100.2

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ABSTRACT: A region for injection of minority carriers is provided at one end of an extended semiconductive channel which is contiguous along one side with a collector region, and an electric field is provided in the channel such that a magnetic field applied substantially perpendicular to the channel preferentially deflects minority carriers to or from the collector.

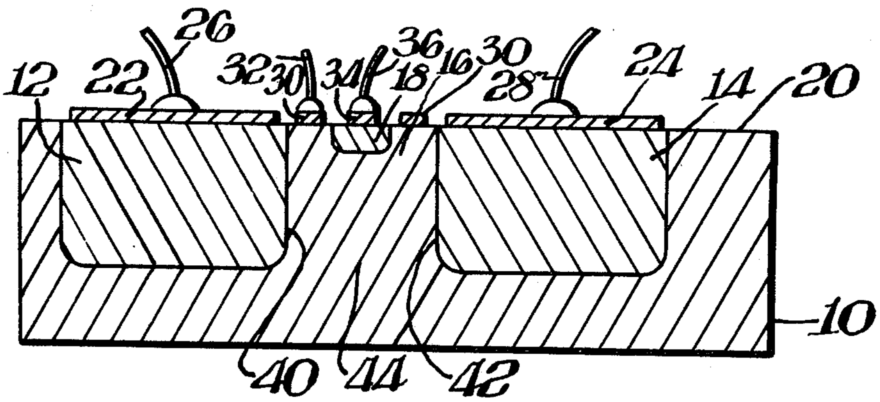


Fig.1.

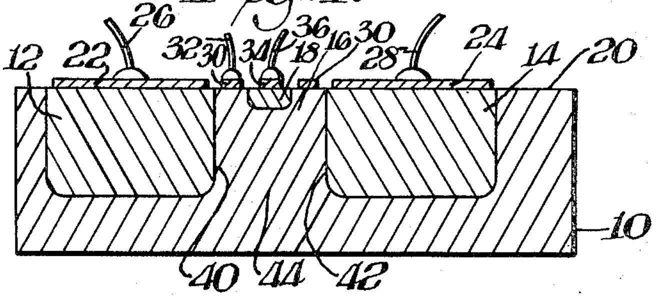


Fig.5.

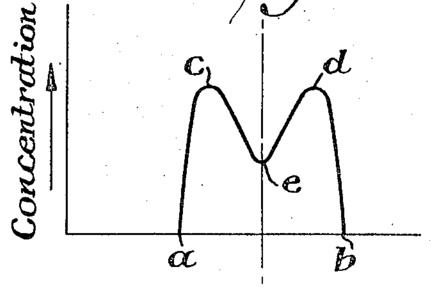


Fig.2.

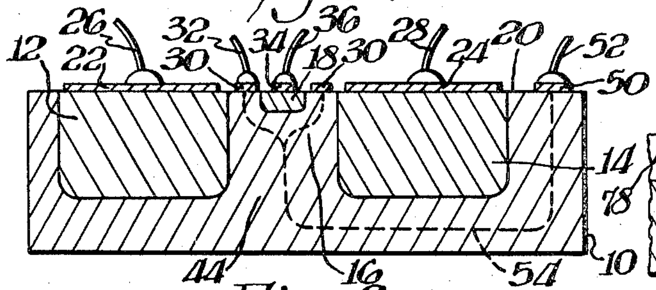


Fig. 4.

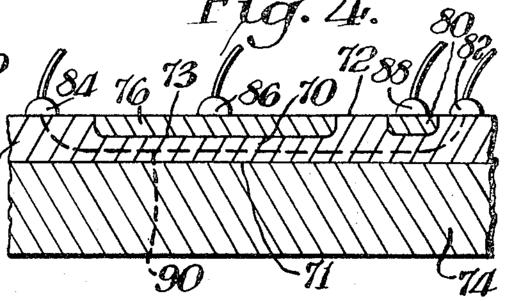


Fig.3.

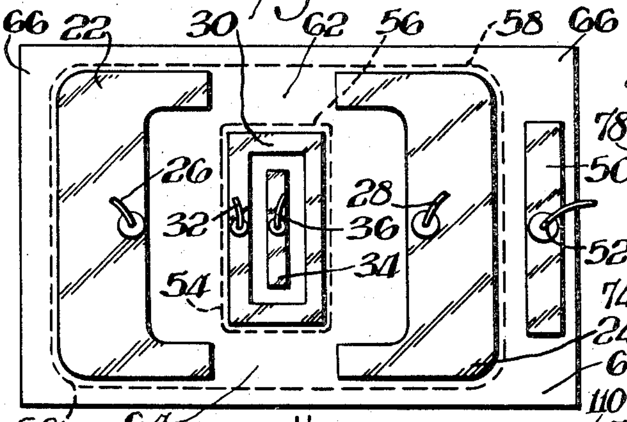


Fig.6.

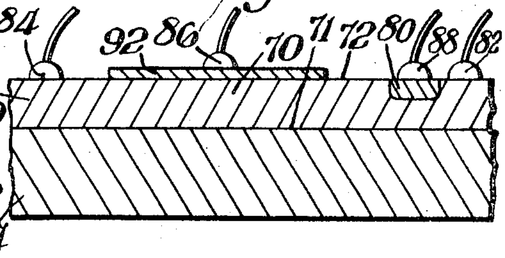


Fig.7.

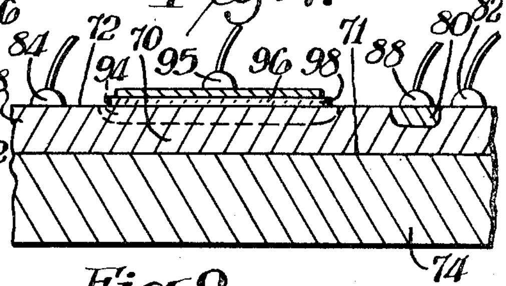


Fig.8.

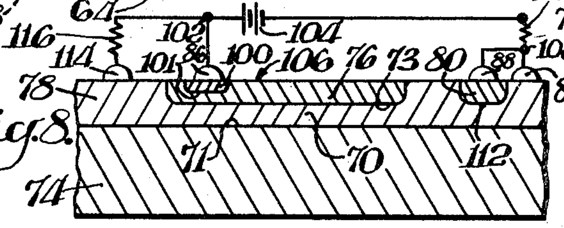
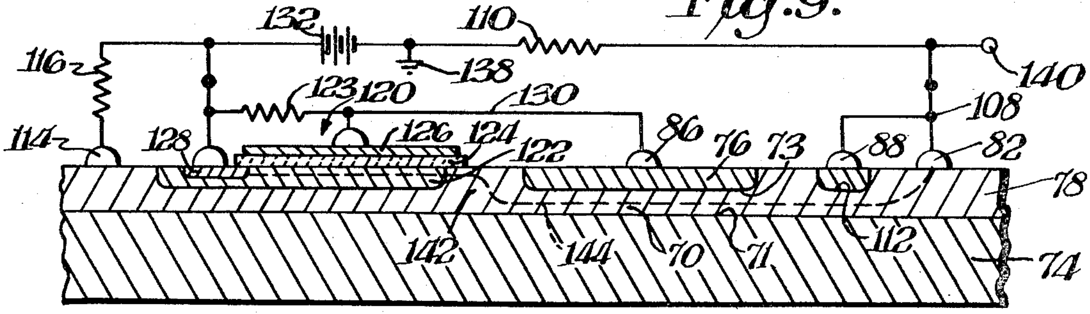


Fig.9.



SEMICONDUCTIVE MAGNETIC TRANSDUCER

BACKGROUND OF THE INVENTION

This invention relates to magnetic transducers and more particularly to a semiconductive magnetic transducer having an elongated semiconductive channel.

Magnetic transducers which are perhaps best known for their application in tape recorders, find many applications in modern electronics, including switching applications and the like. In the prior art, semiconductive magnetic transducers, which utilize magnetic deflection of minority carriers of a baselike semiconducting region to point contact collectors or to an underlying pair of collector regions, is available. However, devices of this type are generally low in sensitivity and limited in their application.

It is an object of this invention to provide a highly sensitive semiconductive magnetic transducer.

It is another object of this invention to provide a magnetic transducer having an elongated channel contiguous along one side with a collector region.

It is still another object of this invention to provide a magnetic transducer having an electric field disposed in an elongated semiconductive channel so as to enhance the flow of minority carriers along the channel.

It is a further object of this invention to provide a semiconductive magnetic transducer in combination with semiconductive regions which provide amplifying characteristics.

It is a still further object of this invention to provide a semiconductive magnetic transducer which also provides unipolar and bipolar characteristics.

SUMMARY OF THE INVENTION

Broadly, a semiconductive magnetic transducer provided in accordance with the invention comprises an elongated semiconductive channel bounded on one side by a collector region of minority carriers, means disposed at one end of said channel for injection of minority carriers therein, and said channel having an electric field therein of such polarity as to direct the minority carrier flow along the axis of said channel such that a magnetic field applied across the channel will deflect said drifting minority carriers and control their collection in said collector region.

Broadly, a magnetic transducer-amplifier provided in accordance with the invention comprises a body of semiconductor material, a semiconductive channel in said body, at least one collector region of said body adjoining said channel, means for injecting minority carriers in said channel, an amplifying unit disposed in said body with its input coupled to said collector such that the output of said amplifying device is proportional to the minority carrier flow to said collector.

In a more limited sense, the transducer-amplifier includes a feedback within said body from said amplifying device such that minority carrier flow is increased. This is accomplished in one embodiment by making said collector also operate as source of majority carriers of said channel which thereby increases the minority carrier injection and flow of said channel.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a view in section of a semiconductive magnetic transducer provided in accordance with the invention;

FIG. 2 is a view in section of another embodiment of the invention wherein an electric field of the channel is provided by externally charged contacts at opposing ends of the channel;

FIG. 3 is a plan view of the semiconducting structure of FIG. 2;

FIG. 4 is a view in section of another embodiment which provides a semiconductive channel parallel to the wafer surface;

FIG. 5 is a graph of the lateral impurity distribution in the channel of the structure of FIG. 4;

FIG. 6 is a view in section of still another embodiment of the invention wherein a collector of the device is provided by a Schottky barrier contact;

FIG. 7 shows a further embodiment of the invention wherein a collector of the device is provided by an inversion layer region;

FIG. 8 is a view in section of a transducer-amplifier provided in accordance with the invention; and

FIG. 9 is a view in section of a further embodiment wherein a transducer and an MOS amplifier are integrally combined.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In order to provide a clear and concise description of the invention, a brief analysis of the magnetic deflection of minority carriers travelling in a semiconductive channel is first presented.

In the preferred embodiments, the novel transducer utilizes an extended semiconductive channel having a pair of collectors of minority carriers which border on the sides of the channel, and an emitter, or other means for injection of minority carriers is disposed at one end of the channel such that minority carriers injected into the channel may be preferentially deflected towards or away from the collectors by a magnetic field.

In such a case, the force acting on the charge q moving at velocity v in a magnetic flux density B which is orthogonal to v is:

$$F_H = vB\ 10^{18}$$

where the force F_H expressed in terms of an equivalent electric field as V/cm., v is in cm./sec. and B is in gauss.

The lateral (i.e., orthogonal to v and B) displacement in the time t is:

$$\delta = \mu F_H t = \mu L' B\ 10^{18}$$

where $L' = vt$ is the distance travelled along the channel in the time t, and if a channel having a length $L > L'$ and a width W between collectors is assumed, we have a transducer efficiency of

$$\delta / w = \mu B\ 10^{18}\ L'/W .$$

For instance, if $\mu = 10^3$ cm.^{2}/volt sec., $B = 10^2$ gauss, $L' = 10^{14}$ cm and $W = 10^{-3}$ cm, then $\delta / W = 10^{-4}$, and consequently, $\Delta I_c = 10^{-4}\ I_E$, assuming that the entire emitter current I_E is injected into the channel, and ΔI_c is the change in the collector current caused by the magnetic flux.

Of course L', the distance travelled along the channel bounded by two collectors, can be limited by the bulk lifetime τ, but for narrow channels bounded by two collectors it is more likely that it will be limited by lateral Brownian motion whereby minority carriers are sucked up by the collector space charge regions. Now since the transit time t_T from the center of the channel to one of its boundaries by Brownian motion is:

$$T_T = (W/2)^2 / 2D ,$$

where D is the diffusion constant of the minority carriers which is related to their mobility by Einstein's law $D = \mu kT/q$ when k is the Boltzmann constant and T the absolute temperature, if there is no electric field along the channel the effective length L' in the region between the collectors is:

$$L' \cong (2D\tau)^{1/2} \text{ or } (2Dt_T)\ 1/2 ,$$

whichever is smaller. Thus, L' cannot be larger than about $W/2$. However, by providing an electric field F along the channel, the distance travelled becomes

$$L' \cong \mu F \tau \text{or } L' \cong \mu F t_T = F(W/2)^2 / 2(kT/q) ,$$

whichever is smaller.

Thus, using an electric field along the channel, the ratio $L'/W/2$ can be made larger than unity with corresponding increase in the sensitivity of the device. For instance, consider the case of an exponential acceptor distribution in a p-type channel:

$$C = C_o\ exp(-x/x_o)$$

where C_o is the concentration at the end of the channel where minority carriers (electrons) are injected, and x is the distance along the channel from this injection point.

Then the built-in field is:

$$F=kT/q\,x_o.$$

If the value of L' is limited by lateral diffusion of electrons to one of the channel boundaries, rather than by bulk recombination, one obtains by substitution of F into one of the previous equations:

$$L'=(W/2)^2/2\,x_o.$$

Therefore, the ratio L'/W, which enters the transducer efficiency as outlined previously, becomes:

$$L'/WW/8\,x_o.$$

In order to maximize this expression, it would appear desirable to choose x_o as small as possible, i.e., to select a steep impurity gradient, However, the impurity gradient has to extend along the entire channel length L, and the concentration, C_L, at $x=L$ has to be still sufficiently large to provide a significant doping of the semiconductor, and since:

$$x_o=L/Ln(C_o/C_L)$$

one has,

$$L'/(W/2)=\sqrt{Ln(C_o/C_L)/2}$$

For

$C_o=10^{19}$ cm.$^{-3}$, $C_L=10^{14}$ cm.$^{-3}\sqrt{Ln(C_o/C_L)/2}$ becomes equal to 2.4, i.e., the channel length should be chosen at least 2.4 times the half-width of the channel.

Using the above equations, we may also express the optimized x_o in terms of the channel width W as follows:

$$x_o=\frac{(W/2)}{\sqrt{2L_n(C_o/C_L)}}$$

The denominator is 4.8 for the numerical example chosen. Thus for a channel width of $W=10^{13}$ cm. and a dopant concentration at the ends of the channel as indicated above, one should select $x_o\cong 10^{14}$ cm. and a channel length L of at least 1.2×10^1cm., and for silicon at room temperatures the electron lifetime τ in the p-type channel should be at least $(W/2)^2/2D\cong 5<\frac{2}{3}{}_{10}^{15}$ sec.

In FIG. **1**, a semiconductor body **10** of P-type silicon or the like is provided with a pair of spaced apart N-type collector regions **12** and **14** which form a channel region **16** of the P-type body interposed between them. An injector region **18**, in this case an N-type emitter region, is provided at one end of channel **16** where it extends to the wafer surface **20** as shown. Conductive contacts **22** and **24** with appropriate leads **26**, **28** provide low resistance or ohmic contact to collectors **12** and **14** respectively. Contact **30** and lead **32** connect to the injection end of channel **16**, and contact **34** and lead **36** connect to injector region **18**.

For an understanding of the invention, consider that channel **16** has a width W as measured between opposed collector faces **40** and **42** and a length L, as measured from surface **20** to a point **44** near the bottom of regions **12** and **14**. Then, minority carriers injected from region **18** flow along channel **16** to regions **12**, **14**, or recombine with majority carriers either in channel **16** or in the semiconductive body beyond the channel.

If a magnetic flux B (not shown) is directed into the paper, that is, a magnetic field is applied substantially perpendicular to the longitudinal axis of the channel and parallel to the interface **40** and **42**, the minority carriers will be deflected away from one collector region and towards the other depending upon the polarity of the applied magnetic field.

In the preferred embodiments, the channel is elongated to increase its length, and the drift velocity v is increased by an electric field provided in the channel by either a suitable impurity profile or an externally applied electric bias. The elongated channel is provided in the structure of FIG. **1** between deep diffused pockets **12** and **14** which extend to the wafer surface, and a longitudinal channel field is built in to this structure by providing an impurity distribution in channel **16** having large impurity concentration at wafer surface **20** which gradually diminishes to a low concentration at the channel end **44**. Consequently, electrons injected at the end of high impurity concentration (adjacent to region **18**) are driven by this field towards the low concentration at end **44** such that drift velocity v is increased.

The structure of FIG. **1** may be made by conventional means, as for example, by first doping a silicon wafer **10** with acceptor impurities such as boron or the like. For instance, boron may be diffused into surface **20** from an ambient vapor phase to provide P-type conduction having a high concentration at this surface and a gradually diminishing concentration in the direction of the base of the wafer. Thereafter, spaced apart N-type regions **12**, **14** and an N-type injector region **18** are formed in wafer **10** by conventional techniques, for example, by diffusion of donor impurities such as phosphorus or the like through mask openings into spaced apart portions of surface **20**. Low resistance contact films of aluminum or the like, may then be deposited by conventional means on appropriate surface portions, and finally, leads are then provided by any of the bonding techniques commonly employed in the semiconductor arts.

Since regions **12** and **14** are deep regions while region **18** is comparatively shallow, the former would generally be diffused into wafer **10** before the formation of region **18**. Of course, the diffusant chosen for region **18** could also be slow moving as compared to that of regions **12** and **14**.

A preferred channel length of at least 2.4 times the half-width of the channel is provided in this embodiment by spacing of regions **12** and **14** in accordance with the diffusion constant of the impurities used. In addition, the values of X_o and the dopant concentrations at the ends of the channel are made to conform to those indicated in the preceding theoretical discussion.

As previously indicated, there are inherent restrictions in providing a large built-in longitudinal field over a long channel, however, these restrictions can be overcome by generating an electric field from an external power source in connection to contacts located at opposite ends of the channel.

In the case of an externally applied channel field, the length L' is restricted by the saturation drift velocity of minority carriers which is approached with increasing field F. In the case of silicon, this saturation velocity is $v_s=10^7$ cm./sec. Thus

$$L'=v_s t_T=v_s(W/2)^2/2D \text{ or}$$
$$L'/(W/2)=vW/4D\,.$$

Where $W=4\times 10^{14}$ cm.. $^4D=10^2$ cm.^{2}/sec. and $v_s=10^7$ cm./sec., one obtains $L'/(W/2)=40$, and $L'=8\times 10^{13}$ cm.

In this estimate, we have used the diffusion constant for holes at low field conditions which strictly does not apply to the "hot" electrons flowing at the saturation drift velocity. Nevertheless, the error thereby introduced is minor and does not detract from the fact that large channel length/width ratios can be employed with externally applied fields.

An externally applied field is provided in the structure of FIGS. **2** and **3** by means of an additional contact **50** and lead **52** which connect to wafer **10** to permit application of an electric bias to channel **16** from an external source (not shown). In these FIGS. parts identical to those of FIG. **1** are identified by corresponding reference numerals.

Preferably, the unit of FIGS. **2** and **3** are constructed in a manner similar to that of FIG. **1** to provide a long narrow channel, however, since a field is externally applied a graded impurity concentration of channel **16** is unnecessary. Assuming, a P-type channel (P-type wafer) in the structure of FIG. **2** contact **50**, if positively biased as compared to contact **30**, will act as a source of majority carriers (holes) while contact **30** acts as a drain of these carriers, and majority carrier flow from contact **50** to **30** proceeds along the dotted line **54**.

The majority drain contact **30**, preferably surrounds injector region **18** and is substantially concentric to it at surface **20**. Consequently, the deepest point of the injector region faces the most positive value of channel **16** comparing points along the injector-channel interface, and the injected electrons are concentrated at the center of the channel.

In contrast to devices having a built-in field, when the field is externally applied between electrodes located at the channel ends, steps must be taken to confine the majority carrier flow to the channel. Hence, it is necessary to completely surround the channel by the collectors or external boundaries of the semiconductive wafer. This may be accomplished by making regions **12** and **14** extend around the channel. This can be seen from FIG. 3 wherein regions **12** and **14** substantially conform to contacts **22, 24** which they underlie. A small gap **62** and **64** are provided at the ends of the collector regions, and these are biased positive with respect to the surrounding *p*-type layer such that the space charge layer generated at the collector junctions extends from regions **12, 14** to the dotted lines **56** and **58**. This space charge layer leaves a *p*-type opening for the channel **16** (within line **56**), but covers completely gaps **62** and **64** between the horseshoe-shaped collector regions **12, 14**. In this manner, channel **16** is laterally pinched off from the surrounding *p*-layer **66**, yet regions **12, 14** remain insulated from each other by gaps **62, 64**.

The structures illustrated in FIGS. **1—3** provide a vertical channel perpendicular to the wafer surface; however, there are several advantages of structures having a horizontal channel parallel to the wafer surface since this provides: (1) access of the channel to a highly localized magnetic field, for instance, the field of the domains on magnetic tape; (2) an elongated channel without the necessity of deep diffusion of the collector regions; (3) other means of collecting injected minority carriers than the use of reverse biased *p—n* junctions; and (4) ease of providing a lateral impurity profile in the channel.

A structure having a horizontal channel is shown in FIG. 4 which depicts a structure having a *p*-type channel **70** parallel to the wafer surface **72**. In this embodiment, the bulk of wafer **74** is an *N*-type substrate which provides one collector region. Substrate **74** is overlaid by a *p*-type epitaxial layer **78** which has an elongated *N*-type region **76** disposed in upper surface **72**. Region **76** provides the other collector, and together with substrate **74** forms a ribbonlike channel **70** from the interposed portion of layer **78**. An *N*-type injector region **80** is laterally spaced from region **76** at one end of channel **70**, and is positioned between region **76** and a majority drain contact **82** which connects to layer **78**. A majority source contact **84** is provided at the other end of channel **70**, and contacts **86** and **88** are provided to regions **76** and **80**, respectively. It should be noted that drain contact **82** is, in this case, made negative with respect to source contact **84** so that majority carrier flow is along line **90** from contact **84** to **82**, and enhances minority carrier flow in an opposite direction through channel **70** from region **80**. The minority carrier flow in channel **70** is then magnetically deflected to either collector **74** or **76** by a magnetic field applied parallel to wafer surface **72** and orthogonal to channel flow **90**; that is, orthogonal to the plane of the figure.

A built-in electric field can also be utilized in this embodiment to increase sensitivity. That is, the lateral transit time may be increased by providing a lateral drift field in the channel which opposes the flow of injected minority carriers toward the channel-collector interface.

The lateral field may be accomplished by providing a concentration valley, that is a saddlelike impurity profile, perpendicular to the longitudinal axis of the channel. For example, the impurity concentration (e.g., boron concentration) of the gaseous ambient may be decreased during epitaxial growth of layer **78** and then again increased to the original level so as to provide the distribution plotted in FIG. **5**.

In FIG. **5**, the impurity concentration is plotted along the ordinate while the distance from the channel center is plotted along the abscissa. Herein, points *a* and *b* represent the channel edges or channel-collector interfaces **71** and **73** of FIG. **4**. This graphically illustrates the desired saddlelike impurity distribution having maxima at points *c* and *d*, adjacent the channel edges, and a minimum at *e* which corresponds to the channel center.

Hence, between *c* and *d*, there is a built-in field which tends to drive majority carriers away from and minority carriers toward the channel axis *e*. Consequently, the applied magnetic force has to overcome this lateral drift field in order to propel minority carriers toward either collector.

It should also be understood of course, that a built-in longitudinal drift field could also be utilized in the parallel channel structure of FIG. **4**, and conversely, the lateral field of FIG. **5** could also be employed by appropriate construction in the vertical channel structure of FIG. **1**.

In another embodiment, shown in FIG. **6**, the upper collector is provided by a Schottky barrier contact **92**. In this case, region **76** and junction **73** of FIG. **4** is replaced by metallic layer **92** which is deposited on surface **72** in accordance with well known methods of preparation. For example, a thin layer of chromium may be deposited on surface **72** of the *p*-type layer **78** to provide the Schottky barrier contact. This then provides a channel portion **70** of epitaxial layer **78** interposed between collector substrate **74** and collector **92**.

In still another embodiment as shown in FIG. **7**, collector region **76** of FIG. **4** is replaced by an inversion layer **94**, induced in the upper surface of layer **78** by a positively biased metal film **96** which overlies an insulating film **98**. For example, a layer of aluminum or the like deposited over a silicon dioxide film by conventional MOS techniques would be suitable.

In this case, contact to inversion region **94** is provided by a connection to its lateral edge (not shown) or by a lead (not shown) insulatively extended through film **96** and **98**.

In he embodiments shown in FIGS. **4, 6**, and **7**, the upper collector regions (**76, 92** or **94**) and their appropriate contacts may be laterally extended (that is in a direction into the paper) to provide a thin ribbonlike channel, and the extreme edges of the channel can be laterally terminated in each case by the wafer edge or by a pair of grooves or the like, cut or etched, in surface **72** parallel to channel **70** and penetrating to collector **74**.

The described transducers can also be combined in an integrated arrangement with an amplifying unit, for example by utilizing one collector as a base region of a bipolar PNP transistor such as that shown in FIG. **8**, or may be combined with an MOS-type unipolar transistor, for example as shown in FIG. **9**.

In FIG. **8**, the transducer of FIG. **4** is modified by providing a *p*-type emitter region **100**, formed by diffusion or the like, in upper collector **76**. In this case, contact **86** is affixed to region **100** so that current flowing from channel **70** into region **76** must pass through the *p—n* junction **101** between region **76** and **100**. Thus, channel collector **76** can be made to also operate as the base region of a bipolar PNP transistor **106** whose collector is a portion of channel **70**.

In operation, contact **86** is connected at **102** to the positive side of a voltage source **104** such that PNP transistor **106** operates in a manner similar to contact **84** of FIG. **4**, as a source of holes in channel **70**. Consequently, the input to transistor **106** is partly controlled by the collector current of the transducer. Drain contact **82** is also connected in common to injector contact **88** at **108** and then over a load resistance **110**, such as a 5 kilo ohm resistor, to the negative terminal of source **104** as shown.

Then, the voltage drop caused by the flow of holes in channel **70** between transistor **106** and drain contact **82** provides a slightly negative bias for the injecting *p—n* junction **112** since contact **88** of region **80** is connected to **82**. Consequently, minority carriers are injected over junction **112** into channel **70**, and some of them are collected by the *n*-layer **76**, thus providing the base current of the transistor **106**. Hence, the device has internal feedback, since the minority carrier current from channel **70** to collector **76** governs the majority carrier current of channel **70** which, in turn, determines the voltage drop in the channel between junction **112** and contact **82**, and thus the injected minority carrier current.

Hence, the device in question has two states: an "on" state where a substantial channel current and base current are flowing with heavy injection minority carrier (electrons in this case) from region **80**; and an "off"-state with little or no minority carrier current in channel region **70**, little or no majority carrier channel current, and little or no injection over junction **112**. The two states provide a large voltage variation across resistor **110**, from which the output voltage is derived.

Switching from the "on"-state to the "off"-state is provided by magnetic deflection of minority carriers away from the collector region **76**. However, for some applications, it is also desireable to provide an additional majority carrier source contact **114** connected over a resistance **116**, for example 50 kilo ohms, to the positive terminal **102** of the battery. In this case, there will be a finite channel current and some limited injection over junction **112**, although the transistor **106** might still be off due to magnetic deflection of most of the electrons away from the collector **76**. Reversal of the polarity of the magnetic flux can trigger such a device into the on-stage of transistor **106** thereby providing greatly enhanced power through load resistor **110**.

FIG. **9** shows a further arrangement whereby the transducer illustrated in FIG. **4** is modified such that the current change to collector **76** is amplified by an MOS-transistor **120**. Herein, transistor **120** consists of an *n*-type region **122** whose surface is partially covered with an insulating film **124** and an overlying gate contact **126**.

A *p*-type region **128** is disposed within region **122** and spaced away from collector **76**. Region **128** provides a conventional MOS source region of transistor **120** and is connected through a resistor **123** to gate **126** and region **76**. Resistor **123** and region **128** are connected, in turn, to the positive side of a voltage source **132**.

Injector region **80** and contact **82** are connected in common through load resistor **110** to a ground terminal **138** and the negative side of voltage source **132**. As in the structure of FIG. **8**, source terminal **114** is connected to voltage source **132** over resistor **116**, and finally an output terminal **140** is provided in connection to load resistor **110** as shown. This provides a voltage output between terminal **140** and ground **138**.

A sufficiently large negative bias voltage is applied against region **122** by means of the positive voltage of gate electrode **126** which causes a *p*-inversion layer to form at the interface between region **122** and insulator **124**, thereby providing an inversion conductance between the *p*-pocket **128** and the terminal end **142** of the *p*-channel **70**. The negative bias to region **122** results from electron current flow from channel **70** into collector **76** which, in turn, flows over register **123** to the positive terminal of battery **132**.

Again, as in the structure of FIG. **8**, we have an "on"-stage in which electron current over junction **112**, magnetically directed to collector **76**, causes a gate bias which turns on MOS-transistor **120**. This, in turn, provides the hole channel current along dotted line **144** causing increased electron injection from region **80**. In the "off"-stage, with no electron collection by region **76** (due to the magnetic field) transistor **120** is turned off, and little or no electron injection from region **80** is present.

The described devices can of course be utilized in many different applications. For example, the structures shown in FIGS. **8** and **9** are suitable for use in switching applications such as for a magnetically activated light switch, or the like. This may be accomplished by any suitable arrangement which provides reversal of the magnetic polarity across the channel. That is, a conventional U-shaped magnet (not shown) may be rotatably mounted over the device so that its field may first pass perpendicular to the channel in one direction and then made to pass in the reverse direction by rotation of the magnet through 180° to provide off-on states of the switch. Concentration of the magnetic field can also be enhanced by the use of soft iron pole pieces or the like extended laterally from the sides of the transducer to the magnet faces. Then, rotation of the magnet to bring its opposite poles to bear on the pole pieces provides field reversal and circuit switching.

Many different embodiments are possible, of course. For example, *N*-type channels with appropriate collector and injector regions may be employed. In this case, regions of opposite type to those given in the description would also be required for the amplifier portions of the transducer-amplifier structures.

In addition, substrate **74** may be an insulative member such as sapphire or the like which provides a supporting base upon which layer **78** may be epitaxially deposited, for example. In this embodiment the channel is sandwiched between one collector and an insulating means.

Semiconductive materials other than silicon may also be employed. Both the built-in and externally applied channel field may be utilized, and many different embodiments of the transducer-amplifier structure may be possible.

Consequently, many different embodiments are possible without departing from the spirit and scope of the invention, and it should be understood that the invention is not to be limited except as in the appended claims.

I claim:

1. A semiconductive magnetic transducer comprising an elongated semiconductive channel, means disposed at one end of said channel for generation and injection of a constant flow of minority carriers therein, at least one region for collection of minority carriers contiguous with a side of said channel that is substantially parallel to the flow of minority carriers and of opposite conductivity type from said channel, wherein a magnetic field will deflect said drifting minority carriers thereby affecting their collection in said collector region, and a nonvariable electric field provided within said channel by a gradually decreasing concentration of impurities from the injection end of said channel to the opposite end thereof imparting a drift to said minority carriers along the axis of said channel and away from the point of injection such that the natural drift velocity of the injected minority carriers within the channel is substantially increased thereby permitting a corresponding increase in sensitivity for the transducer.

2. The transducer of claim **1** including a lateral variation in impurity concentration having a saddle-shaped concentration provided by an impurity distribution of gradually decreasing concentration from the channel sides towards its axis.

3. The transducer of claim **1** including at least one other region for collection of minority carriers, said other collector region also being contiguous with a side of said channel and spaced from said one collector region.

4. The transducer-amplifier of claim **3** wherein said collector regions extend around said channel and are spaced apart a short distance at their ends, and said collector regions are biased electrically against said channel to an extent that the space charge layers between said collectors and channel extend across the spacing between said collectors so that the channel is fully surrounded by said collectors and their space charge regions.

5. A semiconductive magnetic transducer-amplifier comprising in combination a body of semiconductive material; a semiconductive channel disposed within said body; at least one collector region of said body adjoining said channel and of opposite conductivity type from said channel; means to inject minority carriers into said channel from an emitter located at said surface at one end of said channel in order that minority carriers moving along said channel can be deflected to said collector by a magnetic field applied to said channel; and an enhancement MOS transistor disposed adjacent said channel with its inversion layer in series connection therewith, and said collector region being coupled to the gate of said transistor and biased in accordance with the flow of minority carriers into said collector such that said MOS transistor operates as a source of majority carriers to said channel.

6. The transducer of claim **5** wherein said MOS transistor includes a first region of the same conductivity type as said collector region, said first region spaced apart from said collector and disposed in said channel at the opposite end from said injection region, said first region having a majority source region disposed therein, said majority source region being spaced away from said collector region, said transistor having a gate electrode overlying and insulatively spaced from said first region, said gate overlying a portion of said first region which is disposed between its source region and said collector region, said collector region coupled to said gate electrode, and said minority flow into said collector providing a bias of said gate electrode which inverts the underlying region such

that said source region injects majority carriers through said inverted region into said channel.

7. The transducer-amplifier of claim 7 wherein said channel includes a source and a drain of majority carriers disposed at opposing ends of said channel, said majority carrier drain being located at the injection end of said channel, said injection means being disposed between said drain and said collector, and said injection means being conductively connected to said drain so as to control minority carrier injection in accordance with majority carrier flow.

8. A semiconductive magnetic transducer-amplifier comprising in combination a body of semiconductive material; a semiconductive channel of opposite conductivity type from said body and disposed within said body so as to be contiguous with said body along a substantially planar surface; a collector region of opposite conductivity type from said channel and contiguous with the outside planar surface of said channel, means to inject minority carriers into said channel from an emitter located at the surface at one end of said channel; a source of majority carriers located at the surface at the other end of said channel; circuit means to provide a flow of majority carriers along said channel from said source of majority carriers toward said emitter of minority carriers, thereby generating a drift field along said channel so that minority carriers drifting along said channel are deflected to said collector by a magnetic field applied to said channel; and an emitter region within said collector and of opposite conductivity type from said collector, which together with said collector and said channel forms a bipolar transistor such that the output of said transistor amplifier operates as a source of majority carriers for said channel and is proportional to minority carrier flow deflected to said channel.

9. The transducer-amplifier of claim 8 including means for controlling the injection of minority carriers into said channel in accordance with said majority carrier flow thereby providing a bistable device having one state characterized by a comparatively large minority carrier flow and another state of little minority carrier flow in said channel.

10. The transducer of claim 9 including a magnetic field in said channel, said magnetic field directed across said channel so as to control minority flow into said collector, and means for varying said magnetic field to control said minority flow into said collector and thereby switch said bistable device from one state to the other.

11. The transducer-amplifier of claim 9 wherein said channel includes a source and a drain of majority carriers, said majority carrier drain being located at the injection end of said channel, said injection means being disposed between said drain and said collector, and said injection means being conductively connected to said drain so as to control minority carrier injection in accordance with majority carrier flow.