

The Claims Defining the Invention are as Follows:

1. An advanced processing apparatus, comprising:

a plurality of quantum processing elements
arranged in a 2D matrix; each processing element
5 comprising silicon and a dielectric material forming an
interface and an electrode arrangement suitable to confine
one or more electrons or holes in the silicon, for each
quantum processing element, to form a quantum dot operable
as a qubit;

10 a plurality of interconnected control members
forming a matrix of control members; each control member
comprising a silicon metal-oxide-semiconductor transistor
disposed above a respective quantum processing element and
configured to interact with the electrode arrangement to
15 perform quantum operations with the processing element;
and

a plurality of control lines; each control line
being connected to a plurality of control members via the
metal-oxide-semiconductor transistors to enable
20 simultaneous operation of a plurality of processing
elements.

2. The apparatus of claim 1 wherein the quantum operations
comprise any one of initialisation, quantum control and
readout of the processing element.

25 3. The apparatus of claim 1 or claim 2 wherein the
electrode arrangement comprises one or more electrodes
which are controllable to form the quantum dot and operate
the quantum dot as a qubit.

4. The apparatus of any one of the preceding claims wherein the processing elements are arranged in the 2D matrix at an interface which is formed between a silicon layer and a dielectric layer; the interface, the silicon layer and the dielectric layer being shared by the processing elements.
5. The apparatus of claim 4 wherein the electrode arrangement is disposed onto the dielectric layer and the quantum dot is formed within the silicon layer and in proximity of the interface.
6. The apparatus of any one of the claims 4 or claim 5 wherein each control line is arranged along a row or a column of the 2D matrix of processing elements and is capable of interacting with all the processing elements disposed along the row or column.
7. The apparatus of claim 6 wherein each control line is connected with one or more of the control members associated with the processing element.
8. The apparatus of any one of the preceding claims wherein each processing element is associated with at least two control members.
9. The apparatus of claim 8 wherein a first control member is arranged to provide a biasing voltage to form the quantum dot and a second control member is arranged to operate the quantum dot as a qubit.
10. The apparatus of claim 9 wherein the biasing voltage is selected to calibrate the processing element in relation to other processing elements of the matrix.

11. The apparatus of any one of claim 9 or claim 10 wherein a first set of control lines is arranged in a manner such that the biasing voltage is applicable to the first control member of selected processing elements to
5 form the quantum dots.

12. The apparatus of any one of claims 8 to 11 wherein the control lines are arranged in a manner such that a specific processing element can be selected for quantum operation.

10 13. The apparatus of any one of claims 8 to 12 wherein the control lines are arranged in a manner such that a control voltage is applicable to the second control member of the selected processing elements to operate the qubits.

14. The apparatus of any one of the preceding claims
15 wherein the electrode arrangement is operable to form the quantum dot and tune the quantum dot so that the energy at which the state of the qubit is affected can be adjusted over a range of energy values.

15. The apparatus of any one of the preceding claims
20 wherein the electrode arrangement is operable to control a quantum property of the quantum dot to operate the quantum dot as a qubit.

16. The apparatus of claim 14 or claim 15 wherein the qubit logic states are controlled by voltages applied to
25 the electrode arrangement to tune an exchange interaction between spins of electrons or holes of the quantum dots.

17. The apparatus of claim 14 or claim 15 wherein the qubit logic states are controlled by voltages applied to the electrode arrangement to tune a capacitive interaction

between one or more electrons or holes of the quantum dots.

18. The apparatus of any one of claims 14 to 17 wherein the electrode arrangement is operable to tune the electron
5 or hole spin resonance frequency of the quantum dot.

19. The apparatus of claim 18 wherein the electrode arrangement is operable to electrically drive the electron or hole spin resonance frequency of the quantum dot.

20. An advanced processing apparatus comprising a
10 plurality of multi-qubit modules; each multi-qubit module comprising an apparatus in accordance with any one of the preceding claims.

21. The apparatus of claim 20 wherein the plurality of multi-qubit modules are interconnected by superconducting
15 resonators or spin-buses.

22. A system comprising an advanced processing apparatus in accordance with any one of claims 1 to 21 and a classical computing apparatus, wherein the classical computing apparatus controls the advanced processing
20 apparatus to perform a quantum algorithm.