Two-Qubit Dynamics with Josephson Qubits

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History

History

Topic of this slide

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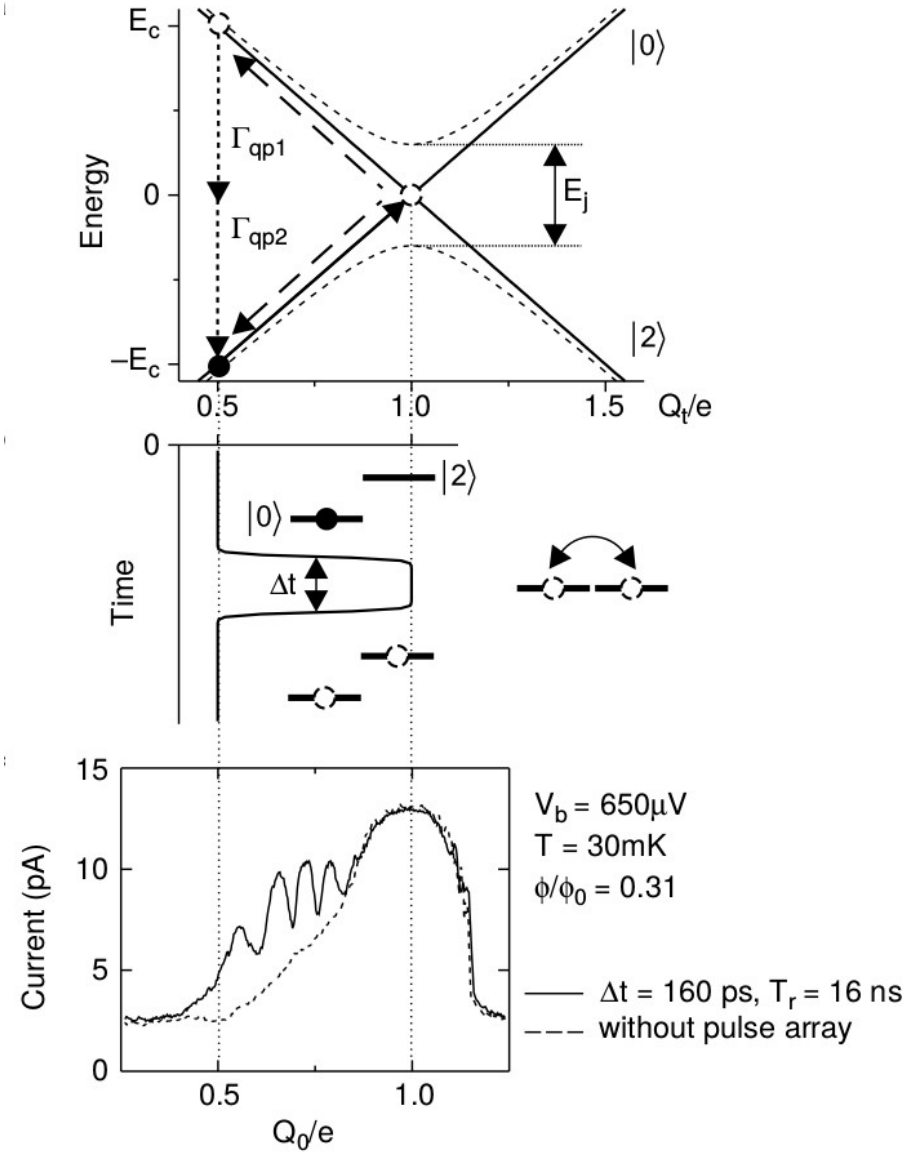


Figure : A simple caption

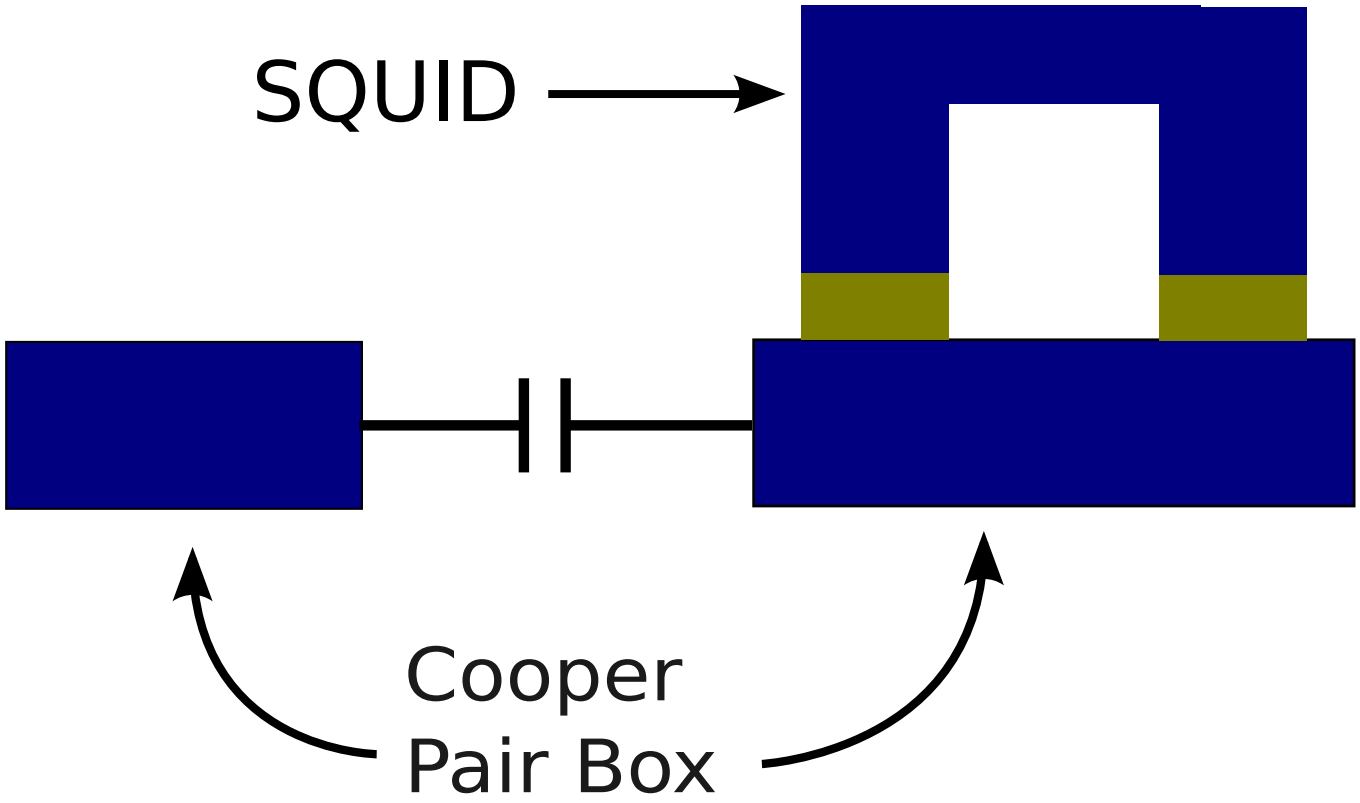
Coupling of Two Qubits

Coupling of Two Qubits

Review

Coupling of Two Qubits

Basic Idea



Coupling of Two Qubits

The Circuit

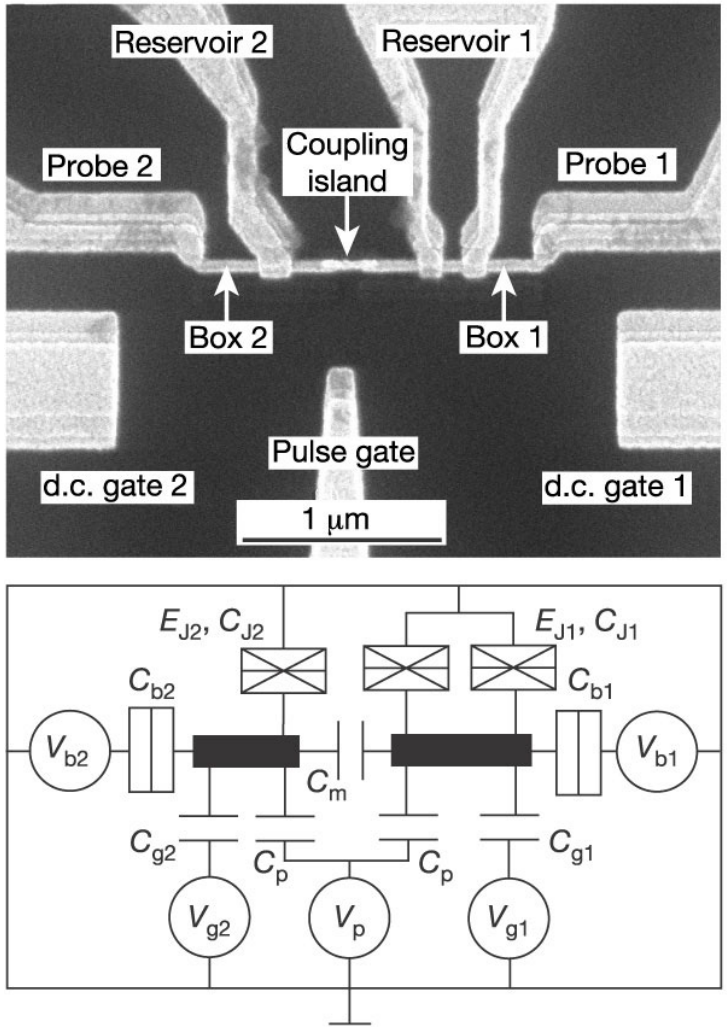


Figure : http://www.nature.com/nature/journal/v421/n6925/full/nature01365.html

Coupling of Two Qubits

Theory

Hamiltonian

Coupling of Two Qubits

Parameter Measurements

Coupling of Two Qubits

Charging Diagram of Single-Qubit Case

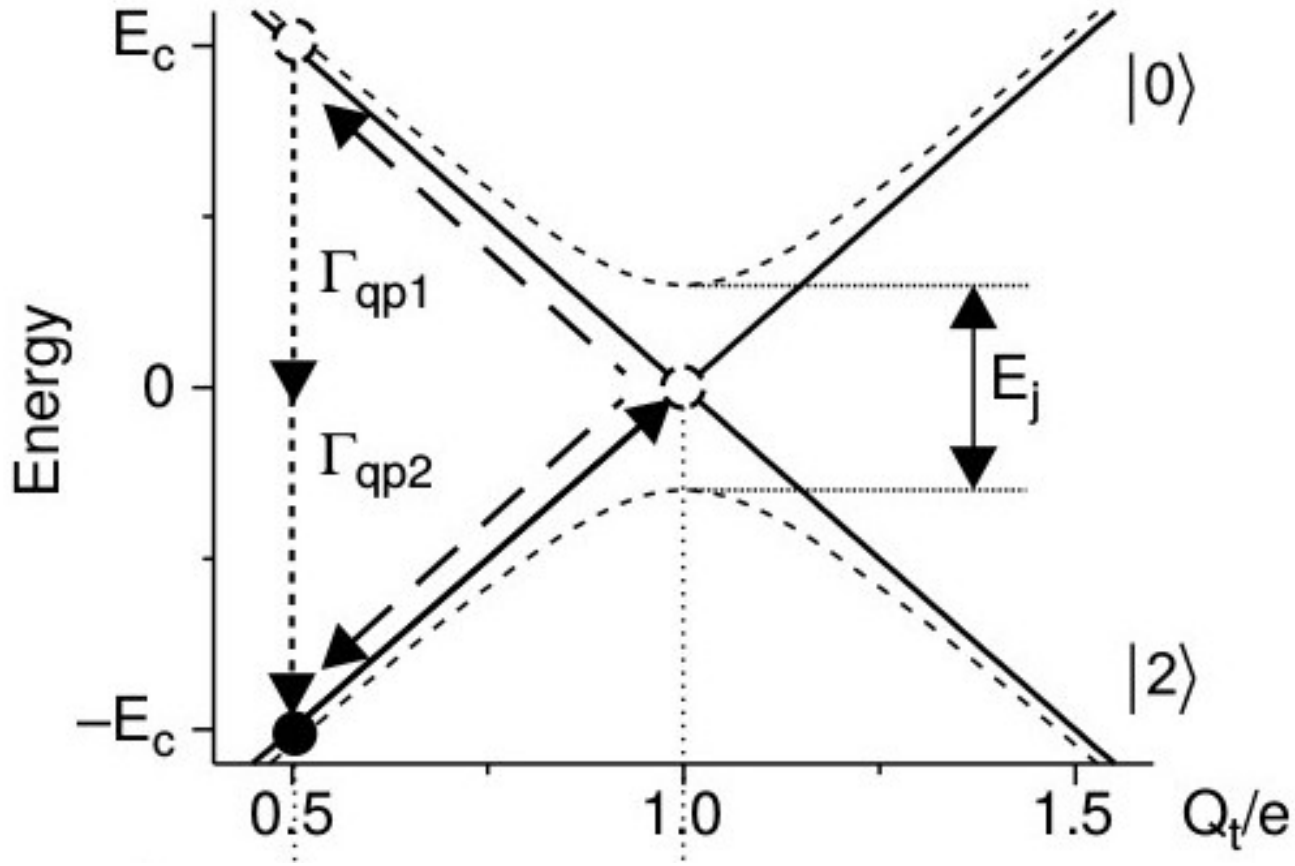


Figure : http://www.nature.com/nature/journal/v398/n6730/abs/398786a0.html

Coupling of Two Qubits

Charging Diagram Level Curves

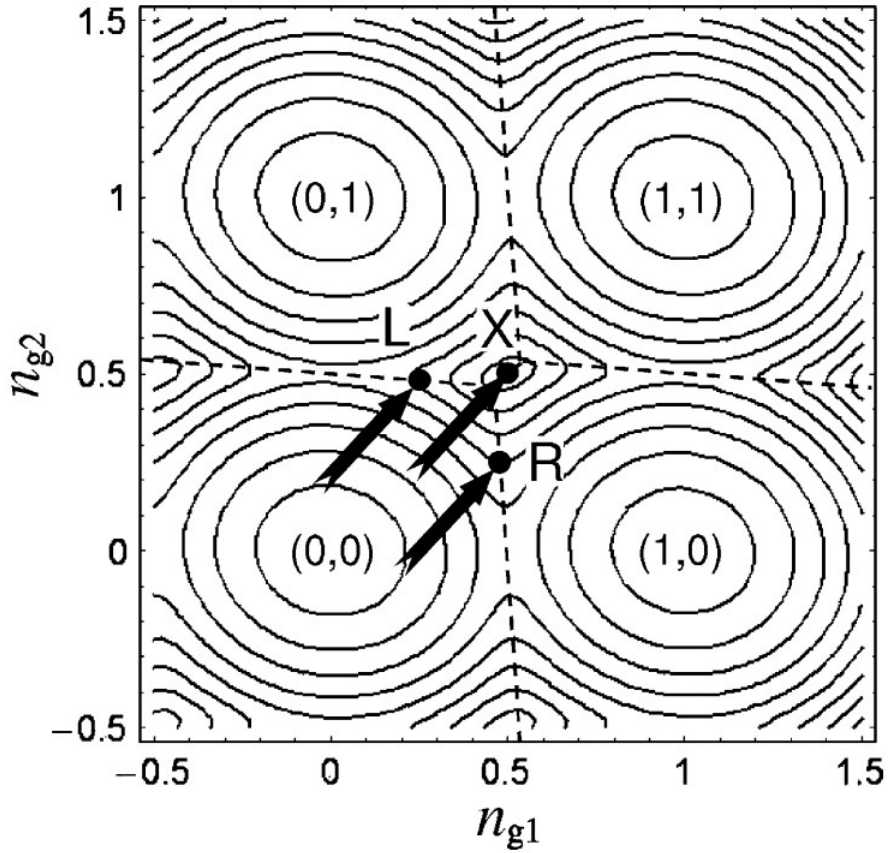


Figure : http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.193.5098&rep=rep1&type=pdf

Coupling of Two Qubits

Charging Diagram of Two-Qubit Case

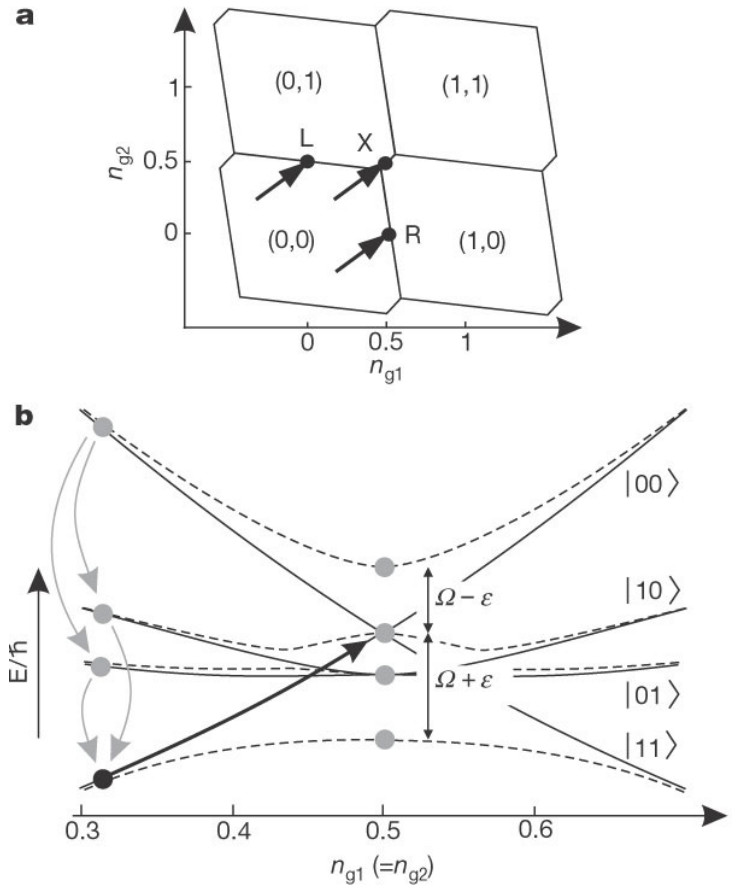


Figure : http://www.nature.com/nature/journal/v421/n6925/full/nature01365.html

Coupling of Two Qubits

Charging-Energy Diagram

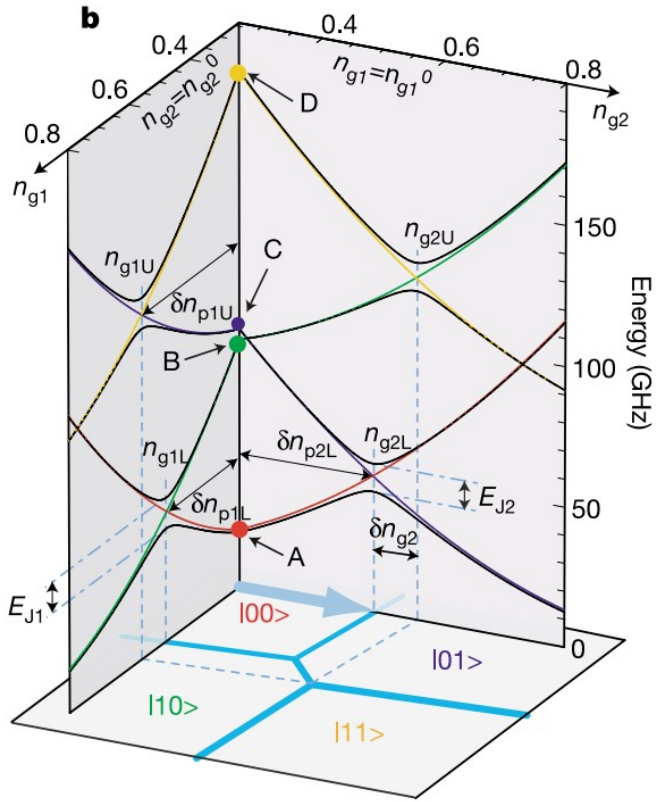
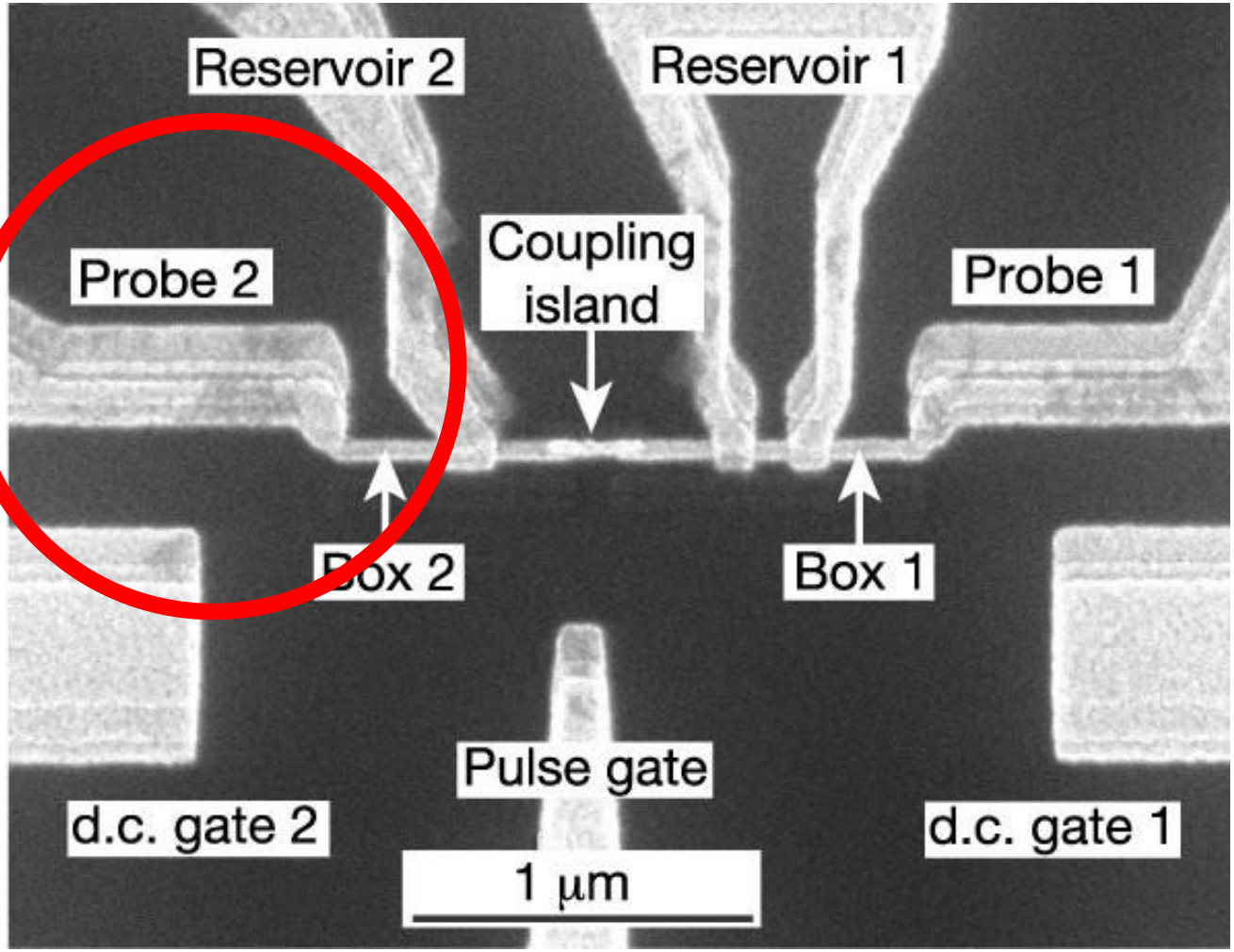


Figure : http://qudev.ethz.ch/content/courses/QSIT09/pdfs/Yamamoto2003.pdf

Coupling of Two Qubits

State Readout



Coupling of Two Qubits

Theory

Hamiltonian

$$H = \begin{bmatrix} E_{00} & -\frac{1}{2}E_{J1} & -\frac{1}{2}E_{J2} & 0 \\ -\frac{1}{2}E_{J1} & E_{10} & 0 & -\frac{1}{2}E_{J2} \\ -\frac{1}{2}E_{J2} & 0 & E_{01} & -\frac{1}{2}E_{J1} \\ 0 & -\frac{1}{2}E_{J2} & -\frac{1}{2}E_{J1} & E_{11} \end{bmatrix}$$

Where...

- $E_{n1n2} = E_{c1}(n_{g1} - n_1)^2 + E_{c2}(n_{g2} - n_2)^2 + E_m(n_{g1} - n_1)(n_{g2} - n_2)$
- E_{Ji} is the Josephson energy of the i^{th} box
- $E_{c1,c2} = 4e^2 C_{\Sigma 2,\Sigma 1}/2(C_{\Sigma 1}C_{\Sigma 2} - C_m^2)$ are the effective Cooper pair charging energies
- $C_{\Sigma i}$ is the sum of all capacitances connected to the i^{th} island
- $n_{g1,g2} = (C_{g1,g2}V_{g1,g2} + C_p V_p)/2e$ is the charge, indiced by the gate and pulse voltages, on the qubits
- $E_m = 4e^2 C_m/(C_{\Sigma 1}C_{\Sigma 2} - C_m^2)$

Coupling of Two Qubits

Frequency Responces

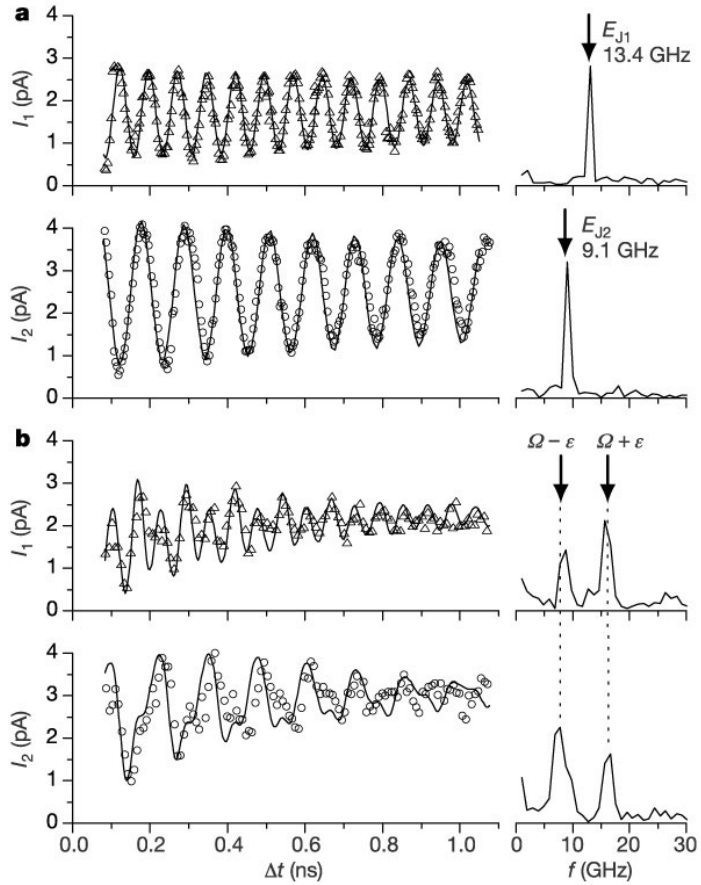
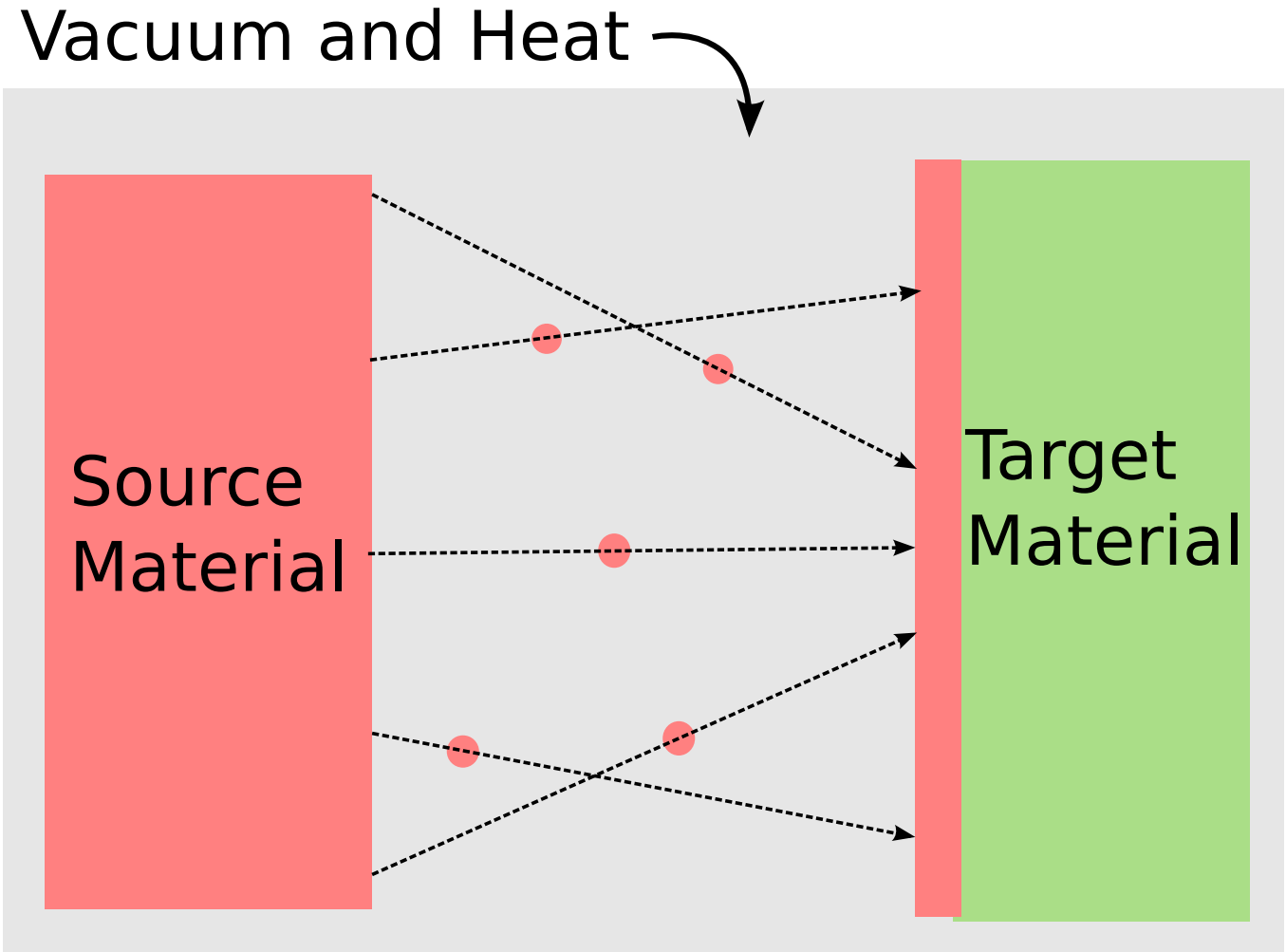


Figure : http://www.nature.com/nature/journal/v421/n6925/full/nature01365.html

Fabrication Techniques

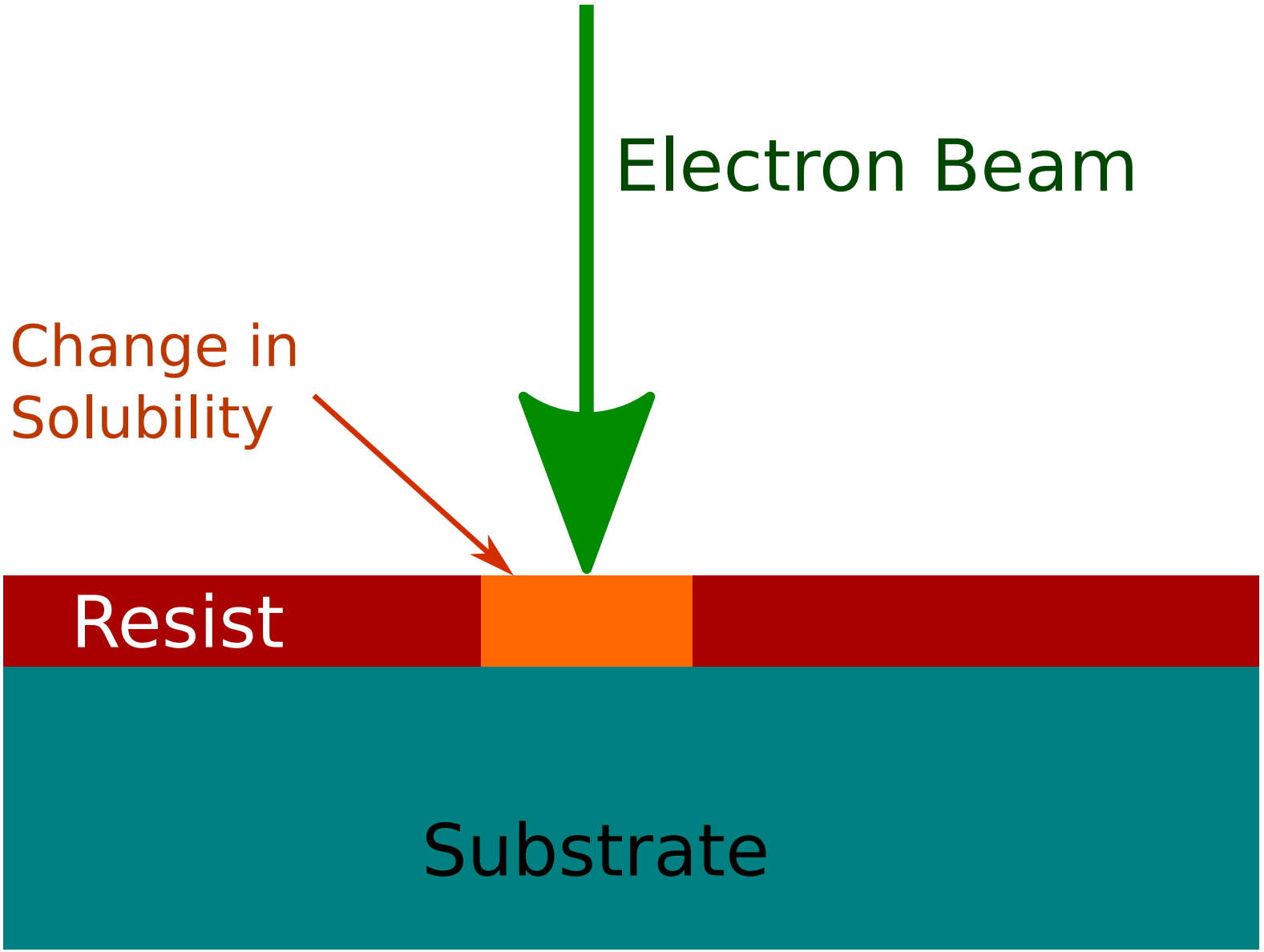
Fabrication Techniques

Evapouration (Deposition)



Fabrication Techniques

Electron Beam Lithography (EBL)



Fabrication Techniques

Etching

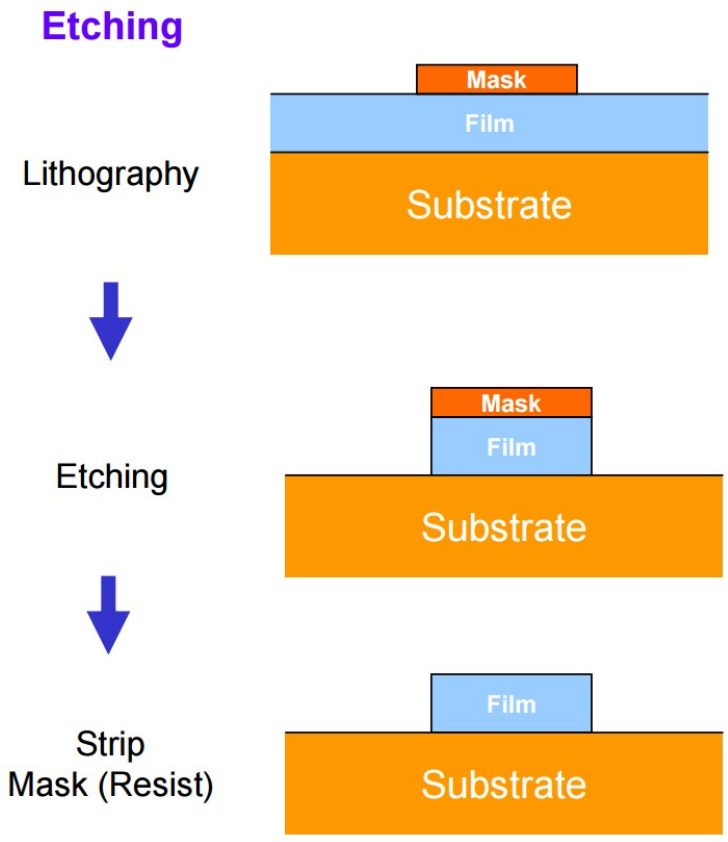


Figure : http://www.mrsec.harvard.edu/education/ap298r2004/Erli%20chen%20Fabrication%20III%20-%20Etching.pdf

Fabrication Techniques

Lift-off

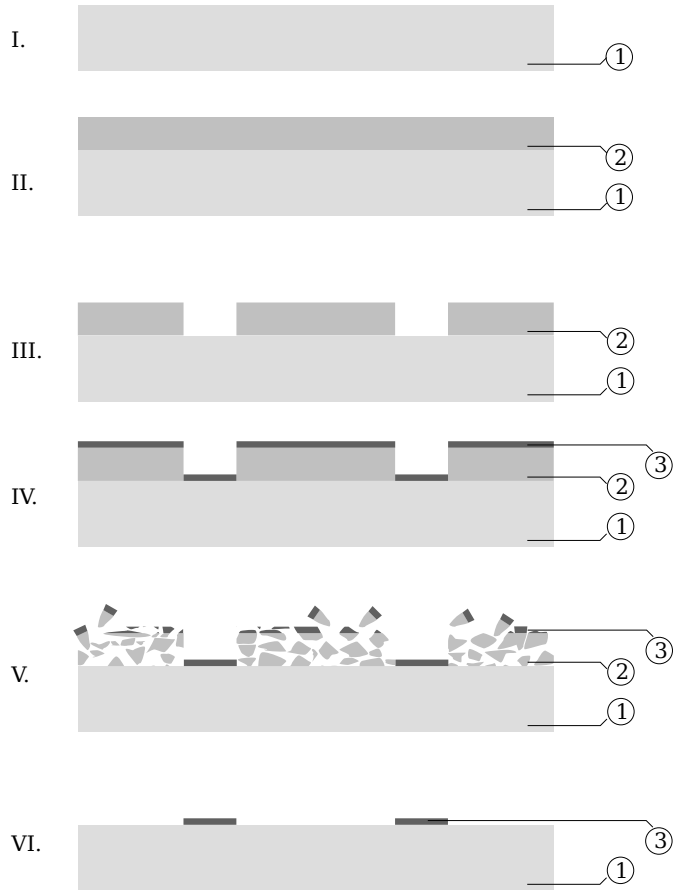


Figure : http://en.wikipedia.org/wiki/Lift-off_%28microtechnology%29

Fabrication Techniques

SEM image of a SQUID qubit

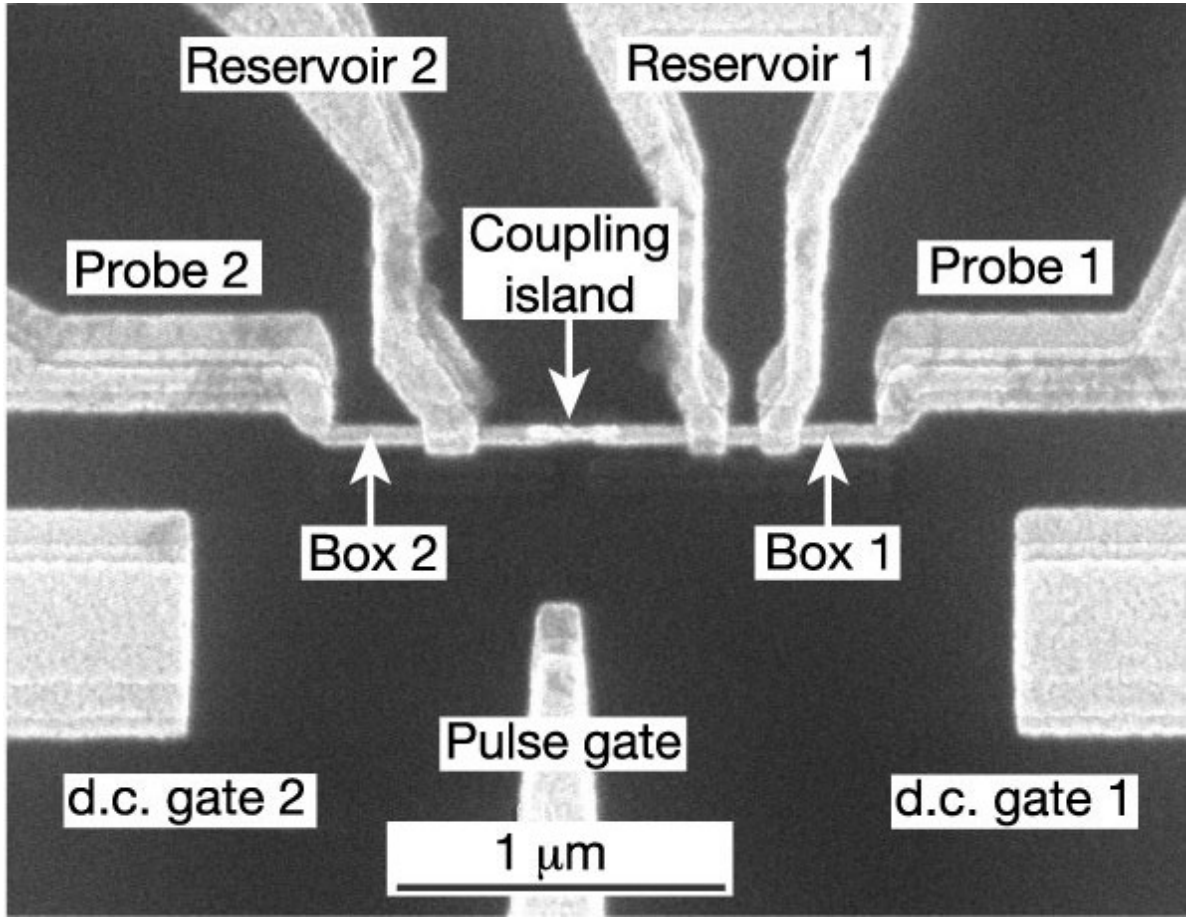


Figure : http://www.nature.com/nature/journal/v421/n6925/full/nature01365.html

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Reference Papers

http://www.nature.com/nature/journal/v421/n6925/full/nature01365.html
http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.193.5098&rep=rep1&type=pdf
(Figures cited individually)