(12) UK Patent Application (19) GB (11) 2 072 927 A

(21) Application No 8109252
(22) Date of filing 24 Mar 1981
(30) Priority data
(31) 134906
(32) 28 Mar 1980
(33) United States of America (US)
(43) Application published 7 Oct 1981
(51) INT CL[3] G11B 9/06
(52) Domestic classification G5R B261 B361 B36Y B650 B670 B789 LN
(56) Documents cited None
(58) Field of search G5R
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(54) Ion implanted diamond video disc stylus

(57) An improved playback stylus for use with a capacitive high information disc wherein the playback stylus comprises a diamond dielectric support element having a bottom surface which contacts the disc and a conductive layer adjacent to the bottom surface. The improvement comprises forming the conductive layer as an ion implanted layer in the support element. The prepared ion is boron.

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SPECIFICATION

Ion implanted diamond video disc stylus

This invention relates to a stylus for use with a high density information disc. More particularly, this invention relates to a stylus of a diamond dielectric support material which is ion implanted to form a conductive surface.

U.S. Patent 3,842,194 of Clemens discloses a high density information disc for use in a playback system utilizing variable capacitance. In one configuration of the Clemens' system information representative of recorded pictures and sound is encoded in the form of a relief pattern in a relatively fine spiral groove at the surface of the disc record. For example, groove widths of about 2.6 micrometers and groove depths of about 0.5 micrometer may be used. During playback a pickup stylus about 2.0 micrometers wide having a thin conductive electrode thereon, for example about 0.2 micrometer thick engages the groove as the record is rotated by a supportive turntable. Capacitive variations between the stylus electrode and the record surface are sensed to recover the prerecorded information.

Clemens discloses in the aforementioned patent a triangular shaped stylus having one face coated with a conductive coating. In particular, transition metals such as hafnium, titanium or tantalum may be used as the conductive coating.

Keizer, in U.S. Patent 4,162,510, incorporated herein by reference, discloses a playback stylus which may be used with a grooved capacitive video disc system. The keel tipped pickup stylus comprises a dielectric support element having a body, a constricted terminal portion and shoulders interconnecting the body with the constrictive terminal portion. The constrictive terminal portion is defined by a prow, a substantially flat rear surface remote from said prow, side surfaces extending from the edges of the rear surface, a bottom surface extending from the bottom edge of the rear surface and a plurality of additional surfaces extending from the prow and intersecting the bottom and the side surfaces. The maximum separation between the substantially parallel side surfaces is less than the given groove width. A metal conductive coating is applied to the flat rear surface.

However, a problem has been encountered with the use of a metal conductive coating. When the stylus contacts the record surface the portion of metal coating closest to the record surface may wear away. Furthermore, problems have been encountered at the interface between the metal coating and the diamond dielectric support material. Poor adhesion is often observed with concomitant flaking off of the metal coating. Therefore, it would be desirable to have a diamond stylus wherein a separate metal layer would no longer be needed.

An improved playback stylus for use in a capacitive high density information disc system comprises a diamond dielectric support element, a bottom surface which contacts the video disc and adjacent to the bottom surface, a conductive layer formed by ion implantation into the support element.

Ion implantation is a method for introducing atoms into the surface layer of a solid substrate. Ions of the atoms to be introduced are accelerated so that they bombard the substrate surface at a uniform high energy, generally in the kilo-electron-volt (keV) to mega-electron-volt (MeV) energy range. The distribution of the ions after they have come to rest has a Gaussian shape as a function of the depth beneath the substrate surface. The effective thickness of the ion implanted layer is defined as twice the standard deviation of the Gaussian distribution of the implanted ions.

In the present invention the face of the diamond dielectric support element is ion implanted so as to form a layer which is to act as the conductive layer. The diamond may be either natural or synthetic.

In ion implantation the ions are accelerated and generally travel in a straight line. As a result, only the exposed area of the substrate will be implanted. This property is particularly useful for a video disc system because if areas other than the electrode face are ion implanted, spurious signals may be picked up which interfere with those picked up by the electrode face.

The depth at which ions are implanted is a function of the energy of the accelerated ions. The greater the energy the deeper the ions are implanted into the diamond. The thickness of the ion implanted conducting layer must be sufficient to pick up the signal recorded in the video disc replica. A preferred thickness has been found to be from about 1000 to about 1200 angstroms for best electrical performance. Generally accelerating energies of about 50 to 300 keV may be used. If the conductive layer thickness prepared by the ion implantation is too small, the capacitance between the stylus electrode and the video disc surface will be too small and as a result the recovered signal will be too weak to be useful. If the electrode thickness is too great, the pickup stylus will simultaneously recover signals from more than one signal element and undesirable crosstalk or interference will result.

Useful ions to ion implant diamond styli include those derived from H_2, Ar, B, As or Li. The increased conductivity of the ion implanted surface is believed to be due, in part, to the damage caused to the diamond by the ion implantation process. Therefore, increased conductivity of the ion implanted surface is obtained regardless of the ion used.

A four-point probe may be used to measure the sheet resistance of the ion implanted diamond surface. It has been found that Ar implanted to the same depth as B gives a sheet resistance about four to five times greater than the value obtained for B. That is, B is preferred because the resultant ion implanted layer has a lower resistivity and is therefore more conductive.

The ion implantation dose is the number of implanted ions per square centimeter of implanted surface. As determined by the four-point probe, we have found that the value for sheet resistance as a function of B dose goes through a minimum value. This minimum in the sheet resistance, about 80 ohms per square, occurs at a dose of 1.8×10^{16} B atoms per square centimeter. At higher or lower doses the sheet resistance increases and may become too high for use as a conductive layer. However sheet resistance of the ion implanted layer at 915 megahertz (MHz) of about 360 ohms per square or less allows the ion implanted stylus to be useful for recovering signals recorded in a conductive video disc vinyl replica. In general, a dose of between about 1 and 4×10^{16} B atoms per square centimeter, which corresponds to a sheet resistance of about 95 to 210 ohms per square, is preferred to form a diamond stylus of the invention.

Another consideration is the effect of ion implantation on the physical properties of the diamond. Ion implantation causes damage to the diamond surface, which on the one hand gives it desirable conductivity properties but on the other hand lessens the crystallinity of the diamond in the regions of bombardment, which results in embrittlement. Damage has also been found to increase as a function of dose. For example, a dose of 5×10^{16} B^{11} atoms per square centimeter or greater results in chipping of the stylus tip during playback. All doses herein are at 200 keV.

The ion implanted conductive layer may be electrically coupled to the signal processing equipment by any convenient method. A preferred method of electrical coupling is capacitive coupling. For example, the surface of the face of the diamond dielectric support element which was ion implanted may be coated with a silver paint or an evaporated metal layer. If the surface capacitive coupling layer does not extend to the bottom surface of the stylus and thereby contact the surface of the disc, the coupling layer need not have the toughness and wearability of the metal conductive layers of the prior art which contact the disc record surface.

The stylus tip may be fabricated either prior to or after ion implantation. U.S. Patent 4,104,832, incorporated herein by reference, discloses a method for manufacturing a keel tipped stylus. A tapered dielectric support element made from a hard material such as diamond, is contacted with an abrasive lapping disc having a deep, trapezoidal, corase pitched groove. The lands on the lapping disc lap the shoulders of the keel tipped stylus and the walls of the abrasive groove form the substantially parallel side surfaces of the constricted terminal portion.

The stylus of this invention is not limited to use with grooved capacitive video discs but may be employed with non-grooved capacitive video discs as well.

The present invention will be further illustrated by the following Example, but it is to be understood that the invention is not meant to be limited to the details described herein.

EXAMPLE

A $0.25 \times 0.25 \times 2.00$ millimeter keel-tipped natural diamond was cemented to a 2.25 inch (5.7 centimeter) diameter 0.8 millimeter thick polished stainless steel wafer with silver paste. A {110} diamond face was parallel to the wafer surface. The wafer was then placed in the target chamber of an Accelerators, Inc. (Austin, Texas) 300 keV ion implanter. The normal to the surface of the wafer to which the diamond was attached was 6° off from alignment with the axis of the implant beam in order to prevent channelling. A B^{11} implant beam was raster scanned, that is, x—y scanned, across the {110} diamond face by means of electrostatic deflection plates. The energy of the ion implant beam was 200 keV. The beam was shut off after a dose of 2.4×10^{16} B" atoms per square centimeter had been achieved, as measured by a current integrator (Brookhaven Instruments).

The sheet resistance of the buried layer at 915 MHz was 360 ohms per square.

The ion-implanted face was covered with silver paint and connected to a video disc cartridge. Satisfactory pictures were obtained during playback of a capacitive video disc vinyl replica.

It should perhaps be explained that the capacitive coupling provided by the silver paint to the ion implanted layer arises because few if any ions remain at the surface of the diamond face leaving a dielectric layer between the ion implanted layer and the paint layer.

CLAIMS

1. A playback stylus for use with a high density information disc in a system in which information encoded in the surface of the disc is recovered by processing capacitive variations between a conductive layer of the stylus and the disc surface when there is relative motion between the stylus and the disc, said playback stylus comprising a diamond dielectric support element that has a bottom surface for contacting the disc and, adjacent to the bottom surface, a conductive layer which is an ion implanted layer.

2. A stylus according to claim 1 wherein the stylus is keel-tipped.

3. A stylus according to claim 1 or 2 wherein the ion implanted in the diamond support element is boron.

4. A stylus according to claim 3 wherein the sheet resistance at 915 MHz of the ion implanted layer is about 360 ohms per square or less.

5. A stylus according to any preceding claim wherein the ion implanted layer is from about 1000 to about 1200 angstroms thick.

6. A stylus according to any preceding claim with means for capacitively coupling its ion implanted layer to a signal processing system for recovering the encoded information.

7. In a method for fabricating a playback stylus comprising a diamond dielectric support element for use with a capacitive information system including a high density information conductive

disc, the steps of forming a bottom surface of the support element for contacting the disc, and preparing a conductive layer adjacent to the bottom surface by ion implanting a portion of the diamond dielectric support element.

8. The method of claim 7 wherein boron is the ion implanted.

9. The method of claim 8 wherein the dose is from 1×10^{16} to about 4×10^{16} B atoms per square centimeter.

10. The method of claim 7, 8 or 9 wherein the accelerating energy is about 50 to about 300 keV.

11. The method of claim 7, 8 or 9 used for a keel-tipped stylus.

12. A playback stylus substantially as herein before described.

13. A method for fabricating a playback stylus substantially as herein before described.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1981. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.