CLAIMS

1. A method of making a Josephson junction for a superconducting qubit, comprising:

providing a substructure having a surface with first and second trenches defined therein, said first trench being substantially perpendicular to and intersecting said second trench, said substructure having a bridge structure extending over said first trench adjacent said intersection of said first and second trenches;

evaporating a first superconducting material at a glancing angle along a first direction to deposit said first superconducting material in said first trench so as to extend under said bridge structure from said first direction;

evaporating a second superconducting material substantially at the glancing angle substantially opposite to the first direction to deposit the second superconducting material in the first trench so as to extend under said bridge structure from said glancing angle substantially opposite to said first direction and to provide a first superconducting lead;

oxidizing the first and second superconducting materials to form an oxidized layer on the first and second superconducting materials at least within said first trench;

evaporating a third superconducting material at an angle substantially perpendicular to said surface of the substructure to deposit the third superconducting material in said second trench within the substructure without rotating the substructure to form a second superconducting lead; and

lifting off regions of said deposited first, second and third superconducting materials and said oxide layer to leave a vertical Josephson Junction at said intersection of said first and second trenches electrically connected at a first end thereof through said first superconducting lead and at a second end thereof through said second superconducting lead.

2. The method according to claim 1, wherein the first, second and third superconducting materials are a same superconducting material.

3. The method according to any of the preceding claims, wherein providing the substructure comprises:

providing a substrate;

depositing a fourth superconducting material on a surface of the substrate;

removing a portion of the fourth superconducting material from the surface of the substrate to uncover a portion of the surface of the substrate;

depositing a first resist layer on the fourth superconducting material and on the uncovered portion of the surface of the substrate; and

depositing a second resist layer on the first resist layer to form superposed first and second resist layers.

4. The method according to the preceding claim, wherein the fourth superconducting material is a same superconducting material as the first, second or third superconducting material.

5. The method according to claim 3, wherein providing the substructure further comprises:

applying electron beam or optical beam lithography to expose a first portion of the superposed first and second resist layers and to expose a second portion of the superposed first and second resist layers.

6. The method according to claim 5, wherein providing the substructure further comprises:

removing the exposed first portion of the superposed first and second resist layers to form the first trench; and

removing the exposed second portion of the superposed first and second resist layers to form the second trench and form the bridge structure extending over said first trench with a remaining portion of the second resist layer, the bridge structure being substantially parallel to the second trench.

7. The method according to the preceding claim, wherein evaporating the first superconducting material at the glancing angle along the first direction to deposit the first superconducting material in the first trench comprises depositing the first superconducting material under the bridge structure.

8. The method according to the preceding claim, wherein evaporating the second superconducting material substantially at the glancing angle substantially opposite to the

first direction to deposit the second superconducting material in the first trench comprises depositing the second superconducting material in zones shadowed by the bridge structure and not filled by the first superconducting material during the evaporating of the first superconducting material.

9. The method according to claim 3, wherein the substrate is selected from the group consisting of Silicon (Si), Germanium (Ge), and Sapphire.

10. The method according to claim 3, wherein the first, second, third and fourth superconducting materials are selected from the group consisting of Niobium (Nb) and Aluminum (Al).

11. The method according to claim 3, wherein removing the portion of the superconducting material from the surface of the substrate to uncover the portion of the surface of the substrate comprises forming four sectors of the fourth superconducting material and associated buses, the four sectors being separated apart by the uncovered portion of the surface of the substrate.

12. The method according to claim 3, wherein depositing the first resist layer on the superconducting material and on the uncovered portion of the surface of the substrate comprises depositing a layer of monomethyl methacrylate (MMA), and

wherein depositing the second resist layer on the first resist layer comprises depositing a layer of polymethyl methacrylate (PMMA).

13. The method according to any of the preceding claims, wherein the glancing angle is between 5 degrees and 85 degrees relative to the surface of the substructure.

14. The method according to any of the preceding claims, further comprising:

providing a substrate;

evaporating the first superconducting material at the glancing angle along the first direction to deposit said first superconducting material on a surface of the substrate;

evaporating the second superconducting material substantially at the glancing angle substantially opposite to the first direction to deposit the second superconducting material

on the surface of the substrate to form four sectors of the first and second superconducting materials and associated buses, the four sectors being separated apart by the uncovered portion of the surface of the substrate.

15. A superconducting qubit, the superconducting qubit being made by:

providing a substructure having a surface with first and second trenches defined therein, said first trench being substantially perpendicular to and intersecting said second trench, said substructure having a bridge structure extending over said first trench;

evaporating a first superconducting material at a glancing angle along a first direction to deposit said first superconducting material in said first trench so as to extend under said bridge structure from said first direction;

evaporating a second superconducting material substantially at the glancing angle substantially opposite to the first direction to deposit the second superconducting material in the first trench so as to extend under said bridge structure from said glancing angle substantially opposite to said first direction and to provide a first superconducting lead;

oxidizing the first and second superconducting materials to form an oxidized layer on the first and second superconducting materials at least within said first trench;

evaporating a third superconducting material at an angle substantially perpendicular to said surface of the substructure to deposit the third superconducting material in said second trench within the substructure without rotating the substructure to form a second superconducting lead; and

lifting off regions of said deposited first, second and third superconducting materials and said oxide layer to leave a vertical Josephson Junction at said intersection of said first and second trenches electrically connected at a first end thereof through said first superconducting lead and at a second end thereof through said second superconducting lead.

16. The superconducting qubit according to claim 15, wherein the first, second and third superconducting materials are a same superconducting material.

17. The superconducting qubit according to any of the preceding claims 15 to 16, wherein providing the substructure comprises:

providing a substrate;

depositing a fourth superconducting material on a surface of the substrate;

removing a portion of the fourth superconducting material from the surface of the substrate to uncover a portion of the surface of the substrate;

depositing a first resist layer on the fourth superconducting material and on the uncovered portion of the surface of the substrate; and

depositing a second resist layer on the first resist layer to form superposed first and second resist layers.

18. The superconducting qubit according to claim 17, wherein the fourth superconducting material is a same superconducting material as the first, second or third superconducting material.

19. The superconducting qubit according to claim 17, wherein providing the substructure further comprises:

applying particle beam or optical beam lithography to expose a first portion of the superposed first and second resist layers and to expose a second portion of the superposed first and second resist layers.

20. The superconducting qubit according to claim 19, wherein providing the substructure further comprises:

removing the exposed first portion of the superposed first and second resist layers to form the first trench; and

removing the exposed second portion of the superposed first and second resist layers to form the second trench and form the bridge structure extending over said first trench with a remaining portion of the second resist layer, the bridge structure being substantially parallel to the second trench.

21. The superconducting qubit according to claim 20, wherein evaporating the first superconducting material at the glancing angle along the first direction to deposit the first superconducting material in the first trench comprises depositing the first superconducting material under the bridge structure.

22. The superconducting qubit according to claim 21, wherein evaporating the second superconducting material substantially at the glancing angle substantially opposite to the first direction to deposit the second superconducting material in the first trench comprises depositing the second superconducting material in zones shadowed by the bridge structure and not filled by the first superconducting material during the evaporating of the first superconducting material.

23. The superconducting qubit according to claim 17, wherein the substrate is selected from the group consisting of Silicon (Si), Germanium (Ge), and Sapphire.

24. The superconducting qubit according to claim 17, wherein the first, second, third and fourth superconducting materials are selected from the group consisting of Niobium (Nb) and Aluminum (Al).

25. The superconducting qubit according to claim 17, wherein removing the portion of the superconducting material from the surface of the substrate to uncover the portion of the surface of the substrate comprises forming four sectors of the fourth superconducting material and associated buses, the four sectors being separated apart by the uncovered portion of the surface of the substrate.