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NASA/Electronics Research Center
Patent Application Abstract
NASA Case No. ERC-10120

A METHOD FOR THE DEPOSITION OF β-SILICON CARBIDE BY ISOEPITAXY

A method for depositing epitaxial β-silicon carbide films having a high degree of crystallographic perfection is disclosed. The deposition of β-silicon carbide is accomplished by depositing silicon carbide on a substrate having a thin layer of β-silicon carbide.

The single figure of the drawing shows the steps of carrying out the invention. As shown in the figure, a silicon wafer is produced by any well-known technique. The silicon wafer is then heated in a high vacuum with a very low partial pressure of unsaturated hydrocarbon to convert a surface layer of the silicon wafer to β-silicon carbide. Silicon carbide is then deposited on this thin film of β-silicon carbide by evaporation, sputtering, or vapor deposition. The invention provides a method for growing a relatively thick film of single crystal β-silicon carbide.

The novelty of the invention resides in the method of depositing β-SiC films on a substrate of β-SiC that has been formed on a wafer of silicon by heating the silicon wafer in a high vacuum with a very low partial pressure of unsaturated hydrocarbon. The disclosed method can be used to fabricate electronic components used in the space program. β-silicon carbide is used for the fabrication of high temperature microelectronic components and in the fabrication of electroluminescent display devices. Prior to this invention no completely satisfactory method for growing thick films, one micron or above, of β-SiC had been devised.

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EMPLOYER: National Aeronautics and Space Administration /ERC

CONTRACT NO.: N/A

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PATENT APPLICATION NO.: 827597

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NASA Case No. ERC-10120 H.E.Farmer/Kor-S&H(AL)

APPLICATION FOR LETTERS PATENT

TO ALL WHOM IT MAY CONCERN:

BE IT KNOWN THAT Kazi E. Haq

a citizen of the United States of America, an employee of the United States Government,

and resident of Concord, Massachusetts

has invented certain new and useful improvements in A METHOD FOR THE DEPOSITION OF β-SILICON CARBIDE BY ISOEPITAXY

of which the following is a specification:

GPO 868-402-3

A METHOD FOR THE DEPOSITION OF β-SILICON CARBIDE BY ISOEPITAXY

Abstract of the Disclosure

A method for depositing epitaxial β-silicon carbide (β-SiC) films having a high degree of crystallographic perfection is disclosed. The method comprises the steps of: (1) converting a surface layer of a silicon wafer to β-SiC by placing the silicon wafer in a high vacuum with a low partial pressure of unsaturated hydrocarbon; and (2) depositing SiC by evaporation, sputtering or chemical vapor deposition on the thin β-SiC layer formed by step (1).

Origin of the Invention

Background of the Invention

This invention relates generally to β-SiC semiconductors, and more specifically, to a method for depositing β-SiC film by isoepitaxy.

The utility of β-silicon carbide as a component in semiconductor devices is well known, for example, as a high temperature microelectronic component, or as electroluminescent display devices, and considerable effort has been expended to fabricate these devices. However, prior art attempts to grow thick films one micron or above of β-SiC have not been entirely successful. Thin films (500 Å - 1000 Å) of β-SiC almost entirely free from structural defects have been grown by the prior art methods. For example, present techniques heat a silicon wafer in

a high vacuum with a very low partial pressure of unsaturated hydrocarbon to convert a surface layer of the Si wafer to β-SiC. However, since the SiC techniques process depend on interdiffusion of silicon and carbon through Si, the crystallographic perfection of the converted layer is limited. However, if the film thickness is increased to the micron range, structural defects such as stacking faults and dislocations appear.

Summary of the Invention

The present invention provides a method for growing relatively thick films of single crystal β-SiC on a β-SiC substrate. The films assume the crystalline structure of the substrate. The method comprises first converting to β-SiC a very thin layer of a silicon wafer. The layer of β-SiC is then used as a substrate for deposition of β-SiC by techniques such as evaporation, sputtering or chemical vapor deposition.

It is therefore an object of this invention to provide a method for depositing a film of β-silicon carbide having a high degree of crystallographic perfection on a substrate.

A further object of this invention is to provide a method for the deposition of β-silicon carbide on a β-silicon carbide substrate.

Another object of this invention is to provide a method for the deposition of β-silicon carbide by isoepitaxy.

Brief Description of the Drawing

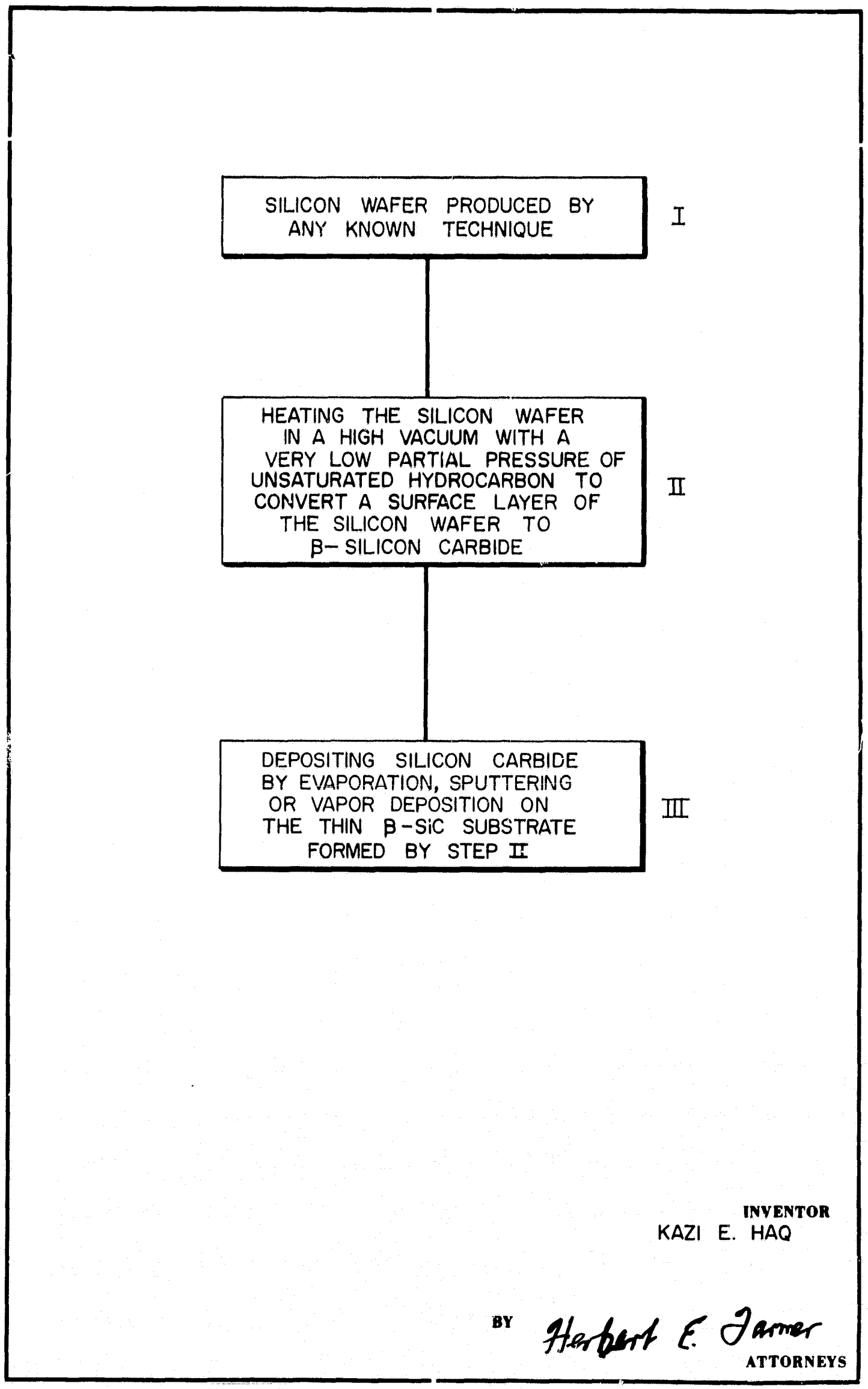
The above mentioned and other objects of the invention will become readily apparent from the following detailed description of the invention when read in conjunction with the annexed drawing in which the single figure shows the steps of the invention.

Description of the Invention

Referring now to the drawing which shows the steps of the method of this invention, Step I involves the production of a silicon wafer. This silicon wafer may be produced by any one of the well-known methods. In Step II the silicon wafer is heated in a high vacuum with a very low partial pressure of unsaturated hydrocarbon. In Step II a surface layer of the silicon is converted to β-silicon carbide. Growth studies, together with electron diffraction observations, suggest that the mechanism of β-silicon carbide film growth involves substitution of carbon for the silicon in the silicon crystal. The substitution leads to a parallel epitaxial relationship between SiC and Si, as can be observed by electron diffraction. The reaction at the Si surface results initially in the formation of a thin film of β-SiC on the silicon wafer. The β-SiC film thus formed is a single crystal up to a certain thickness. Beyond this thickness the film becomes polycrystalline. Step II, therefore, if carried beyond a certain point, one micron, yields a device having an ill-defined Si-SiC interface, which is not desirable for electronic applications.

To obtain satisfactory films thicker than those obtainable by Step II, Step III of the invention is performed. In Step III, SiC is deposited on the thin β-SiC film produced by Step II. The silicon carbide is deposited on the β-SiC substrate by evaporation, sputtering or vapor deposition. The silicon carbide so deposited assumes the crystalline structure of β-SiC substrate.

The method just described provides a means for readily growing β-SiC films. Compared to other known methods it is easier to deposit single crystalline films by isoepitaxy. Furthermore, films developed by the method of this invention have a high degree of crystalline perfection. This invention meets the present need in the industry for relatively thick single crystal β-SiC films. In addition, it should be noted that the entire film growing process can be carried out in a single pump down of the vacuum chamber if in Step III a vacuum deposition process such as evaporation of sputtering is utilized.



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