Claims

1. A semiconductor alloy composition, wherein the semiconductor alloy composition is $Ga_{1-x}In_xN_yAs_{1-y-z}Sb_z$, wherein,
the content values for x, y, and z are within composition ranges as follows: $0.07 \leq x \leq 0.18$, $0.025 \leq y \leq 0.04$ and $0.001 \leq z \leq 0.03$;
the content levels are selected such that the semiconductor alloy composition exhibits a bandgap from 0.9 eV to 1.1 eV; and a short circuit current density Jsc greater than 13 mA/cm^2 and an open circuit voltage Voc greater than 0.3 V when illuminated with a filtered 1 sun AM1.5D spectrum in which all light having an energy greater than the bandgap of GaAs is blocked;
the semiconductor alloy composition is characterized by a thickness greater than 1 μm.

2. The semiconductor alloy composition of claim 1, wherein the semiconductor alloy composition is characterized by a thickness from 1 μm to 2 μm.

~~3. The semiconductor alloy composition of claim 1, wherein the semiconductor alloy composition is characterized by a thickness greater than 1 μm.~~

~~4~~3. The semiconductor alloy composition of claim 1, wherein the semiconductor alloy composition is substantially lattice matched to GaAs.

~~5~~4. The semiconductor alloy composition of claim 1, wherein the semiconductor alloy composition is substantially lattice matched to Ge.

~~6~~5. The semiconductor alloy composition of claim 1, wherein the semiconductor alloy composition is n-doped.

~~7~~6. The semiconductor alloy composition of claim 1, wherein the semiconductor alloy composition is p-doped.

~~8~~7. The semiconductor alloy composition of claim 1, wherein the semiconductor alloy composition is in the form of a layer of semiconductor material.

~~9~~8. The semiconductor alloy composition of claim 1, wherein the content values are selected such that the semiconductor alloy composition is lattice matched to GaAs or Ge.

~~10~~9. A multijunction solar cell comprising:
a first subcell comprising the semiconductor alloy composition according to claim 1; and

at least one second subcell overlying the first subcell to form the multijunction solar cell.

~~11~~10. The multijunction solar cell of claim ~~10~~9, comprising a substrate underlying the first subcell, wherein,
the substrate is selected from GaAs and Ge, and
the first subcell is substantially lattice matched to the substrate.

~~12~~11. The multijunction solar cell of claim ~~10~~9, wherein the at least one second subcell is selected from a $Ga_{1-x}In_xN_yAs_{1-y-z}Sb_z$ subcell, a GaInNAs(Sb) subcell, a (Al)(In)GaP subcell, an (In)(Al)GaAs subcell, an (Al)InGaP subcell, and an (In)GaAs subcell.

~~13~~12. The multijunction solar cell of claim ~~10~~9, wherein the first subcell is characterized by a lattice constant that is within 0.5% of the lattice constant of the at least one second subcell when fully relaxed.

~~14~~13. The multijunction solar cell of claim ~~10~~9, wherein the first subcell is not a current-limiting subcell upon illumination of the multijunction solar cell using the AM1.5D spectrum.

~~15~~14. The multijunction solar cell of claim ~~10~~9, wherein $0.001 \leq z < 0.02$.

~~16~~15. The multijunction solar cell of claim ~~10~~9, wherein the first subcell is characterized by a thickness from 1 μm to 2 μm.

~~17. The multijunction solar cell of claim 10, wherein the first subcell is characterized by a thickness greater than 1 μm.~~

~~18~~16. The multijunction solar cell of claim ~~10~~9, wherein a base of the first subcell comprises p-type $Ga_{1-x}In_xN_yAs_{1-y-z}Sb_z$.

~~19~~17. A multijunction solar cell comprising:
a substrate selected from Ge and GaAs;
a first subcell overlying the substrate, wherein the first subcell comprises a base comprising the semiconductor alloy composition according to claim 1;
the first subcell is substantially lattice matched to the substrate;
the first subcell is characterized by a thickness greater than 1 μm; and
at least one second subcell overlying the first subcell.

~~20~~18. A multijunction solar cell comprising:

at least one subcell comprising $Ga_{1-x}In_xN_yAs_{1-y-z}Sb_z$, the at least one subcell having a low antimony (Sb) content and enhanced indium (In) content and enhanced nitrogen (N) content, wherein the content levels are selected to achieve a bandgap from 0.9 eV to 1.1 eV, wherein the content values for x, y, and z are within compositions ranges as follows: $0.14 \leq x \leq 0.18$, $0.025 \leq y \leq 0.04$ and $0.001 \leq z \leq 0.03$, wherein low corresponds to the content value for z and enhanced corresponds to the content value for x~~,~~.

~~21. The multijunction solar cell according to claim 20, wherein~~ the at least one $Ga_{1-x}In_xN_yAs_{1-y-z}Sb_z$ subcell is substantially lattice matched to a substrate, and wherein the at least one subcell is characterized by a thickness greater than 1 μm.

~~22~~19. The multijunction solar cell according to claim ~~21~~17, further comprising at least one additional subcell that is substantially lattice matched to the at least one $Ga_{1-x}In_xN_yAs_{1-y-z}Sb_z$ subcell.

~~23~~20. The multijunction solar cell according to claim ~~21~~17, wherein the at least one $Ga_{1-x}In_xN_yAs_{1-y-z}Sb_z$ subcell has a lattice constant that is within 0.5% of the lattice constant of the substrate.

~~24~~21. The multijunction solar cell according to claim ~~20~~17, wherein the at least one $Ga_{1-x}In_xN_yAs_{1-y-z}Sb_z$ subcell is capable of producing an open circuit voltage of at least 0.3 V under illumination of the multijunction solar cell at an intensity of 1,000 W/m^2 using the AM1.5D spectrum.

~~25~~22. The multijunction solar cell according to claim ~~20~~17, wherein the at least one $Ga_{1-x}In_xN_yAs_{1-y-z}Sb_z$ subcell is not a current-limiting subcell upon illumination of the multijunction solar cell using the AM1.5D spectrum.

~~26~~23. A method for manufacturing a multijunction solar cell comprising:
forming a first subcell comprising $Ga_{1-x}In_xN_yAs_{1-y-z}Sb_z$, wherein,
the content levels are selected to achieve a bandgap from 0.9 eV to 1.1 eV;
the content values for x, y, and z are within composition ranges as follows: $0.07 \leq x \leq 0.18$, $0.025 \leq y \leq 0.04$ and $0.001 \leq z \leq 0.03$;
the first subcell is characterized by a short circuit current Jsc greater than 13 mA/cm^2 and an open circuit voltage Voc greater than 0.3 V when illuminated with a filtered 1 sun AM1.5D spectrum in which all light having an energy greater than the bandgap of GaAs is blocked; ~~and~~
forming at least one second subcell overlying the first subcell to form the multijunction solar cell; and

the first subcell is characterized by a thickness greater than 1 μm.

~~27~~24. The method of claim ~~26~~23, wherein the first subcell is substantially lattice matched to the at least one second subcell.

~~28~~25. The method of claim ~~26~~23, wherein the at least one second subcell is selected from a $Ga_{1-x}In_xN_yAs_{1-y-z}Sb_z$ subcell, a GaInNAs(Sb) subcell, a (Al)(In)GaP subcell, an (In)(Al)GaAs subcell, an (Al)InGaP subcell, and an (In)GaAs subcell.

~~29~~6. The method of claim ~~26~~23, wherein forming the second subcell comprises growing pseudomorphically.

~~30~~27. The method of claim ~~26~~23, wherein the first subcell is characterized by a lattice constant that is within 0.5% of the lattice constant of the at least one second subcell when fully relaxed.

~~31~~28. The method of claim ~~26~~23, wherein the first subcell is not a current-limiting subcell upon illumination of the multijunction solar cell using the AM1.5D spectrum.

~~32~~29. The method of claim ~~26~~23, wherein,
forming a first subcell comprises substantially lattice matching the first subcell to a substrate; and
the substrate is selected from Ge and GaAs.

~~33~~30. The method of claim ~~26~~23, wherein $0.001 \leq z < 0.02$.

~~34~~31. The method of claim ~~26~~23, wherein the first subcell is characterized by a thickness from 1 μm to 2 μm.

~~35. The method of claim 26, wherein the first subcell is characterized by a thickness greater than 1 μm.~~

~~36~~32. The method of claim ~~26~~23, wherein a base of the first subcell comprises p-type $Ga_{1-x}In_xN_yAs_{1-y-z}Sb_z$.

~~37~~33. A method for manufacturing a multijunction solar cell comprising:
forming a first subcell comprising $Ga_{1-x}In_xN_yAs_{1-y-z}Sb_z$, wherein,
the content levels are selected to achieve a bandgap from 0.9 eV to 1.1 eV;

the content values for x, y, and z are within composition ranges as follows: $0.07 \leq x \leq 0.18$, $0.025 \leq y \leq 0.04$ and $0.001 \leq z \leq 0.03$;
the first subcell is characterized by a short circuit current Jsc greater than 13 mA/cm^2 and an open circuit voltage Voc greater than 0.3 V when illuminated with a filtered 1 sun AM1.5D spectrum in which all light having an energy greater than the bandgap of GaAs is blocked;
the first subcell is characterized by a thickness greater than 1 μm; and
a base of the first subcell comprises p-type $Ga_{1-x}In_xN_yAs_{1-y-z}Sb_z$; and
forming at least one second subcell overlying the first subcell to form the multijunction solar cell;
forming the first subcell comprises substantially lattice matching the first subcell to a substrate; and
the substrate is selected from Ge and GaAs.

~~38~~34. The method of claim ~~37~~33, wherein forming the at least one second subcell comprises epitaxially growing.

~~39~~35. The method of claim ~~37~~33, wherein forming the at least one second subcell comprises joining.