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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

REPLY TO
ATTN OF: GP

TO: USI/Scientific & Technical Information Division
Attention: Miss Winnie M. Morgan

FROM: GP/Office of Assistant General Counsel for
Patent Matters

SUBJECT: Announcement of NASA-Owned U. S. Patents in STAR

In accordance with the procedures agreed upon by Code GP and Code USI, the attached NASA-owned U. S. Patent is being forwarded for abstracting and announcement in NASA STAR.

The following information is provided:

U. S. Patent No. : 3,540,989

Government or Corporate Employee : California Institute of Technology Pasadena, California

Supplementary Corporate Source (if applicable) : JPL

NASA Patent Case No. : XNP-09469

NOTE - If this patent covers an invention made by a corporate employee of a NASA Contractor, the following is applicable:
Yes [x] No [ ]

Pursuant to Section 305(a) of the National Aeronautics and Space Act, the name of the Administrator of NASA appears on the first page of the patent; however, the name of the actual inventor (author) appears at the heading of Column No. 1 of the Specification, following the words ". . . with respect to an invention of . . ."

Elizabeth A. Carter

Elizabeth A. Carter
Enclosure
Copy of Patent cited above

FACILITY FORM 602

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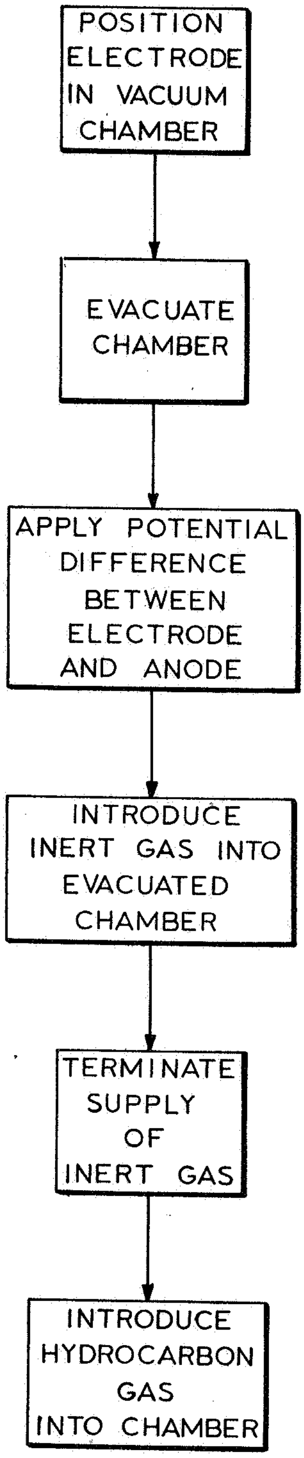
Nov. 17, 1970 JAMES E. WEBB 3,540,989

ADMINISTRATOR OF THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROCESS FOR REDUCING SECONDARY ELECTRON EMISSION

Filed June 8, 1967



N71-25555 40%

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1543

United States Patent Office

3,540,989

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PROCESS FOR REDUCING SECONDARY ELECTRON EMISSION

James E. Webb, Administrator of the National Aeronautics and Space Administration, with respect to an invention of Hubert Erpenbach, Pasadena, Calif.

Filed June 8, 1967, Ser. No. 645,573

Int. Cl. H01j *43/02*

U.S. Cl. 204—168 1 Claim

ABSTRACT OF THE DISCLOSURE

A method of depositing a hard coat of carbon on the surface of a metallic element, consisting of placing the element in a chamber, evacuating the chamber and applying a potential between the element and an anode, the element being at the lower potential. Then an inert ionizable gas is injected into the chamber at a controlled rate and pressure. It produces surface glowing which cleans the metallic surface. Thereafter, the supply of the inert gas is terminated, and while the potential is applied, a carbon-containing gas is injected into the chamber. The gas ionizes, with carbon ions being attracted by the element to form a hard carbon film thereon.

ORIGIN OF THE INVENTION

The invention described herein was made in the performance of work under a NASA contract and is subject to the provisions of Section 305 of the National Aeronautics and Space Act of 1958, Public Law 85–568 (72 Stat. 435; 42 U.S.C. 2457).

BACKGROUND OF THE INVENTION

Field of the invention

This invention relates to a method of treating metal surfaces and, more particularly, to a method of treating surfaces of metals through which energy is transmitted to reduce the secondary emission of electrons therefrom.

Description of the prior art

The problem of secondary emission and its effect on the efficiency of operation of various electronic devices and systems is well known by those familiar with the field of electronics. For example, secondary emission occurs in various electron discharge devices, such as vacuum tubes, as well as in waveguide sections in electron tubes used in high frequency communication.

Herebefore, various techniques have been developed to reduce secondary emission in vacuum tubes or the like by carbon-coating the electrodes, such as the anode and/or grids, which are the sources of the secondary emitted electrons. The carbon coating is generally accomplished by heating the electrode to be coated in a conventional manner, while passing a carbon-containing gas thereover. As a result, the carbon gas cracks with some of the carbon adhering to the heated electrode.

Although when employing prior art techniques, some carbon coating is achieved, the coating or carbon film is of an amorphous structure which is only loosely bonded to the electrodes. Consequently, the reduction in the secondary emission is quite limited. Known methods are inadequate whenever it is necessary to practically eliminate secondary emission. Their inadequacy was experienced when attempting to employ them in treating elements, used in a space communication system in which it is vital to practically eliminate secondary emission to optimize the system's efficiency or transmission power.

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OBJECTS AND SUMMARY OF THE INVENTION

Accordingly, it is a primary object of this invention to provide a new method for treating elements to reduce secondary emission therefrom.

Another object of this invention is to provide a new improved method in which elements are coated in a novel manner so as to minimize secondary emission therefrom.

A further object of this invention is the provision of a new method of carbon coating elements to produce a satisfactory carbon film thereon, in order to substantially eliminate secondary emission therefrom.

Still a further object of this invention is to provide a new method in which novel steps are employed to produce a carbon film on an element subjected to electron bombardment in order to substantially eliminate secondary emission therefrom.

These and other objects of the invention are achieved by providing a method in which an element which may be subjected to electron bombardment is first cleaned by ionization bombardment. This is accomplished by connecting the element as a potentially negative cathode with respect to a potentially positive anode and passing over the cathode an ionizable gas, whose ions bombard the cathode. The ion bombardment causes the cathode to glow, thoroughly cleaning its surface. Thereafter, while the potential between the cathode-forming element and the anode is maintained, a carbon-containing gas is passed over the element. As a result of the potential difference, the gas is decomposed or ionized with free carbon ions coating the element. The film of carbon formed on the potentially charged element is hard, forming a very tight interfacial bond with the element. Such a film greatly reduces any secondary emission from the element when the element is subjected to electron bombardment in subsequent conventional usage.

The novel features that are considered charactristic of this invention are set forth with particularity in the appended claims. The invention will best be understood from the following description when read in connection with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

The drawing is a simplified process block diagram of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Although the teachings of the present invention are applicable for coating any element which may be subjected to electron bombardment in order to minimize secondary emission therefrom, it will be described in conjunction with an exemplary waveguide element. The steps of the novel method may best be explained in conjunction with the drawing in which the various steps are diagrammatically represented as blocks. Therein, the waveguide element is referred to as the electrode, since the invention is applicable for coating any element and is not limited to waveguides only.

In practice, the waveguide element is placed in an evacuable chamber. An electrically conductive element, hereafter also referred to as the anode, is positioned either within the chamber or externally thereof but in proximity to the waveguide element so that an electric field may be produced therebetween. Thereafter, the chamber is evacuated down to approximately 10^{-5} torr, and a high voltage potential is applied between the waveguide and the anode which is spaced apart from it. The potential is preferably in the order of 5 kilovolts, with the anode being at a positive potential with respect to the waveguide element, which can be regarded as the cathode.

As long as there is a vacuum in the chamber, the waveguide element remains unaffected. Then, to clean the surface of the element on which the carbon film is to be applied, an ion-forming gas, preferably inert, such as argon, is admitted into the chamber at controlled rate and pressure. As the argon gas is introduced into the chamber, the outside surface of the waveguide section begins to glow. Finally, as more argon gas is injected, a sparkling potential is produced between the anode and inside the waveguide element, so that the entire internal diameter begins to glow and the glow on the outside surfaces is extinguished. This phenomenon is explainable by the law of Paschen, well known in physics.

The glowing of the inside surfaces of the waveguide element is maintained for a sufficiently long duration, for example 15 minutes, until the surfaces of the element are thoroughly clean. The cleaning is for the purpose of removing occluded gases and other deleterious substances from the surfaces of the waveguide element. The use of ion bombardment to clean the element has been found to be most effective.

After the cleaning step, while the potential difference between the anode and the waveguide section is still applied, the supply of argon is terminated and a carbon-containing gas, such as methane is injected into the chamber. The carbon-containing gas ionizes and disassociates under the influence of the anode-to-waveguide element potential difference. Carbon ions of the disassociated gas strike or bombard the clean surface of the waveguide to form a hard film thereon.

It has been found that film produced on the element surface is very hard and of the polycrystalline type, rather than the porous type produced by prior art methods. Also, due to the energy with which the carbon ions strike the clean surface, a very tight interfacial bond is produced between the element surface and the carbon film. Thus, the carbon film adheres to the waveguide element for an indefinite period.

In one actual reduction to practice, a copper waveguide section was processed in accordance with the teachings of the invention as herebefore disclosed, resulting in a reduction of approximately 95% in the secondary electron emission from the surfaces thereof. The hard polycrystalline type film and the very tight interfacial bond, produced with the element, account for the adherence of the carbon film to the element for practically an indefinite period. Such characteristics may be useful in protecting metallic surfaces, such as copper, for other purposes than reduction of secondary emission. For example, the teachings may be applied to protect metallic surfaces which may be subjected to adverse effects in a non-vacuum environment. For example, instead of coating or plating metals as is done at present to protect them from corrosion or oxidation, they may be protected with a coat of carbon film, bonded to them by the method herein disclosed, to achieve the desired protection.

There has accordingly been shown and described a novel method of coating a metallic surface with a carbon film to reduce secondary emission of the surface as well as to protect it from corrosion and oxidation. It is appreciated that those familiar with the art may make modifications and/or substitute equivalents in the arrangement as shown without departing from the spirit of the invention. Therefore, all such modifications and/or equivalents are deemed to fall within the scope of the invention as claimed in the appended claim.

I claim:

1. A method of producing a hard crystalline film of carbon on the surface of an electron-emissive electrode with which the film produces a tight interfacial bond, the steps comprising:

placing the electrode in an evacuable chamber; evacuating the chamber down to a pressure of about 10^{-5} torr;

applying a potential difference between the electrode and an anode with the electrode being potentially negative with respect to the anode;

injecting an inert gas into said evacuated chamber at a selected rate and pressure to form ions which strike said surface in sufficient number and force to cause the surface to glow during which the surface is cleaned from occluded gases and deleterious substances as a result of the striking ions of said inert gas; and

while said potential difference is applied and the surface of said electrode is glowing, gradually terminating the supply of said inert gas and gradually injecting an ionizable lower hydrocarbon gas into said chamber when the potential difference between said metallic member and said anode is in the order of 5,000 volts, the potential difference causing the formation of carbon ions which strike said metallic member while the surface thereof is glowing to form a hard carbon film thereon which has polycrystalline characteristics.

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ROBERT K. MIHALEK, Primary Examiner

U.S. Cl. X.R.

204—164; 313—107