

[54] **INTEGRATED CATHODE AND CHANNEL
PLATE MULTIPLIER**

[75] Inventors: **Keun Ho Chang**, Arlington; **John Rennie**, Alexandria, both of Va.

[73] Assignee: **The United States Government as represented by the Secretary of the Army**, Washington, D.C.

[22] Filed: **July 3, 1974**

[21] Appl. No.: **485,657**

Related U.S. Application Data

[62] Division of Ser. No. 308,898, Nov. 22, 1972, abandoned.

[52] U.S. Cl. **29/572; 29/576; 29/592; 313/95**

[51] Int. Cl.² **B01J 17/00**

[58] Field of Search **29/572, 576, 576 B, 584, 29/592**

[56] **References Cited**

UNITED STATES PATENTS

3,327,151	6/1967	Adams	313/95
3,478,213	11/1969	Simon	250/207
3,497,759	2/1970	Manley	315/11

3,562,894	2/1971	Rome	29/592
3,569,997	3/1971	Lehovec	29/572
3,627,575	12/1971	Doyle	29/592

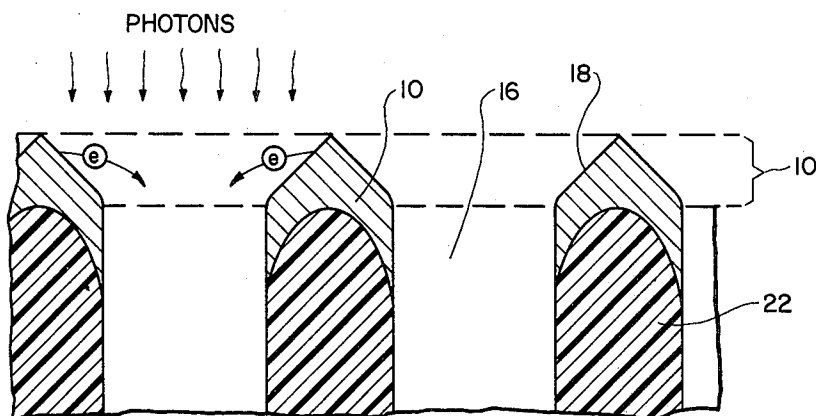
Primary Examiner—W. Tupman

Attorney, Agent, or Firm—Max L. Harwell; Nathan Edelberg; Robert P. Gibson

[57] **ABSTRACT**

A microchannel plate in which a novel input electrode is made of one material that integrally functions as a photocathode as well as a conductive layer. An output electrode is made from vacuum deposited thin metallic film of, for example, nickel, chromium, inconel, nicrome, etc. The input electrode may be made of some multi-alkali photocathode or made of a semiconductor, such as a gallium arsenide single crystal film. The microchannel plate is ordinarily made of glass. However, the plate may be made of a highly resistive semiconductor, such as gallium phosphide. The input electrode may further contain any conventionally available photocathode, such as S-20, or a single crystalline semiconductor epitaxially grown on the input side of a semiconductor microchannel plate.

3 Claims, 4 Drawing Figures



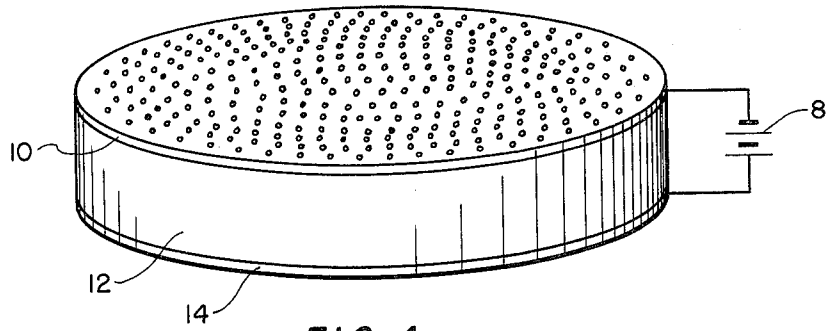


FIG. 1

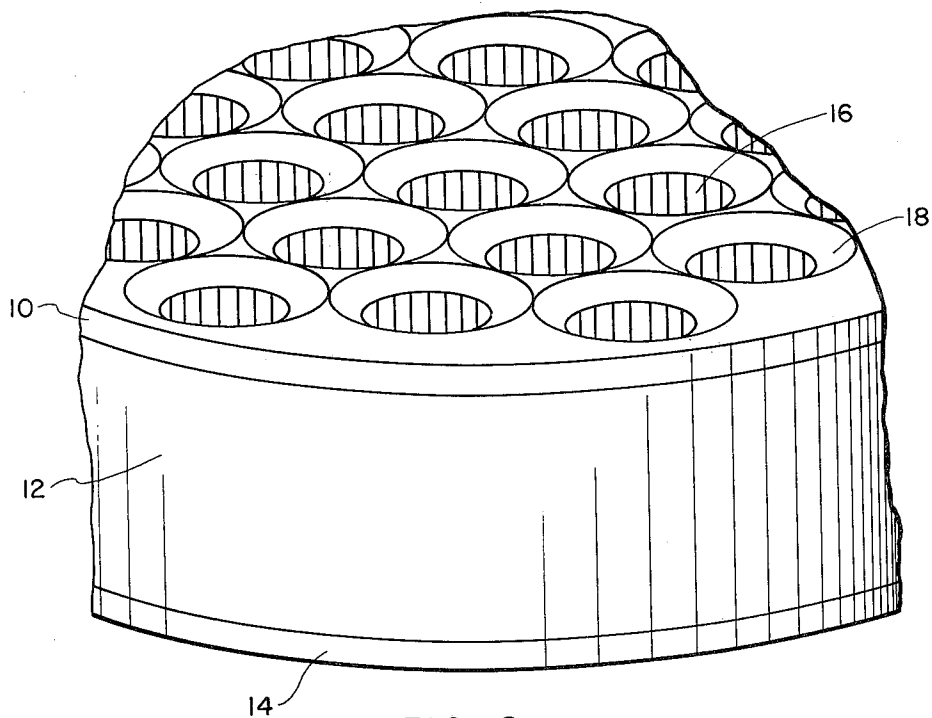


FIG. 2

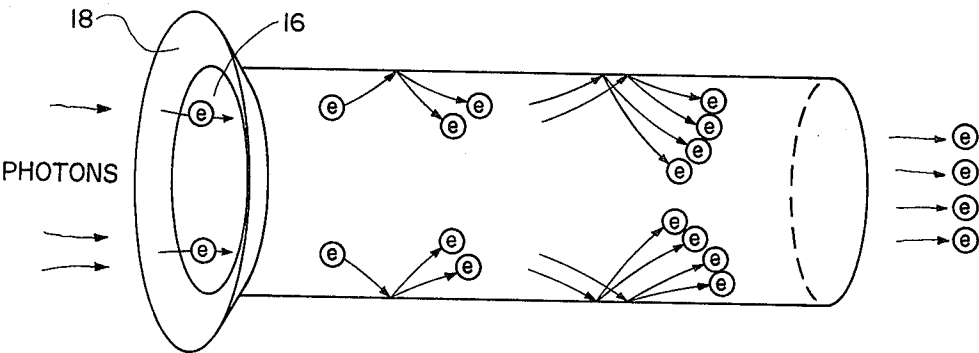


FIG. 3

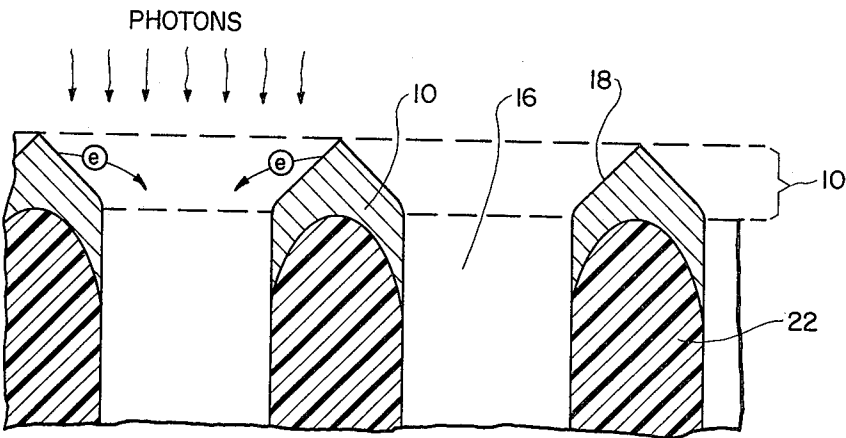


FIG. 4

INTEGRATED CATHODE AND CHANNEL PLATE MULTIPLIER

The invention described herein may be manufactured, used, or licensed by or for the Government for governmental purpose without the payment to us of any royalty thereon.

This is a division of application Ser. No. 308,898, filed Nov. 22, 1972, now abandoned.

BACKGROUND OF THE INVENTION

In previous microchannel plate electron multipliers the electron emitting photocathode is generally separated from, but close to, the input electrode of the microchannel plate. Even if the input conductor and photocathode are contiguous with each other, each layer is made of different material. The present invention provides one integral layer, deposited on the input side of a microchannel plate, that functions both as an electron emitter and as an input electrode bias source for the microchannel plate wafer.

SUMMARY OF THE INVENTION

This invention is a microchannel plate in which the input electrode is made of a material that functions as a cathode as well as an input electrode. This material may be some conventional multi-alkali photocathode. The photocathode may also be any conventionally available photocathode, such as S-20, or it may be a single crystalline semiconductor, when used with a semiconductor microchannel plate wafer, with the single crystalline semiconductor epitaxially grown on the input side of the microchannel plate to form an input electrode. Gallium arsenide may be used as the photocathode single crystalline material epitaxially grown on a semiconductor microchannel plate wafer made of gallium phosphide.

The microchannel plate and photocathode are made of different materials in most cases. However, the photocathode electrode may be made of the same material as the microchannel plate in the case of gallium arsenide single crystal, and the input electrode doped with zinc to make the photocathode a low resistivity layer as well as a good photocathode. Electron multiplication takes place when an electron begins moving between the input and output electrodes. A phosphor screen is positioned close to the output electrode and emits light therefrom when struck by these electrons.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows the wafer of a microchannel plate according to the present invention;

FIG. 2 shows a magnified view of the input side of the microchannel plate wafer;

FIG. 3 illustrates a schematic of the amplification mechanism of one microchannel; and

FIG. 4 shows a cross-section of the integrated photocathode and input electrode.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 1, a typical microchannel plate of the present invention is shown with the input electrode 10 and output electrode 14 on the opposite sides of a microchannel plate wafer 12. A voltage source 8 is connected to electrodes 10 and 14. This voltage connected to electrodes 10 and 14 supplies the proper electron accelera-

tion bias across the microchannel plate wafer 12. Wafer 12 is formed by a stack of short pipes in which the length of the pipes is the thickness of the wafer. These pipes, or channels, may be formed through wafer 12 by focussing electron beams on one side of the wafer and burning holes therethrough. The channels may also be drilled with laser beams by using a prepared highly reflective metallic template produced by photoetching or other means and then shine high power pulses or collimated laser beams through the template onto the input electrode side and out the output electrode side. After the channels are drilled, the next step in the process is to chemically etch the input side of wafer 12 so that the solid portions of wafer 12 are partially etched forming an oval shape. The oval shape is shown in FIG. 4 by numeral 22. The output side of wafer 12 is covered by some chemically inert material during the etching and, therefore, the solid portion on the output side of wafer 12 remains rather blunt. The material used to produce electrode 10 is epitaxially deposited on the input side of wafer 12, filling in over the oval shape forming peaks and resulting beveled edges 18. Beveled edges 18 surround channels 16 on the input side. Photons striking the beveled edges 18 cause electrons to be emitted therefrom. Wafer 12 functions as an electron multiplier when the electrons emitted from electrode 10 enter the channels. The electrons entering the channels are accelerated therethrough by voltages applied to electrodes 10 and 14.

Novel features of this microchannel plate are the beveled shape of input electrode 10 and the fact that electrode 10 is made of an integral layer functioning not only as an electron acceleration electrode but also as a cathode. Input electrode 10 accomplishes this integrated action by being made of only one material, with this material deposited directly on the input side of wafer 12. Wafer 12 may be made of glass. However, it may be made of any semiconductor, such as gallium phosphide, where intrinsic resistivity is very high.

Electrode 10 may be made of a single crystalline semiconductor, such as gallium arsenide, epitaxially grown on the input side of the wafer. Electrode 10 may also be made of some conventionally available photocathode material, such as S-20. Output electrode 14 is a metallic thin film vacuum deposited on the output side of wafer 12, and may be made of nickel, chromium, inconel and nicrome, etc., or alloys thereof.

The cathode function of input electrode 10 operates in the reflective mode. In operation when photons strike the input electrode, electrons are knocked off, or reflected, in the reflective mode. When the electrons are reflected off the beveled edge 18 of input electrode 10 as shown in FIGS. 3 and 4 these electrons are then drawn into channels 16 by the electric field within the channels caused by bias voltages on electrodes 10 and 14. These reflected electrons pass through the channels striking the side walls thereof and causing secondary electron emission from the walls of the microchannel plate wafer. In this manner, the few electrons emitted from input electrode 10 by photoemission are multiplied through the channels of wafer 12 by secondary emission and emerge as a much higher multiple of electrons.

The microchannel plate of the present invention is the type used as an electronic image amplifier in an image intensifying device. That is, a faint optical image projected on input electrode 10 is converted into a

highly amplified electronic image. About 50% of the incoming optical image is projected on beveled edges 18, causing electrons to be reflected off 18 into channels 16. A thin phosphor screen is placed in close proximity to the output electrode 14 such that the electrons from the electronic image strike the screen and converts the amplified electronic image back to an optical image.

Some of the dimensions and features of the present microchannel plate are as follows. The wafer 12 is from 1 to 2 centimeters in diameter and is about 0.015 to 0.02 centimeters in thickness. Wafer 12 is preferably made of a single crystal semiconductor, such as gallium phosphide. The resistivity of wafer 12 is about 10⁸ ohms per centimeter. Electrode 10 is preferably gallium arsenide or some other semiconductor single crystal that is about 5 micrometers in thickness with a resistivity of about 1 ohm per centimeter. The thickness and resistivity of the output electrode 14 is not critical but is probably about the same as for electrode 10. The diameter of each channel 16 is about 10 micrometers. The value of voltage source 8 is about 300 direct current volts when using the materials and the physical dimensions described above. The microchannel plate gain is about 18,000.

We claim:

1. A method of fabricating a microchannel plate electron multiplier comprising the steps of:
providing a microchannel plate wafer having an input

side and an output side with a plurality of microchannels therethrough;
chemically etching said input side of the wafer to form oval shape solid portions around the plurality of microchannels at the input side;
epitaxially depositing an input electrode material containing photocathodic material therein over said oval shape solid portions forming a beveled edge around each of said plurality of microchannels;
depositing an output electrode on said output side of said wafer;
providing a direct current voltage source; and
connecting said voltage source across said input and output electrodes for providing electron acceleration bias across said wafer whereby photons impinging on said input electrode cause electrons to be emitted therefrom and accelerated through said plurality of microchannels and out of said output electrode.

2. A method of fabricating a microchannel plate electron multiplier as set forth in claim 1 wherein said input electrode is made of gallium arsenide single crystal film and said wafer is made of gallium phosphide.

3. A method of fabricating a microchannel plate electron multiplier as set forth in claim 1 wherein said input electrode is made of some multialkali photocathode material.

* * * * *