

PATENT SPECIFICATION

(11)

1 503 969

1 503 969

(21) Application No. 33193/75 (22) Filed 8 Aug. 1975 (19)

(31) Convention Application No. 524 108 (32) Filed 15 Nov. 1974 in

(33) United States of America (US)

(44) Complete Specification published 15 March 1978

(51) INT. CL.² B41J 3/20

(52) Index at acceptance

B6F 5A21 5AY 7L1 7LY 8A12A 8A12Y L8



(54) THIN FILM THERMAL PRINT HEAD

(71) We, HEWLETT-PACKARD COMPANY of 1501 Page Mill Road, Palo Alto, California 94304, United States of America, a corporation organised and existing under the laws of the State of California, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a thin film thermal print head for operation in an environment including a source of ions. U.S. Patent No. 3,609,294 describes a thermal printing head in which planar resistive heater elements are covered by a protective layer of material having substantial thermal conductivity and electrical resistivity. The protective layer is shaped to provide a raised area over each of the heater elements. These raised mesa-like areas are merely thicker portions of the overcoating which protects the entire structure. The mesa-like areas provide concentrations of heat in close proximity to the thermally sensitive recording material. However, since the material is selected for high thermal conductivity, conduction of heat generated by the resistive heater elements to the surface of the recording material is dissipated by transmission of some of that heat into the thinner portions of the overcoating layer. Thus the thermal efficiency of this system is necessarily low. In the present invention, the resistive elements are formed over a mesa of glass glaze which places the source of heat itself in close proximity with the thermally sensitive recording material and reduces the heat dissipated throughout a protective overcoating layer. The thermal efficiency of the present invention is therefore much higher.

An ion migration barrier is also known from U.S. Patent No. 3598956, the barrier comprising an electrically conductive shield which isolates the resistive heater elements from ions which shortened heater element life. The migration barrier is insulated from the heater elements and from the thermally

sensitive recording material by layers of glass, and is most effective when electrically biased or grounded. The ion barrier of the present invention is effective without electrical biasing or grounding, and does not require an insulating layer of glass between it and the heater elements. In addition the ion barrier of the present invention enhances adhesion of the wear layer to the heater elements.

The ion barrier described above is formed during a heat treatment process which also serves to adjust the value of the resistive elements. By controlling the temperature and time of heat treatment, the resistor values may be increased to a resistance value compatible with drive electronics. Since deposits of resistive material are more uniform in thin film technology than in other fabrication processes, external trimming resistors are generally not required. However, since heat treatment effects the resistance of all heater elements uniformly, it does allow the upward adjustment of that resistance to accommodate the electronic drive circuitry.

The present invention provides a thin film thermal print head for operation in an environment including a source of ions, the print head comprising, a substrate, a layer of glass glaze covering the substrate and having a plurality of mesas formed on the surface thereof; a layer of resistive material covering the mesas to form resistive heater elements thereon; a plurality of electrical conductors coupled to the heater elements for connecting electrical power thereto; a layer formed by oxidating the resistive material covering each of the heater elements to insulate the heater elements from the ions, and a layer of wear-resistant material covering the layer of oxide and having relatively high thermal conductivity.

The resistive heating elements are deposited on the mesas for more efficient marking of thermally sensitive recording material. The mesas may be formed in the glass glaze by etching, and then resistive and conductive materials can be deposited over the mesas by thin film techniques.

Thereafter, the raised heater elements and

conductors may be delineated chemically, then heat-treated to increase resistance of and to grow a protective oxidised layer over the individual heater elements. Since the resistance value of the heater elements can be controllably increased as a function of the temperature and time of heat treatment, external trimming resistors can be eliminated. The protective oxidised layer which forms over the resistors during heat treatment can provide better adhesion to wear-resistance materials and an effective barrier to migration of ions from the recording material into the heater elements which cause degradation of performance and shortened element life.

An embodiment of the invention is described with reference to the accompanying drawings, in which:—

Fig. 1 is a cross-section of a substrate with glass glaze showing the mesa formed thereon for one heater element.

Fig. 2 is a cross-section of the substrate of Fig. 1 including the layers of resistive and conductive materials.

Fig. 3 shows the change of resistance versus time at various temperatures for tantalum nitride.

Fig. 4 is a cross-section of the substrate of Fig. 2 including the protective oxide and wear layer.

Fig. 5 is a top view of a thermal print head having a plurality of heater elements.

Referring to Fig. 1, substrate 10 is coated with a thick layer of high-temperature glass glaze 12. The glaze is then coated with a photoresist, baked, exposed and developed, leaving an etch resistant pattern of photoresist material where the mesa is desired. The remaining unprotected glaze is then etched with hydrofluoric acid to a thinner layer thickness than mesa 14. Substrate 10 can be 94%—99% aluminum oxide.

After the mesa has been formed for each resistive heater element as shown in Figure 1, a coating of resistive material is deposited over the entire glass glaze area by thin film techniques such as evaporation or sputtering. Thereafter, by similar thin film techniques, a layer of conductive material is deposited over the same area. For the preferred embodiment of the present invention, the resistive material may be either tantalum nitride or tantalum/aluminum alloy and the conductor material may be either gold or aluminum.

Referring now to Figure 2, resistive material 20 is shown covering mesa 14. After applying, baking, exposing and developing photoresist to delineate the pattern of electrical conductors to the heater elements, conductor material 22 is then chemically etched to form individual conductors to each resistive heating element. Since resistive material 20 must be removed from the

areas between conductors, that material is removed by a suitable chemical etching process or equivalent. Photoresist material is then again applied over the entire area, except where the resistive heating element is to be formed over mesa 14, thus delineating the resistive heating element. After baking, exposing and developing the photoresist, the conductor material is then chemically etched from the top of the resistor covering mesa 14.

Prior to application of a wear-resistant material over the heater elements, the entire substrate is heat-treated. As shown in Figure 3, by controlling the temperature and the time of heat treatment, the amount of resistance change in each resistive heating element can be controlled. While the resistance change is essentially uniform for all of the resistive heater elements on the substrate, this heat treatment provides a method by which the resistance value of the heater elements can be upwardly adjusted to accommodate particular electronic drive circuits.

During the heat treatment process, a protective oxidised layer grows over each individual resistive heater element. This protective oxidised layer serves as a barrier against migration of ions from commonly known sources such as the thermally sensitive recording material itself. Such ions migrating to and into the heater elements tends to contaminate those elements which reduces their reliability and shortens their life. In addition, this oxidised layer provides a better adhesion of a wear layer applied to each heater element after heat treatment.

Referring now to Figure 4, wear layer 30 is now applied over the immediate area of each heater element. The material is a wear-resistant, thermally-conductive material such as aluminum oxide. Thus a resistive heater element formed over mesas of glass glaze having a chemical ion migration barrier and protected by a wear layer has been constructed, which provides efficient developing of thermally sensitive recording material. The printing portion of the resistive heating element is shown in Figure 3 at 34. Protective oxidised layer 32 improves reliability in an ion-laden environment by a factor of approximately six to one. It can be shown that six times the number of heater element failures were encountered after printing more than 30,000 feet of paper without the protective oxidised layer than with the protective oxidised layer present.

Referring now to Figure 5, thin film thermal print head 40 comprises 7 resistive heater elements, for example 41, common conductor 42 and individual conductors, for example, 44. Each of the resistive heater elements and the conductors were formed as

explained above for one of such elements. Print head 40 may be used for forming 5×7 matrix alphanumeric characters along one axis of thermally sensitive recording material such as is described in our copending U.K. Patent Application No. 38531/75 (Serial No. 1,503,970).

WHAT WE CLAIM IS:—

- 10 1. A thin film thermal print head for operation in an environment including a source of ions comprising:
 - a substrate;
 - a layer of glass glaze covering the substrate and having a plurality of mesas formed on the surface thereof;
 - 15 a layer of resistive material covering the mesas to form resistive heater elements thereon;
 - 20 a plurality of electrical conductors coupled to the heater elements for connecting electrical power thereto;
 - a layer formed by oxidising the resistive material covering each of the heater elements to insulate the heater elements from the ions; and
 - 25

a layer of wear-resistant material covering the layer of oxide and having relatively high thermal conductivity.

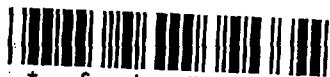
2. A thin film thermal print head as in claim 1 wherein the resistive material is selected from the group consisting of tantalum nitride and tantalum aluminum alloy.

3. A thin film thermal print head as in claim 1 wherein the wear-resistant material is aluminium oxide.

4. A thin film thermal print head as in claim 1 wherein the layer formed by oxidising the resistive material is formed by heating the heater elements.

5. A thin film thermal print head for operation in an environment including a source of ions substantially as herein described with reference to the accompanying drawings.

For the Applicants:
CARPMAELS & RANSFORD,
Chartered Patent Agents,
43, Bloomsbury Square,
London, WC1A 2RA.



explained above for one of such elements. Print head 40 may be used for forming 5×7 matrix alphanumeric characters along one axis of thermally sensitive recording material such as is described in our copending U.K. Patent Application No. 38531/75 (Serial No. 1,503,970).

WHAT WE CLAIM IS:—

- 10 1. A thin film thermal print head for operation in an environment including a source of ions comprising:
 - a substrate;
 - a layer of glass glaze covering the substrate and having a plurality of mesas formed on the surface thereof;
 - 15 a layer of resistive material covering the mesas to form resistive heater elements thereon;
 - 20 a plurality of electrical conductors coupled to the heater elements for connecting electrical power thereto;
 - a layer formed by oxidising the resistive material covering each of the heater elements to insulate the heater elements from the ions; and
 - 25

a layer of wear-resistant material covering the layer of oxide and having relatively high thermal conductivity.

2. A thin film thermal print head as in claim 1 wherein the resistive material is selected from the group consisting of tantalum nitride and tantalum aluminum alloy.

3. A thin film thermal print head as in claim 1 wherein the wear-resistant material is aluminium oxide.

4. A thin film thermal print head as in claim 1 wherein the layer formed by oxidising the resistive material is formed by heating the heater elements.

5. A thin film thermal print head for operation in an environment including a source of ions substantially as herein described with reference to the accompanying drawings.

For the Applicants:
CARPMAELS & RANSFORD,
Chartered Patent Agents,
43, Bloomsbury Square,
London, WC1A 2RA.