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Published: 01/07/2019

Please cite the original version:
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Abstract

Utilizing the ultra-high sensitivity of a superconducting single-walled carbon nanotube (SWCNT) sensor to probe the quantum ground state is a promising experimental approach for investigations of macroscopic quantum phenomena. We approach the challenge with suspended, 300 nm long SWCNT contacted on MoRe leads. MoRe is used because it can withstand temperatures above 900 °C. Such temperatures are used in our annealing process as well as in CNT CVD growth processes. Good transparency of the superconductor-nanotube contacts allows observation of proximity induced supercurrents of up to 50 nA, tuneable by gate induced charge. Additionally, we have developed a method to pick-up and place individual suspended SWCNT selectively on metal-electrodes. Using such weak links in an optomechanical microwave setting, coupling emerges on the order of 2 MHz can be reached between the mechanical resonator and the electrical cavity.

Measuring supercurrent in CNT

- We fabricated source/drain pairs of 200 nm MoRe [1] and a separation of 300 nm and deposited aerosol-synthesised [2] carbon nanotubes onto a chip with multiple pairs.
- Promising tubes are selected and cooled down to 10 mK.
- We can measure a supercurrent of up to 52 nA with a responsivity of $\partial IC/\partial Vg = 290$ nA/V.

Carbon nanotube transfer

- CVD grown CNTs are picked up from a separate chip at 70 °C. The PMMA is patterned with holes of 2 µm × 10 µm.

Limits of CNT supercurrent

- CNT coupled to two leads with equidistant energy levels and four time degenerate (two valleys and two spins)
- The escape rates to both sides are then given by $r_L > 0.5$ and $r_R > 0.5$ (no Coulomb blockade) and the CNT has 4 channels with a transparency $\tau = \frac{1 - (1 - r_L)(1 - r_R)}{\sqrt{2}}$.
- The cavity readout frequency is around $2\pi f_c = 24$ GHz and a charging energy $E_C/2e^2/h = 24$ GHz
- The coupling between the Qubit and phonon corresponding to the CNT vibration is $g = \hbar \approx 200 \text{MHz}$.

References

[5] Manuyama Lab webpage, Univ. of Tokyo

Acknowledgements

This work was performed as part of the Academy of Finland Centre of Excellence program (project 312295) and supported by ERC grant no. 670743.