

[54] FIELD EFFECT ELECTRON EMITTER

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DC

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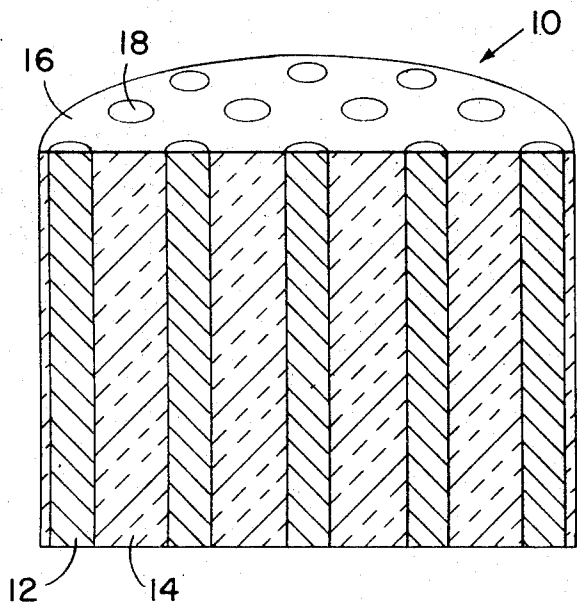
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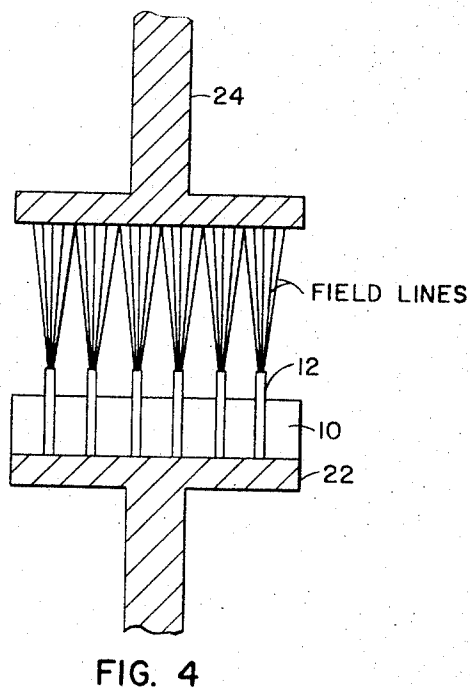
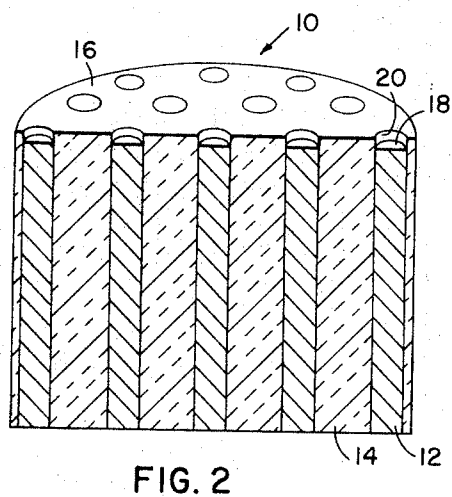
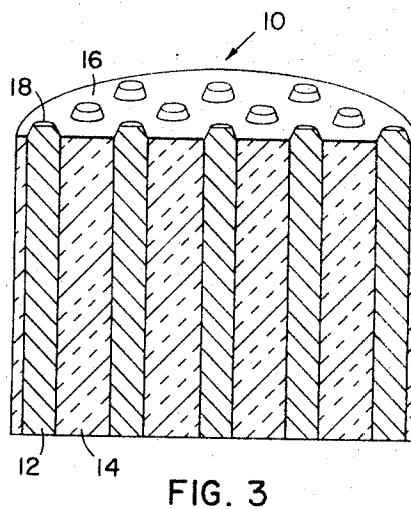
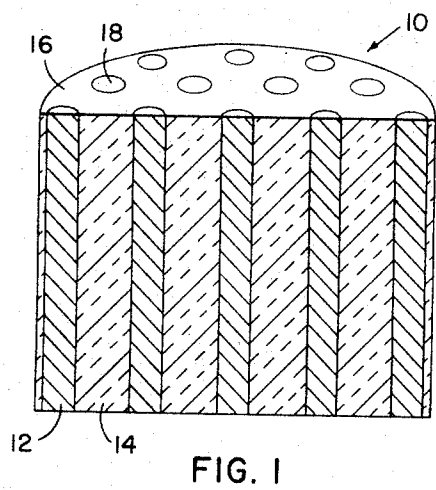
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[57] ABSTRACT

A unique electron source comprises an oxide-metal composite capable of emitting electrons at ambient temperatures when subjected to an electric field. The quantity of electrons emitted depends on the electric field provided for the emitter and thermionic emission is not employed during any stage of emission. The electron source, a field effect emitter, can have more than a million metal fibers for each square centimeter of emitter surface area. The metal fibers are normally less than one micron in diameter and are uniformly embedded within an oxide insulator for emitting electrons from the ends of the metal fibers.

6 Claims, 6 Drawing Figures





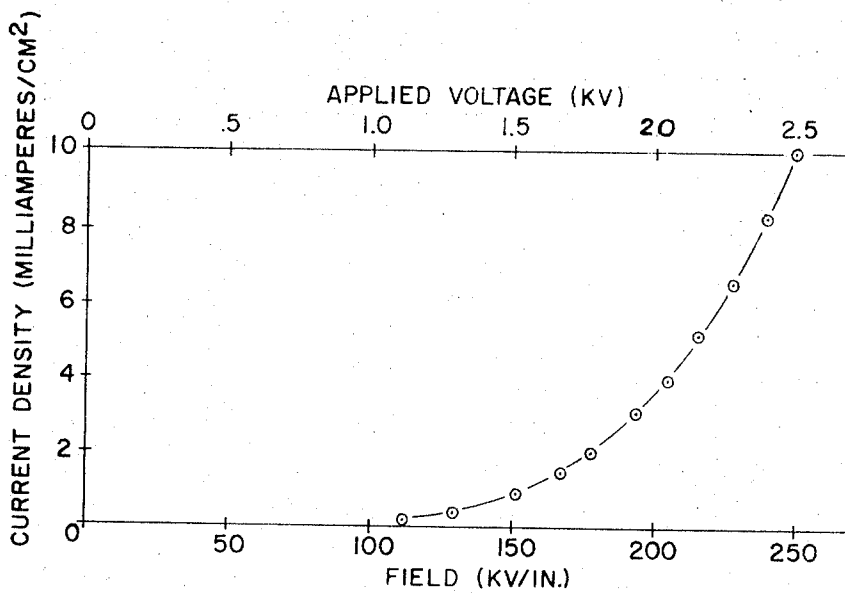


FIG. 5

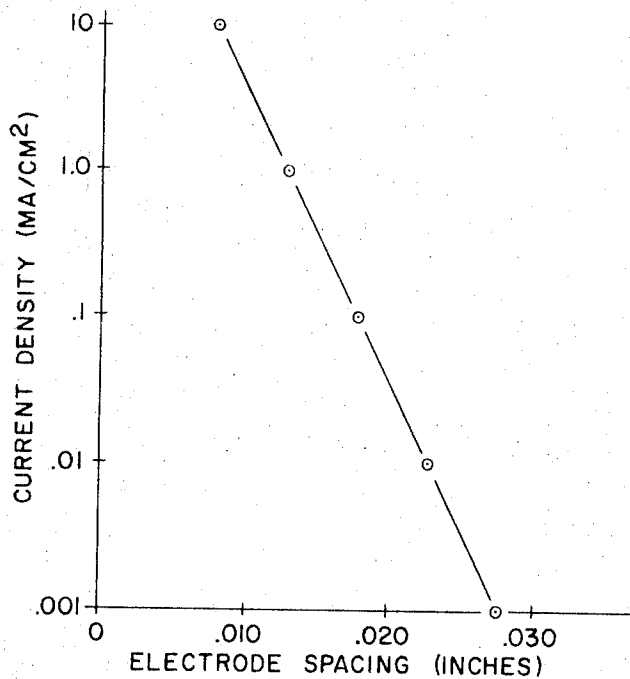


FIG. 6

FIELD EFFECT ELECTRON EMITTER

DEDICATORY CLAUSE

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

BACKGROUND OF THE INVENTION

A material that is capable of emitting electrons at ambient temperatures has been the object of research and investigation for a number of years. An ambient temperature emitter has obvious advantages over thermionic cathode or emitter structures, requiring no heater or auxiliary heater-related equipment. Warm-up time, which is required for heated emitters, is unnecessary for field effect emitters. It is well established that a pointed conductor will emit electrons at very high voltages at ambient temperatures when subjected to an electric field, as has been demonstrated in the design of early electro-static generators such as the Van de Graaff accelerator. However, the current available from these types of generators is extremely low and the potentials are much higher than are usable for the majority of applications. Therefore, a single point operating in a vacuum is essentially a field effect electron emitter but the current available is too small for practical devices.

SUMMARY OF THE INVENTION

An oxide-metal matrix is formed into a cathode structure or electron emitter. The matrix comprises ordered metal fibers separated by an insulating oxide. The emitter may comprise more than a million fibers arranged in parallel for each square centimeter of surface area with the ends of the fibers forming the emitter surface. The fiber ends are all of substantially the same diameter, the distance between adjacent fiber ends being substantially the same. All of the fiber ends except boundary fibers are the same distance from any associated collector or anode in order that each emitting point by subjected to the same electric field intensity. Since the emitter composite is a firm material, it can be machined or ground flat, fulfilling all the requirements for a field effect electron emitter. The fiber diameter and the number of fibers can be varied over a large range, allowing the composite to be grown as required for individual applications.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic, sectional view of an oxide-metal composite for field effect emission.

FIG. 2 is a diagrammatic view of a partial composite with the metal fibers etched below the oxide.

FIG. 3 is a diagrammatic view of a partial composite with the oxide insulator etched below the metal fibers.

FIG. 4 is a diagrammatic view of a typical diode configuration employing the field effect electron emitter and showing field lines.

FIG. 5 is a graph of applied voltage and electric field versus current density for the field effect emitter.

FIG. 6 is a graph of electrode spacing versus current density for a fixed applied voltage between the field effect emitter and an adjacent anode.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A single sharp point operating in a vacuum in an electric field is essentially a field effect electron emitter. However, the current available is too small for practical devices. To be useful for electronic devices, the emitter must comprise numerous points for each square centimeter of area. For such a large quantity of points per square centimeter, the ends of each emitter have such a small surface area that it is not necessary for each emitter to have a sharpened point to be a field effect electron emitter. However, the ends or points must be approximately uniform, the distance between points must be about uniform and all points must be about the same distance from the collector or anode in order that each emitting point be subjected to the same electric field. FIGS. 1, 2 and 3 disclose particular embodiments of oxide-metal composites or emitters 10 for field effect emission of electrons and may comprise approximately 10^6 metal fibers 12 arranged uniformly in spaced apart relationship for simultaneously or randomly emitting electrons from one end thereof when subjected to an electric field. Metal fibers 12 or rods are supported and insulated from adjacent rods by filler 14. The emitting fibers or rods 12 may be tungsten (W) or other low vapor pressure metals that may be arranged as a vast plurality of substantially parallel fibers. The oxide matrix 14 providing the insulating filler for fibers 12 may be of any suitable oxide such as uranium oxide (UO_2) or zirconium oxide (ZrO_2).

FIG. 4 is typical of the field effect emitter employed in an electron tube. Emitter composite 10 has a support face joined as by brazing or soldering to a conductive backing plate 22 whereby the cathode potential is provided to emitting fibers 12. An anode structure 24 is spaced apart from emitter 12. When a potential is placed across the two electrodes, electric field lines developed between the electrodes concentrate at one end on the ends of fibers 12 and at the other end along the anode surface. Since the field, as represented by the field lines, concentrates on the emitter fiber ends electrons are emitted from the fiber. The electrons then travel along the field lines to the anode, producing electron flow in the system. The amount of current flow from a given emitter depends on the electric field or potential applied to the anode. The fibers need not protrude above the oxide for operation of the device.

FIG. 1 discloses emitting ends 18 or rods 12 to be common with surface 16 of oxide 14 and FIG. 2 discloses rod ends 18 terminating below the oxide surface with a void region 20 thereabove. A predetermined variable time of chemical etching is employed to provide the desired separation between surface 16 and the plane of rod ends 18. Etching of rods 12 to some level below the oxide surface is desirable, for example, in the event that a separate conductive element is to be joined directly to the oxide surface. As shown in FIG. 4, the field lines tend to concentrate at the metal tips. This occurs regardless of whether the tips extend above the oxide surface, are flush with the surface or are below the surface. These configurations allow emitter operation at lower field values with limiting of the maximum current density of the composite.

In FIG. 3 the emitting ends 18 or rods 12 are shown projecting above oxide surface 16. Chemical etching of the oxide provides the desired amount of rod exposure.

The etching also results in a tapered or sharpened end which enhances electron field emission.

In typical electron tube operation, FIG. 5 discloses a general curve of current density and electric field buildup for an applied voltage across a field effect emitter and anode structure. The current density varies with the quantity of emitter fibers, which shifts the curve laterally for specific structures. FIG. 6 shows the increase in current density as the electrodes spacing is decreased. Accurate spacing for specific requirements may be achieved by depositing or placing an electrode film on the oxide matrix surface wherein the fibers have been etched below the surface.

The oxide-metal, field effect electron emitter provides for improved electron emission, structural compactness, and reduced components over prior art emitters. The thermionic emitter, the usual emitter for electronic devices, usually operates only at temperatures above 800° C. The field effect electron emitter operates at the prevailing ambient temperatures. It differs from the sharp point field effect emitter which is primarily a laboratory device in that it comprises an oxide-metal matrix in which metal fibers are separated by non-conducting oxides and wherein it is not necessary for a sharp point to extend beyond the surface for proper operation. The field effect emitter parameters can be controlled by controlling growth rates of the metal-oxide composites such that the composite can be tailored for individual sizes and configurations.

A preferred embodiment of the invention has been chosen for purposes of illustration and description. The preferred embodiment illustrated is not intended to be exhaustive nor to limit the invention to the precise form disclosed. It is chosen and described in order to best explain the principles of the invention and the application thereof in practical use to thereby enable others skilled in the art to best utilize the invention in various embodiments and modifications as are best adapted to the particular use contemplated. It will be apparent to those skilled in the art that changes may be made in the form of the structure disclosed without departing from the spirit of the invention as set forth in the disclosure. It is, therefore, to be understood that within the scope of the appended claims, the invention may be practiced

otherwise than as specifically described. Accordingly, it is desired that the scope of the invention be limited only by the appended claims.

We claim:

1. An ambient temperature cathode comprising: an electron emitter having a plurality of minute, parallel, conductive rods, said rods having first ends thereof terminated in a plane for emitting electrons therefrom, each of said rods being a low vapor pressure metal having a diameter less than one micron, a conductive backing plate in common with the second end of each of said rods for conveying an electrical potential thereto, and said emitter having more than a million metal rods for each square centimeter of emitter surface area.
2. An ambient temperature cathode as set forth in claim 1 and further comprising an insulating filler encompassing said conductive rods for insulating each rod from adjacent rods.
3. A cathode as set forth in claim 2 wherein said rods are tungsten said filler is a uranium oxide matrix, and said metal rods terminate in a plane forming the surface of said matrix.
4. A field effect electron emitter for use in electron tubes comprising: a plurality of parallel metal fibers, an insulating oxide matrix encompassing and supporting said fibers, a conductive backing plate in common with a first end of each of said fibers for supplying an electrical potential thereto, the other ends of said fibers forming a plane for emitting electrons therefrom at prevailing ambient temperatures, and approximately one million parallel fibers for each square centimeter of emitter surface, said fibers having a diameter less than one micron and being evenly spaced apart for providing a uniform electric field across the equal potential surface thereof.
5. An electron emitter as set forth in claim 4 wherein said metal fibers extend a uniform distance beyond the surface of said oxide for enhancing electron field emission.
6. An electron emitter as set forth in claim 4 wherein said fibers are recessed a uniform distance below the surface of said oxide and said oxide is uranium oxide.

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