GRADED INDEX SILICON GERANIUM ON LATTICE MATCHED SILICON GERANIUM SEMICONDUCTOR ALLOY

Inventors: Yeonjoon Park, Yorktown, VA (US); Sang H. Choi, Poquoson, VA (US); Glen C. King, Yorktown, VA (US); James R. Elliott, Jr., Yorktown, VA (US); Diane M. Stoakley, Yorktown, VA (US)

Assignee: The United States of America as represented by the Administrator of the National Aeronautics and Space Administration, Washington, DC (US)

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See application file for complete search history.

24 Claims, 3 Drawing Sheets

ABSTRACT

A lattice matched silicon germanium (SiGe) semiconductive alloy is formed when a {111} crystal plane of a cubic diamond structure SiGe is grown on the {0001} C-plane of a single crystalline Al₂O₃ substrate such that a <110> orientation of the cubic diamond structure SiGe is aligned with a <1,-1,0> orientation of the {0001} C-plane. A lattice match between the substrate and the SiGe is achieved by using a SiGe composition that is 0.7223 atomic percent silicon and 0.2777 atomic percent germanium. A layer of Si₁₋ₓGeₓ is formed on the cubic diamond structure SiGe. The value of x (i) defines an atomic percent of germanium satisfying 0.2277 < x < 1.0, (ii) is approximately 0.2777 where the layer of Si₁₋ₓGeₓ interfaces with the cubic diamond structure SiGe, and (iii) increases linearly with the thickness of the layer of Si₁₋ₓGeₓ.
**FIG. 3**

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GRADED INDEX
Si_{1-x} Ge_x

LATTICE MATCHED Si Ge

Single Crystalline
Al_2 O_3
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**FIG. 4A**

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Si, Ge, or Si_{1-y} Ge_y

GRADED INDEX
Si_{1-x} Ge_x

LATTICE MATCHED Si Ge

Single Crystalline
Al_2 O_3
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GRADED INDEX SILICON GERANIUM ON LATTICE MATCHED SILICON GERANIUM SEMICONDUCTOR ALLOY

ORIGIN OF THE INVENTION

The invention was made in part by employees of the United States Government and may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to semiconductive structures made from silicon germanium. More specifically, the invention is a lattice matched silicon germanium semiconductive alloy having at least one graded index silicon germanium layer deposited thereon.

2. Description of the Related Art

Silicon germanium (SiGe) is an important semiconductive alloy used in Field Effect Transistors (FETs), High Electron Mobility Transistors (HEMTs), Hetero Bi-polar Transistors (HBTs), Thermo-Electric (TE) devices, photovoltaic solar cells, and photon detectors. Typically, SiGe is grown on common silicon wafer substrates. However, the growth of thick (i.e., greater than tens of nanometers), high-quality (i.e., defect free) SiGe layers on a silicon substrate is difficult because SiGe has a larger lattice constant than silicon. This means that the SiGe layers close to the silicon substrate are strained while severe defects (e.g., threading dislocations, micro twigs, cracks, delaminations, etc.) develop in the layers of SiGe that exceed the critical thickness of hundreds of nanometers because of the lattice mismatch. Thus, at best, only strained SiGe layers with very thin thicknesses (i.e., less than hundreds of nanometers) are utilized for high-quality electronic device fabrication.

Recently, methods for making thicker high-quality SiGe semiconductive alloys were disclosed in U.S. patent application Ser. No. 11/242,415, filed Sep. 27, 2005, the entire contents of which are incorporated by reference. In this application, a lattice matched SiGe semiconductive alloy and method of fabricating same are provided. A substrate of single crystalline Al₂O₃, having a {0001} C-plane is exposed. A {111} crystal plane of a cubic diamond structure SiGe is grown on the {0001} C-plane such that a <110> orientation of the cubic diamond structure SiGe is aligned with a <1,0,-1,0> orientation of the {0001} C-plane. A lattice match between the single-crystal Al₂O₃ and the cubic diamond structure SiGe is achieved by using a SiGe composition that is 0.7223 atomic percent silicon and 0.2777 atomic percent germanium. A layer of Si₁ₓGeₓ is formed on the cubic diamond structure SiGe so-grown on the {0001} C-plane. The value of X defines an atomic percent of germanium satisfying 0.2277<X<1.0. Further, the value of X is approximately 0.2777 where the layer of Si₁ₓGeₓ interfaces with the cubic diamond structure SiGe, and increases linearly with the thickness of the layer of Si₁ₓGeₓ.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A depicts a simplified view of the atomic structure of single crystalline aluminum oxide (Al₂O₃) sapphire;
FIG. 1B depicts an atomic, planar view of the {0001} C-plane of single crystalline Al₂O₃;
FIG. 2A depicts the cubic diamond atomic structure of silicon and germanium;
FIG. 2B depicts an atomic, planar view of the {111} crystal plane of the cubic diamond structure of FIG. 2A;
FIG. 3 is a schematic view of an embodiment of the present invention in which a graded index silicon germanium (SiGe) layer is on top of a lattice matched SiGe alloy;
FIG. 4A is a schematic view of another embodiment of the present invention in which a strained layer is on top of the graded index SiGe layer;
FIG. 4B is a schematic view of another embodiment of the present invention in which two graded index layers are on top of a lattice matched SiGe alloy;
FIG. 4C is a schematic view of another embodiment of the present invention in which a strained layer is between two graded index SiGe layers; and
FIG. 4D is a schematic view of another embodiment of the present invention in which a super lattice is formed by multiple repeats of a strained layer between graded index SiGe layers.

DETAILED DESCRIPTION OF THE INVENTION

The silicon germanium (SiGe)-based semiconductive structure of the present invention includes a high-quality (i.e., free of defects and dislocations) silicon germanium (SiGe) semiconductive alloy. The SiGe semiconductive alloy and the fabrication thereof are described in detail in the above-referenced patent application Ser. No. 11/242,415, filed Sep. 27, 2005, the entire contents of which are incorporated by refer-
The hexagonal relationship with atoms at the vertices where the dark shaded circles represent atoms in the {111} crystal plane of the cubic diamond structure. FIG. 2B depicts a planar view the shortest atomic distance (between atoms) lattice constant perfect or miscut C-plane thereof are well known in C-plane as well as slightly miscut single crystalline Al₂O₃ where BG, is the side dimension lattice constant of germanium composition Z in atomic percent, the lattice constant for B (and, therefore B') is dependent on the composition of the group of six similar planes (i.e., atomic distance between atoms) of "A" and (3)/2. For a SiGe alloy having a cubic diamond structure, the relationship between B and the cubic diamond structure is B = B₀ (sqrt (3)/2). For a SiGe alloy having a cubic diamond structure, the value for B and, therefore B' is dependent on the composition of the alloy. That is, for the general Si₁₋ₓGeₓ alloy with germanium composition Z in atomic percent, the lattice constant B₉₋ₓ₂₋ₓ is defined by

\[ B_{9-x,2-x} = \sqrt{2} B_9 (1-Z) B_{10} \]

where B₉₋ₓ₂₋ₓ is the side dimension lattice constant of germanium (i.e., 5.65791 angstroms), and Bₓ is the side dimension lattice constant of silicon (i.e., 5.43107 angstroms). Applying the above relationships, B₀ is equal to approximately 5.49066 angstroms and the lattice constant B₉₋ₓ₂₋ₓ in the [111] crystal plane of the cubic diamond structure SiGe is equal to approximately 4.5780 angstroms when Z=0.2777.

Thus, defect and dislocation-free SiGe growth is achieved by a lattice matching technique that defines the (i) plane and orientation relationships between cubic diamond SiGe and the Al₂O₃ substrate, and (ii) the composition of the cubic diamond SiGe. For lattice matched SiGe growth on single crystalline Al₂O₃, the {111} crystal plane of cubic diamond SiGe is grown on the {0001} C-plane of single crystalline Al₂O₃. Growth is controlled such that the <110> orientation of cubic diamond SiGe is aligned (i.e., parallel to) with the <1,0,-1,0> orientation of the {0001} C-plane.

The above described plane/orientation alignment achieves an exact lattice match when the cubic diamond SiGe, having a general composition defined by Si₁₋ₓGeₓ, has a germanium composition of 0.2777 atomic percent and a silicon composition of 0.7223 atomic percent. At this composition, the lattice constant B₉₋ₓ₂₋ₓ is given by

\[ B_{9-x,2-x} = 4.5780 \text{ angstroms} \]

which equates to 4.7580 angstroms for Z=0.2777, thereby exactly matching the lattice constant A of single crystalline Al₂O₃. Therefore, by what amounts to a rhombohedral transformation of lattice parameters, lattice matching between cubic diamond SiGe and the single crystalline Al₂O₃ is achieved during the growth process thereby eliminating defects and dislocations caused by lattice mismatches. The lattice matching provided by the present invention will allow a thick, high-quality semiconductive SiGe alloy to be grown for use in a wide variety of electronic devices.

The above-described alloy fabrication can be achieved in a variety of ways. For example, the single crystalline Al₂O₃ can be obtained commercially or manufactured. The single crystalline Al₂O₃ substrate can be cleaned with degreasing and/or etching process before growth of the SiGe semiconductive alloy thereon. Lattice matched SiGe layer(s) can be grown with various standard growth methods, including but not limited to, Molecular Beam Epitaxy (MBE), Metal-Organic Chemical Vapor Deposition (MOCVD), Metal-Organic Chemical Vapor Phase Epitaxy (MOVPE), Hydride Vapor Phase Deposition (HVPE), Liquid Phase Epitaxy (LPE), Physical Vapor Deposition (PVD), Pulsed Laser Deposition (PLD), and sputtering methods. Germanium contents can be measured and calibrated with standard techniques, including but not limited to, Secondary Ion Mass Spectroscopy (SIMS), X-ray Diffraction (XRD), and ellipsometry.

To fabricate the final device structures, standard microfabrication technologies can be used, including but not limited to, lithography, etching, metallization, dopant diffusion/implantation and oxidation. The resulting cubic diamond SiGe on single crystalline Al₂O₃ can be used as is or can be removed from the substrate after growth to a desired thickness. Such methods of removal are well known in the art and could include laser cutting, hydrogen cracking, etc., the choice of which is not a limitation of the present invention.

In accordance with an embodiment of the present invention, the above-described SiGe semiconductive alloy serves as the base for a layer of graded index SiGe as will now be described with the aid of FIG. 3. In FIG. 3, the above-described single crystalline Al₂O₃ is referenced by numeral 30 and the above-described lattice matched SiGe is referenced by numeral 32. In general, a layer 34 of graded index SiGe is formed (e.g., grown) on the cubic diamond SiGe of the described SiGe semiconductive alloy where the composition of layer 34 is of the form Si₁₋ₓGeₓ. The value of X defines the atomic percent of germanium in layer 34. More specifically,
the value of X increases linearly with the thickness T of layer 34 as illustrated by the graph of germanium content adjacent layer 34 in FIG. 3. The minimum value of X or X_{MIN} is at the interface of layers 32 and 34 while the maximum value of X or X_{MAX} is at the full thickness T of layer 34. For the lattice matched SiGe layer 32, the minimum value X_{MIN} should be approximately equal to 0.2777 or the germanium content of lattice matched layer 32. While the best results are achieved when X_{MIN} equals the germanium content of 0.2777 of layer 32, the term "approximately" as used here is meant to define an acceptable range for X_{MIN} satisfying 0.2277<X_{MIN}<0.3277. The maximum value X_{MAX} should satisfy the relationship X_{MAX}<1.0.

The advantages of the above-described structure are numerous. The structure does not create abrupt strain build-up at the interface between layers 32 and 34. Therefore, the present invention provides a reduced number of misfit dislocations as the strain between the layers can be relaxed over a wide range of thicknesses of layer 34. Further, the structure does not present an abrupt potential barrier at the interface between layers 32 and 34. Therefore, the present invention can continuously change the conduction and valence bands to reduce carrier scattering. Still further, the structure slowly changes the bandgap energy so that a continuously varying quantum well can be constructed using the graded index SiGe layer. There is also no abrupt change in the index of refraction so the disclosed structure can reduce light scattering at the interface between layers 32 and 34. Thus, a very smooth waveguide could be constructed using the graded index SiGe layer. Finally, once the graded index SiGe layer is made on the lattice matched SiGe layer on sapphire, strain can be applied to the graded index SiGe layer in a compressive way with a greater germanium content or in a tensile way with a lesser germanium content. Therefore, the present invention provides a number of options in terms of designing the lattice strain factor.

The above-described embodiment of the present invention can be used as the basis for a number of other SiGe-based semiconductive structures. Several non-limiting examples of such semiconductive structures are illustrated in FIGS. 4A-4D. In FIG. 4A, a strained layer 36 is formed on top of the graded index SiGe layer 34. The composition of layer 36 can be pure silicon, pure germanium, or a silicon germanium composition of the general form Si_{1-X}Ge_{X}, where X is the atomic percent of germanium that satisfies the relationship 0.0<Y<1.0. In FIG. 4B, another structure is illustrated where a reverse graded index SiGe layer 38 is formed on layer 34. The composition of layer 38 is of the general form Si_{1-X}Ge_{X}, where X defines the atomic percent of germanium in layer 38. More specifically, the value of X decreases linearly with the thickness T of layer 38 as illustrated by the graph of germanium content adjacent layer 38 in FIG. 4B. The maximum value of X or X_{MAX} is at the interface of layers 34 and 38 while the minimum value of X or X_{MIN} is at the full thickness T of layer 38. The maximum value X_{MAX} should be approximately equal to the maximum value X_{MAX} of the germanium content of layer 34. In the present invention using lattice matched SiGe, the minimum value X_{MIN} should satisfy the relationship 0.2277<X_{MIN}<X_{MAX}. As would be understood by one of ordinary skill in the art, the structure of layers 34 and 38 can be repeated to form a super lattice.

In FIG. 4C, a single embedded strained layer 40 can be (i) grown between layers 34 and 38 by means of sequential epitaxial growth, or (ii) inserted after growth by means of ion implantation as would be well understood in the art. The composition of layer 40 can be pure silicon, pure germanium, or a silicon germanium composition of the general form Si_{1-X}Ge_{X}, where X is the atomic percent of germanium that satisfies the relationship 0.0<Y<1.0. In FIG. 4D, a super lattice structure is illustrated. In this example, the super lattice includes repeats of strained layer 40 interleaved with alternating ones of layers 34 and 38. The composition of each layer 40 can be pure silicon, pure germanium, or a silicon germanium composition of the general form Si_{1-X}Ge_{X}, where Y is the atomic percent of germanium that satisfies the relationship 0.0<Y<1.0.

Although the invention has been described relative to specific embodiments thereof, there are numerous variations and modifications that will be readily apparent to those skilled in the art in light of the above teachings. It is therefore to be understood that, within the scope of the appended claims, the invention may be practiced other than as specifically described.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

The invention claimed is:

1. A silicon germanium (SiGe)-based semiconductive structure adapted to be grown on a [0001] C-plane of single crystalline Al_{2}O_{3}, comprising:
a cubic diamond structure SiGe having 0.7223 atomic percent silicon and 0.2777 atomic percent germanium, said cubic diamond structure SiGe having a [111] crystal plane adapted to be grown on the [0001] C-plane such that a <110> orientation of said cubic diamond structure SiGe is aligned with a <1,0,-1,0> orientation of the [0001] C-plane, and
a layer of Si_{x}Ge_{y} on said cubic diamond structure SiGe so-grown on the [0001] C-plane, wherein X
(i) defines an atomic percent of germanium satisfying 0.2277<X<1.0,
(ii) is approximately 0.2777 where said layer of Si_{x}Ge_{y} interfaces with said cubic diamond structure SiGe, and
(iii) increases linearly with the thickness of said layer of Si_{x}Ge_{y} to a maximum value X_{MAX}.

2. A SiGe-based semiconductive structure as in claim 1 further comprising pure silicon on said layer of Si_{x}Ge_{y}.

3. A SiGe-based semiconductive structure as in claim 1 further comprising pure germanium on said layer of Si_{x}Ge_{y}.

4. A SiGe-based semiconductive structure as in claim 1 further comprising pure silicon on said layer of Si_{x}Ge_{y}.

5. A SiGe-based semiconductive structure as in claim 1 further comprising a layer of Si_{x}Ge_{y} on said layer of Si_{x}Ge_{y}.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

The invention claimed is:

1. A silicon germanium (SiGe)-based semiconductive structure adapted to be grown on a [0001] C-plane of single crystalline Al_{2}O_{3}, comprising:
a cubic diamond structure SiGe having 0.7223 atomic percent silicon and 0.2777 atomic percent germanium, said cubic diamond structure SiGe having a [111] crystal plane adapted to be grown on the [0001] C-plane such that a <110> orientation of said cubic diamond structure SiGe is aligned with a <1,0,-1,0> orientation of the [0001] C-plane, and
a layer of Si_{x}Ge_{y} on said cubic diamond structure SiGe so-grown on the [0001] C-plane, wherein X
(i) defines an atomic percent of germanium satisfying 0.2277<X<1.0,
(ii) is approximately 0.2777 where said layer of Si_{x}Ge_{y} interfaces with said cubic diamond structure SiGe, and
(iii) increases linearly with the thickness of said layer of Si_{x}Ge_{y} to a maximum value X_{MAX}.

2. A SiGe-based semiconductive structure as in claim 1 further comprising pure silicon on said layer of Si_{x}Ge_{y}.

3. A SiGe-based semiconductive structure as in claim 1 further comprising pure germanium on said layer of Si_{x}Ge_{y}.

4. A SiGe-based semiconductive structure as in claim 1 further comprising pure silicon on said layer of Si_{x}Ge_{y}.

5. A SiGe-based semiconductive structure as in claim 1 further comprising a layer of Si_{x}Ge_{y} on said layer of Si_{x}Ge_{y}.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

The invention claimed is:

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a cubic diamond structure SiGe having 0.7223 atomic percent silicon and 0.2777 atomic percent germanium, said cubic diamond structure SiGe having a [111] crystal plane adapted to be grown on the [0001] C-plane such that a <110> orientation of said cubic diamond structure SiGe is aligned with a <1,0,-1,0> orientation of the [0001] C-plane, and
a layer of Si_{x}Ge_{y} on said cubic diamond structure SiGe so-grown on the [0001] C-plane, wherein X
(i) defines an atomic percent of germanium satisfying 0.2277<X<1.0,
(ii) is approximately 0.2777 where said layer of Si_{x}Ge_{y} interfaces with said cubic diamond structure SiGe, and
(iii) increases linearly with the thickness of said layer of Si_{x}Ge_{y} to a maximum value X_{MAX}.

2. A SiGe-based semiconductive structure as in claim 1 further comprising pure silicon on said layer of Si_{x}Ge_{y}.

3. A SiGe-based semiconductive structure as in claim 1 further comprising pure germanium on said layer of Si_{x}Ge_{y}.

4. A SiGe-based semiconductive structure as in claim 1 further comprising pure silicon on said layer of Si_{x}Ge_{y}.

5. A SiGe-based semiconductive structure as in claim 1 further comprising a layer of Si_{x}Ge_{y} on said layer of Si_{x}Ge_{y}.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

The invention claimed is:

1. A silicon germanium (SiGe)-based semiconductive structure adapted to be grown on a [0001] C-plane of single crystalline Al_{2}O_{3}, comprising:
a cubic diamond structure SiGe having 0.7223 atomic percent silicon and 0.2777 atomic percent germanium, said cubic diamond structure SiGe having a [111] crystal plane adapted to be grown on the [0001] C-plane such that a <110> orientation of said cubic diamond structure SiGe is aligned with a <1,0,-1,0> orientation of the [0001] C-plane, and
a layer of Si_{x}Ge_{y} on said cubic diamond structure SiGe so-grown on the [0001] C-plane, wherein X
(i) defines an atomic percent of germanium satisfying 0.2277<X<1.0,
(ii) is approximately 0.2777 where said layer of Si_{x}Ge_{y} interfaces with said cubic diamond structure SiGe, and
(iii) increases linearly with the thickness of said layer of Si_{x}Ge_{y} to a maximum value X_{MAX}.

2. A SiGe-based semiconductive structure as in claim 1 further comprising pure silicon on said layer of Si_{x}Ge_{y}.

3. A SiGe-based semiconductive structure as in claim 1 further comprising pure germanium on said layer of Si_{x}Ge_{y}.

4. A SiGe-based semiconductive structure as in claim 1 further comprising pure silicon on said layer of Si_{x}Ge_{y}.

5. A SiGe-based semiconductive structure as in claim 1 further comprising a layer of Si_{x}Ge_{y} on said layer of Si_{x}Ge_{y}.
7. A SiGe-based semiconductive structure as in claim 1 further comprising:

pure germanium on said layer of Si$_{1-x}$Ge$_x$ and

a layer of Si$_{1-x}$Ge$_x$ on said pure germanium, wherein X' (i) defines an atomic percent of germanium satisfying $0.2277 < X' < 1.0$,

(ii) is approximately $X_{\text{MAX}}$ where said layer of Si$_{1-x}$Ge$_x$ interfaces with said pure germanium, and

(iii) decreases linearly with the thickness of said layer of Si$_{1-x}$Ge$_x$.

8. A SiGe-based semiconductive structure as in claim 1 further comprising:

a layer of Si$_{1-x}$Ge$_x$ on said layer of Si$_{1-x}$Ge$_x$ wherein Y defines an atomic percent of germanium defined by $0.0 < Y < 1.0$; and

a layer of Si$_{1-x}$Ge$_x$ on said layer of Si$_{1-x}$Ge$_x$, wherein X' (i) defines an atomic percent of germanium satisfying $0.2277 < X' < 1.0$,

(ii) is approximately $X_{\text{MAX}}$ where said layer of Si$_{1-x}$Ge$_x$ interfaces with said layer of Si$_{1-x}$Ge$_x$, and

(iii) decreases linearly with the thickness of said layer of Si$_{1-x}$Ge$_x$.

9. A silicon germanium (SiGe)-based semiconductive structure, comprising:

double crystalline Al$_2$O$_3$ with a [0001] C-plane thereof being exposed;

a cubic diamond structure SiGe having 0.7223 atomic percent silicon and 0.2777 atomic percent germanium, said cubic diamond structure SiGe having a [111] crystal plane grown on said [0001] C-plane such that a $<110>$ orientation of said cubic diamond structure SiGe is aligned with a $<1,0,-1,0>$ orientation of said [0001] C-plane; and

a layer of Si$_{1-x}$Ge$_x$ on said cubic diamond structure SiGe so-grown on said [0001] C-plane, wherein X (i) defines an atomic percent of germanium satisfying $0.2277 < X < 1.0$,

(ii) is approximately 0.2777 where said layer of Si$_{1-x}$Ge$_x$ interfaces with said cubic diamond structure SiGe, and

(iii) increases linearly with the thickness of said layer of Si$_{1-x}$Ge$_x$ to a maximum value $X_{\text{MAX}}$.

10. A SiGe-based semiconductive structure as in claim 9 further comprising pure silicon on said layer of Si$_{1-x}$Ge$_x$.

11. A SiGe-based semiconductive structure as in claim 9 further comprising pure germanium on said layer of Si$_{1-x}$Ge$_x$.

12. A SiGe-based semiconductive structure as in claim 9 further comprising Si$_{1-x}$Ge$_x$ on said layer of Si$_{1-x}$Ge$_x$, wherein Y defines an atomic percent of germanium of approximately 0.2777;

and

a layer of Si$_{1-x}$Ge$_x$ on said cubic diamond structure SiGe so-grown on said [0001] C-plane, wherein X (i) defines an atomic percent of germanium satisfying $0.2277 < X < 1.0$,

(ii) is in the range of 0.2277 to 0.3277 where said layer of Si$_{1-x}$Ge$_x$ interfaces with said cubic diamond structure SiGe, and

(iii) increases linearly with the thickness of said layer of Si$_{1-x}$Ge$_x$ to a maximum value $X_{\text{MAX}}$.

13. A SiGe-based semiconductive structure as in claim 9 further comprising a layer of Si$_{1-x}$Ge$_x$ on said layer of Si$_{1-x}$Ge$_x$, wherein X' (i) defines an atomic percent of germanium satisfying $0.2277 < X' < 1.0$,

(ii) is approximately $X_{\text{MAX}}$ where said layer of Si$_{1-x}$Ge$_x$ interfaces with said layer of Si$_{1-x}$Ge$_x$, and

(iii) decreases linearly with the thickness of said layer of Si$_{1-x}$Ge$_x$.

14. A SiGe-based semiconductive structure as in claim 9 further comprising:

pure silicon on said layer of Si$_{1-x}$Ge$_x$; and

a layer of Si$_{1-x}$Ge$_x$ on said pure silicon, wherein X' (i) defines an atomic percent of germanium satisfying $0.2277 < X' < 1.0$,

(ii) is approximately $X_{\text{MAX}}$ where said layer of Si$_{1-x}$Ge$_x$ interfaces with said pure silicon, and

(iii) decreases linearly with the thickness of said layer of Si$_{1-x}$Ge$_x$.

15. A SiGe-based semiconductive structure as in claim 9 further comprising:

pure germanium on said layer of Si$_{1-x}$Ge$_x$; and

a layer of Si$_{1-x}$Ge$_x$ on said pure germanium, wherein X' (i) defines an atomic percent of germanium satisfying $0.2277 < X' < 1.0$,

(ii) is approximately $X_{\text{MAX}}$ where said layer of Si$_{1-x}$Ge$_x$ interfaces with said pure germanium, and

(iii) decreases linearly with the thickness of said layer of Si$_{1-x}$Ge$_x$.

16. A SiGe-based semiconductive structure as in claim 9 further comprising:

a layer of Si$_{1-x}$Ge$_x$ on said layer of Si$_{1-x}$Ge$_x$ wherein Y defines an atomic percent of germanium defined by $0.0 < Y < 1.0$; and

a layer of Si$_{1-x}$Ge$_x$ on said layer of Si$_{1-x}$Ge$_x$, wherein X' (i) defines an atomic percent of germanium satisfying $0.2277 < X' < 1.0$,

(ii) is approximately $X_{\text{MAX}}$ where said layer of Si$_{1-x}$Ge$_x$ interfaces with said layer of Si$_{1-x}$Ge$_x$, and

(iii) decreases linearly with the thickness of said layer of Si$_{1-x}$Ge$_x$.

17. A silicon germanium (SiGe)-based semiconductive structure adapted to be grown on a [0001] C-plane of single crystalline Al$_2$O$_3$, comprising:

a cubic diamond structure defined by a general form Si$_{1-x}$Ge$_x$ and having a [111] crystal plane grown on the [0001] C-plane such that a $<110>$ orientation of said cubic diamond structure is aligned with a $<1,0,-1,0>$ orientation of said [0001] C-plane; and

a layer of Si$_{1-x}$Ge$_x$ on said cubic diamond structure SiGe so-grown on said [0001] C-plane, wherein X (i) defines an atomic percent of germanium satisfying $0.2277 < X < 1.0$,

(ii) is in the range of 0.2277 to 0.3277 where said layer of Si$_{1-x}$Ge$_x$ interfaces with said cubic diamond structure, and

(iii) increases linearly with the thickness of said layer of Si$_{1-x}$Ge$_x$.

18. A SiGe-based semiconductive structure as in claim 17 further comprising pure silicon on said layer of Si$_{1-x}$Ge$_x$.

19. A SiGe-based semiconductive structure as in claim 17 further comprising pure germanium on said layer of Si$_{1-x}$Ge$_x$.

20. A SiGe-based semiconductive structure as in claim 17 further comprising Si$_{1-x}$Ge$_x$ on said layer of Si$_{1-x}$Ge$_x$, wherein Y defines an atomic percent of germanium of approximately 0.2777;

and

a layer of Si$_{1-x}$Ge$_x$ on said cubic diamond structure so-grown on said [0001] C-plane, wherein X (i) defines an atomic percent of germanium satisfying $0.2277 < X < 1.0$,

(ii) is approximately 0.2777 where said layer of Si$_{1-x}$Ge$_x$ interfaces with said cubic diamond structure, and

(iii) increases linearly with the thickness of said layer of Si$_{1-x}$Ge$_x$.

21. A SiGe-based semiconductive structure as in claim 17 further comprising a layer of Si$_{1-x}$Ge$_x$ on said layer of Si$_{1-x}$Ge$_x$, wherein X' (i) defines an atomic percent of germanium satisfying $0.2277 < X' < 1.0$,

(ii) is approximately $X_{\text{MAX}}$ where said layer of Si$_{1-x}$Ge$_x$ interfaces with said layer of Si$_{1-x}$Ge$_x$, and

(iii) decreases linearly with the thickness of said layer of Si$_{1-x}$Ge$_x$.

22. A SiGe-based semiconductive structure as in claim 17 further comprising:

pure silicon on said layer of Si$_{1-x}$Ge$_x$; and

a layer of Si$_{1-x}$Ge$_x$ on said pure silicon, wherein X' (i) defines an atomic percent of germanium satisfying $0.2277 < X' < 1.0$,
(ii) is approximately \( X_{\text{MAX}} \) where said layer of \( \text{Si}_{1-x}\text{Ge}_x \)
intersects with said pure silicon, and
(iii) decreases linearly with the thickness of said layer of
\( \text{Si}_{1-x}\text{Ge}_x \).

23. A SiGe-based semiconductive structure as in claim 17
further comprising:
pure germanium on said layer of \( \text{Si}_{1-x}\text{Ge}_x \); and
a layer of \( \text{Si}_{1-x}\text{Ge}_x \) on said pure germanium, wherein \( X \)
(i) defines an atomic percent of germanium satisfying
0.2277<\( X' <1.0 \),
(ii) is approximately \( X_{\text{MAX}} \) where said layer of \( \text{Si}_{1-x}\text{Ge}_x \)
intersects with said pure germanium, and
(iii) decreases linearly with the thickness of said layer of
\( \text{Si}_{1-x}\text{Ge}_x \).

24. A SiGe-based semiconductive structure as in claim 17
further comprising:
a layer of \( \text{Si}_{1-x}\text{Ge}_y \) on said layer of \( \text{Si}_{1-x}\text{Ge}_x \) wherein \( Y \)
defines an atomic percent of germanium defined by
0.0<\( Y <1.0 \); and
a layer of \( \text{Si}_{1-x}\text{Ge}_x \) on said layer of \( \text{Si}_{1-x}\text{Ge}_n \) wherein \( X' \)
(i) defines an atomic percent of germanium satisfying
0.2277<\( X' <1.0 \),
(ii) is approximately \( X_{\text{MAX}} \) where said layer of \( \text{Si}_{1-x}\text{Ge}_x \)
intersects with said layer of \( \text{Si}_{1-x}\text{Ge}_n \), and
(iii) decreases linearly with the thickness of said layer of
\( \text{Si}_{1-x}\text{Ge}_x \).